SFB 649 Discussion Paper 2014-027

Stale Forward Guidance

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This research was supported by the Deutsche Forschungsgemeinschaft through the SFB 649 "Economic Risk".

http://sfb649.wiwi.hu-berlin.de
ISSN 1860-5664

SFB 649, Humboldt-Universität zu Berlin
Spandauer Straße 1, D-10178 Berlin

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This version:

May 13, 2014

An increasing number of central banks manage market expectations via interest rate projections. Typically, those projections are updated only quarterly and thus, may become stale when new information enters the market. We use data from New Zealand to investigate the time-varying and state-dependent effects of interest rate projections on market expectations and interest rate uncertainty. Confirming the stabilizing effect of fresh central bank announcements, we show that interest rate uncertainty rises between two projection releases. Moreover, rate uncertainty and the importance of macroeconomic news increase if expectations deviate from the rate projected by the central bank. Counterfactual analysis suggests that the efficiency of projections would improve if the central bank updated its projection whenever it becomes stale.

Keywords: Central bank interest rate projections, central bank communication, quantitative forward guidance, interest rate uncertainty.

JEL classification: E52, E58

*Financial support by the German Research Foundation through the CRC 649 *Economic Risk* is gratefully acknowledged. This project was initiated during a research stay at the Reserve Bank of New Zealand. We are thankful for comments received from seminar participants in Berlin, Frankfurt, Sydney, Waterloo (Canada), Cologne and Heidelberg.
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1 Introduction

Since the outbreak of the financial crisis, many central banks have adopted forward guidance, defined as statements about the likely path of the future policy rate, in order to anchor rate expectations more firmly and to curb the volatility of interest rates. The growing literature on central bank communication suggests that forward guidance is also useful in less turbulent times. In particular, the publication of interest rate projections is a powerful tool for both explaining monetary policy and guiding market expectations, see e.g. Rudebusch and Williams (2008) and Hughes Hallett et al. (2012). Yet, only few central banks used forward guidance before the crisis. In 1997, the Reserve Bank of New Zealand (RBNZ) was the first central bank to publish projections of the future 90-day bank bill rate in order to guide interest rate expectations up to three years in the future. The RBNZ publishes projections only once a quarter and a similar timing has been adopted by several other central banks, including the Norges Bank and the Sveriges Riksbank, see Andersson and Hofmann (2010). Consequently, quarterly projections may become stale when new information enters the market. Since the remaining information content of a current projection is not always obvious, stale projections may even undermine the transparency of monetary policy and the expectations management of the central bank. This paper explores the time-varying and state-dependent effects of the RBNZ's projections on interest rate expectations and uncertainty in order to assess the empirical consequences of stale forward guidance.[1]

The usefulness of regularly announced interest rate projections for central bank communication is still under debate. The information content of central bank interest rate projections is typically investigated in event studies that focus on the projections' impact on market rates at or close to the announcement day, see Moessner and Nelson (2008), Ferrero and Secchi (2009), Detmers and Nautz (2012), Moessner (2013) and Winkelmann (2013). In the same vein, Swanson (2006) shows that interest rate uncer-

[1]Recently, the European Central Bank (ECB) and the U.S. Federal Reserve (FED) used forward guidance to *assure* that policy rates will be low for an extended period of time, see ECB (2014). Forward guidance as provided by the RBNZ's regular interest rate projections, however, is not to be misinterpreted as a commitment to the projected interest rate path.

tainty in the United States typically decreases on the day of monetary policy announcements. Bauer (2012) uses an event study to demonstrate that the forward guidance of the U.S. Federal Reserve during the financial crisis both shifted the expected path of the federal funds rate and reduced uncertainty surrounding those expectations. Goodhart and Lim (2011) conclude from a forecast analysis that the RBNZ's interest rate projections are useless for a horizon of more than two quarters ahead. According to Neuenkirch (2012), publication of interest rate projections contributes to a high transparency index of the RBNZ which is found to reduce the bias and variation of rate expectations. However, none of these contributions considers the time-varying information content of probably stale interest rate projections.

Our paper builds on Ehrmann and Sondermann (2012), who investigate the time-varying effect of the quarterly Bank of England Inflation Report on various market interest rates. They find that central bank communication becomes stale, because interest rate uncertainty as well as the relative importance of macroeconomic news rise between two releases of inflation reports. However, their application does not allow to investigate state-dependent effects of central bank communication because the staleness of an Inflation Report cannot be measured directly. In contrast, in our application, the staleness of an interest rate projection is reflected in the futures rate whose maturity exactly matches the rate projected by the central bank. The spread between these interest rates reveals to what extent market expectations continue to rely on the projection and can, therefore, be used as a direct measure for the degree of its staleness. In particular, large deviations of market expectations from the projected rate indicate that the projection has become stale.

We propose two hypotheses on the time- and state-dependent effects of interest rate projections. Hypothesis 1 emphasizes the varying importance of macroeconomic news for rate expectations. Following Ehrmann and Sondermann (2012), macroeconomic news become relatively more important for the formation of rate expectations as the information content of an ageing interest rate projection decreases. Moreover, the relative influence of macroeconomic news on rate expectations should also increase if markets perceive the current projection to be stale, i.e. if the spread between the futures and the projected rate increases. Finally, this state-dependent effect of projections should also be time-dependent. In particular, a stale projection may not be a big issue for market expectations if it is already seen as outdated. Hypothesis 2 focuses on the effects of projections on interest rate uncertainty. Interest rate uncertainty should increase between two releases of central bank projections and if markets perceive the interest rate projection to be stale. Similar to the rationale behind Hypothesis 1, however, the uncertainty-increasing effect of stale projections is the stronger, the longer markets have to wait for an updated projection. We test these predictions on the empirical consequences of stale interest rate projections within an EGARCH model for daily changes in futures rates of various maturities. While results concerning Hypothesis 1 depend on the macroeconomic news variable under consideration, the predictions on the time- and state-dependent effects of central bank projections on interest rate uncertainty are strongly confirmed by the data.

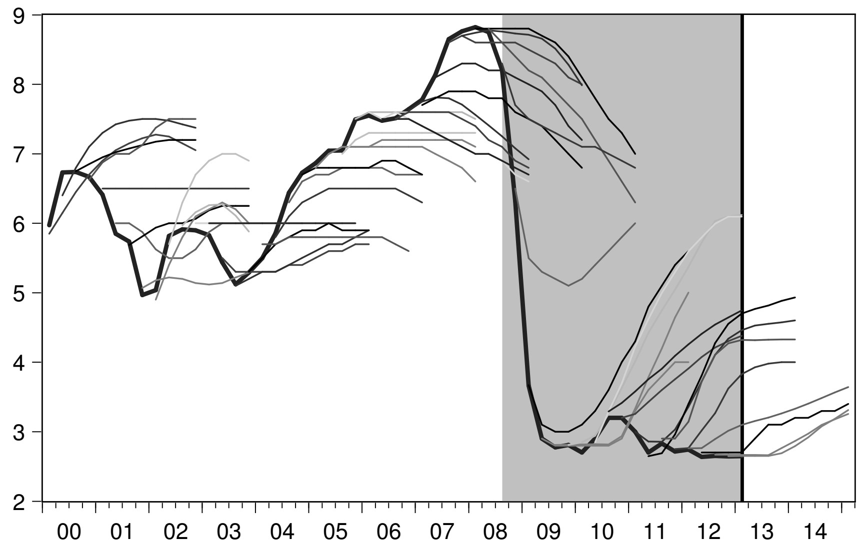
Our estimation results suggest that the efficiency of interest rate projections could be improved by the central bank along two dimensions. On the one hand, projections could be more useful if they were updated more frequently. However, in monetary policy practice providing projections more often may not be a realistic option. This particularly applies for central banks like the ECB and the FED where each new projection would require the approval by a committee, compare Ehrmann and Fratzscher (2007). On the other hand, the central bank could update its projection whenever markets perceive the current projection as too stale. In order to evaluate the volatility effects of alternative implementation schemes, we employ a counterfactual analysis based on our estimated EGARCH models. The results strongly indicate that the performance of the RBNZ's projections would improve by using a more flexible, state-dependent implementation scheme that ensures a certain freshness of projections.

The rest of the paper is organized as follows. In the next section, we introduce the RBNZ's interest rate projections and explain how to measure their degree of staleness using futures data. Section 3 discusses the effects of stale projections on market expectations, interest rate volatility, and the relative importance of macroeconomic news. Section 4 introduces the econometric model and presents the estimation results. Section 5 provides a counterfactual analysis of alternative implementation schemes for interest rate projections. Section 6 offers some concluding remarks.

2 The Interest Rate Projections of the RBNZ

Since 1997, the RBNZ has been projecting the 90-day bank bill rate for the following 8 to 12 quarters within its quarterly Monetary Policy Statement (MPS).[2] Figure 1 shows that interest rate projections change substantially from one release to the next. Apparently, projections often lose much of their relevance over the course of a quarter.

Figure 1 Interest rate projections and the 90-day interest rate



Notes: Quarterly projections for the 90-day bank bill rate around its actual monthly level (continuous bold line). The light shaded area refers to the period as of September 2008. The vertical line represents the end of the sample. Data are taken from the Monetary Policy Statements of the RBNZ from March 2000 through February 2013. *Source:* Detmers and Nautz (2012)

[2] In the following empirical analysis, the sample period runs from March 1, 2000 until February 28, 2013. The sample period does not start already in 1997 because of data availability problems for some control variables, see Appendix. Notice further that this sample period avoids a structural break due to changes in the RBNZ's monetary policy framework in 1999, see Guender and Rimer (2008).

Interest rate projections are published quarterly and are, thus, by construction constant between two publication days. This implies, however, that the actual projection horizon is not constant but shrinks in the course of a quarter. For example, the maturity of a projection for j quarters ahead has declined to virtually $j-1$ quarters when the next projection is about to be published. Therefore, we adjust the quarterly projection data to obtain daily data for projections with a constant maturity of j quarters. The maturity-adjusted projection p_t^j employed in the empirical analysis increasingly incorporates information from the (unadjusted) projection for $j+1$ quarters ahead. More precisely, daily data for the maturity-adjusted p_t^j is obtained as a weighted average of the two unadjusted interest rate projections for j and $j+1$ quarters ahead, where the weight of the projection for $j+1$ quarters rises linearly over time. As a result, p_t^j is not necessarily constant between two publications, compare Figure 3 in the appendix.

We use futures rates on the 90-day bank bill rate j quarters ahead as a proxy for prevailing market expectations about future interest rates. The empirical analysis is restricted to $j = 1, \ldots, 5$ since data for longer-term futures rates are available only from 2007 onward. Following Detmers and Nautz (2012), futures rates are also adjusted in order to obtain data with constant maturity, f_t^j, that exactly match the maturity of the corresponding projection rate p_t^j.

If f_t^j is close to p_t^j, market expectations are in line with the central bank projection suggesting that the perceived information content of the current projection is still high. Yet, new information might lead markets to expect the future interest rate to differ from the current central bank projection. In this case, the information content of the projection has become *stale* and f_t^j should deviate from p_t^j. In the following empirical analysis, we use the spread $|f^j - p^j|_{t-1}$ as a measure for the degree of staleness of the interest rate projection p_t^j.

Table 1 provides first information about the staleness of interest rate projections for different maturities. As expected, the average staleness of projections rises with increasing maturity and is higher during the financial crisis. Time-series plots of futures and projected rates are shown in Figure 3 in the Appendix.

Table 1 The average staleness of interest rate projections

maturity in quarters	j=1	j=2	j=3	j=4	j=5
pre-crisis: March 1, 2000 - Sep 12, 2008					
median($\|f^j - p^j\|$)	16.74	24.39	31.26	36.61	37.39
crisis: Sep 15, 2008 - Feb 28, 2013					
median($\|f^j - p^j\|$)	19.38	31.90	48.94	55.48	55.52

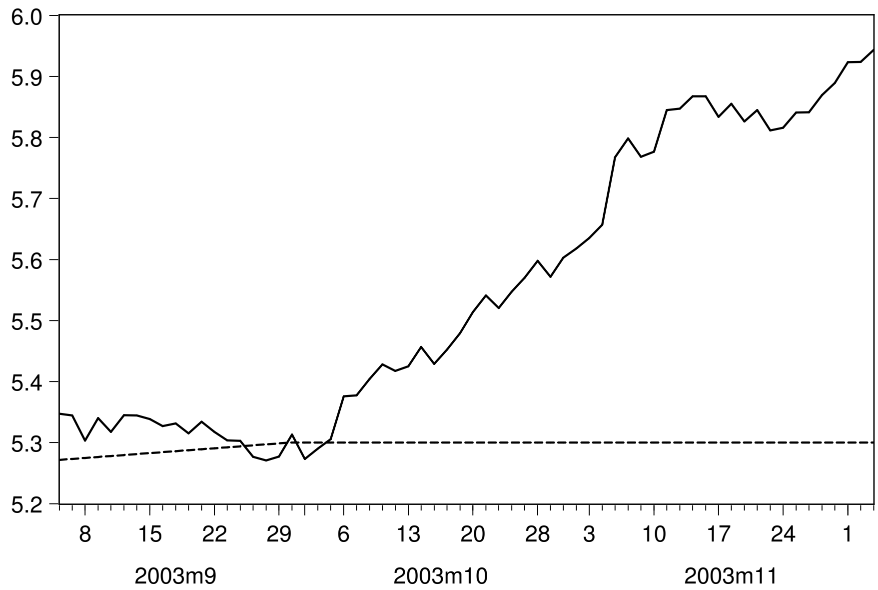
Notes: We use the spread between the futures rate and the corresponding projection, $|f^j - p^j|_{t-1}$, as a proxy-variable for the degree of staleness of an interest rate projection. Median is denoted in basis points. We assume that the crisis period started with the Lehman failure on September 15, 2008.

3 The Time-Varying and State-Dependent Effects of Interest Rate Projections

This section develops two testable hypotheses concerning the time-varying and state-dependent effects of central bank interest rate projections on (1) the dynamics and (2) the volatility of futures rates. All hypotheses stem from the fact that the RBNZ's interest rate projections are released only quarterly and are not updated between releases. Typically, market expectations and thus, futures rates are roughly in line with the central bank interest rate projection, at least shortly after the release of a new interest rate path. However, as time goes by and new information arrives, market expectations may start to deviate from the central bank projection and the spread $|f^j - p^j|$ widens accordingly.

Figure 2 shows the development of market expectations following the projection's release on September 4, 2003. While interest rate expectations are initially in line with the central bank interest rate projection, expectations begin to diverge after about 20 business days. Apparently, with new information entering the market, the remaining information content of the current interest rate projection becomes dubious. The resulting signal-extraction problem may imply (a) time-varying, (b) state-dependent, and (c)

Figure 2 An interest rate projection that becomes stale



Notes: The Figure shows the RBNZ's interest rate projection for $j = 1$ (dashes line) and the corresponding futures rate between two interest rate projections in 2003. The increased spread indicates that markets eventually perceive the central bank projection to be stale.

a combination of time- and state-dependent effects of projections on both, market expectations about future interest rates as well as interest rate uncertainty. Hypothesis 1 focuses on the effects of projections on the relative importance of macroeconomic news for interest rate expectations.

Hypothesis 1: The relative importance of macroeconomic news for rate expectations
a) rises between two releases of interest rate projections
b) is the larger, the wider the spread $|f^j - p^j|$.
c) The effect claimed in b) is the larger, the longer markets have to wait for an updated projection.

The intuition behind Hypothesis 1 is as follows: As time between two releases elapses, interest rate projections age and their significance declines. This implies that macroeconomic news become relatively more important for the formation of rate expectations which explains part a). Similarly, the relative influence of macroeconomic news on rate expectations increases if $|f^j - p^j|$ is large and markets perceive the recent projection to be stale, compare part b). According to part c), this state-dependent effect should also be time-dependent. In particular, a stale projection should not distort market expectations significantly when the new projection is about to be published.

Hypothesis 2: Interest rate uncertainty

a) rises between two releases of interest rate projections

b) is the larger, the wider the spread $|f^j - p^j|$.

c) The effect claimed in b) is the smaller, the longer markets have to wait for an updated projection.

Hypothesis 2a considers the purely time-varying effect of projections on interest rate uncertainty. When the current projection ages, markets cannot be sure of its continuing relevance, especially since the central bank does not comment on the projection once it has been published. Therefore, the information content of a projection declines over time implying increasing interest rate uncertainty until the new projection is published. Beyond this pure time-effect, 2b states that uncertainty also rises if markets believe the recent interest rate projection to be stale, i.e. if the rate expected by the market increasingly deviates from the rate projected by the central bank. Finally, 2c takes into account that effects of stale projections are also time-dependent because markets distinguish between a deviation of futures rates from the central bank projection observed at the beginning and the end of a quarter.

The purely *time-varying* effects of central bank announcements stated in part a) of our hypotheses are also discussed by Ehrmann and Sondermann (2012) who examine the time-varying effects of the quarterly publications of the Bank of England's inflation reports. They do not, however, consider the *state-dependent* effects of stale central bank communication as in part b) and c) of our hypotheses.

4 The Time-Varying and State-Dependent Effects of Interest Rate Projections: Empirical Results

4.1 The Econometric Model

Market expectations about the future 90-day bank bill rate j quarters ahead are reflected in the corresponding futures rate f_t^j. We model the daily change in expectations as follows:

$$\begin{aligned}\Delta f_t &= \alpha + \delta \Delta f_{t-1} + \sum_k \gamma^k x_t^k + \sum_k \gamma^{k,\tau} x_t^k \cdot \tau_t + \sum_k \gamma^{k,s} x_t^k |f-p|_{t-1} \\ &\quad + \sum_k \gamma^{k,s,\tau} x_t^k |f-p|_{t-1} \tau_t + \eta Z_t + \varepsilon_t \qquad (1)\end{aligned}$$

where we suppressed the maturity-index j throughout the equation for the sake of readability and Z_t controls for monetary policy days. According to Equation (1), market expectations depend on various macroeconomic news variables (x^k), interest rate projections ($|f-p|$), and the age of the current projection (τ_t). We calculate $0 \leq \tau_t \leq 1$ as the number of days since the last release divided by the length of the quarter. Thus, τ_t equals 0 at the announcement day and 1 the day before the subsequent announcement. Note the impact of macroeconomic news variables on rate expectations is not necessarily constant over time (γ^k), but could be time-varying ($\gamma^{k,\tau}$) or state-dependent ($\gamma^{k,s}$). Finally, we allow for a combined effect which is captured by the coefficient ($\gamma^{k,s,\tau}$) of the interaction variable $x_t^k|f-p|_{t-1}\tau_t$.

According to Hypothesis 1, the relative importance of macroeconomic news on rate expectations should increase both a) over time between two releases ($\gamma^{k,\tau} > 0$) and b) in the spread $|f-p|$ ($\gamma^{k,s} > 0$). Following part c) of Hypothesis 1, the latter state-dependent effect of macroeconomic news should be the stronger, the longer markets have to wait for an updated projection ($\gamma^{k,s,\tau} < 0$). The set of macroeconomic news variables incorporates surprises resulting from quarterly announcements of GDP (x^{GDP}) and inflation (x^{CPI}) as well as the daily changes of U.S. bond yields with two year maturity (Δr^{US}) and of New Zealand's effective exchange rate (Δe). This set of macroeconomic variables should capture the main determinants of the RBNZ's interest rate policy.[3]

Interest rate uncertainty is not constant over time. Following Ehrmann and Sondermann (2012), the conditional variance of futures rates is assumed to follow an augmented EGARCH(1,1) model. For each maturity $j = 1, \ldots, 5$, we consider the following variance equation:

$$\begin{aligned} log(\sigma_t^2) &= \omega_o + \omega_1 \left| \frac{\varepsilon_{t-1}}{\sigma_{t-1}} \right| + \omega_2 \frac{\varepsilon_{t-1}}{\sigma_{t-1}} + \omega_3 log(\sigma_{t-1}^2) + \psi D_t \\ &\quad + \rho^\tau \tau_t + \rho^s |f - p|_{t-1} + \rho^{s,\tau} |f - p|_{t-1} \tau_t \end{aligned} \tag{2}$$

where D_t controls for monetary policy days as well as announcement days of GDP and inflation data. According to Hypothesis 2a, uncertainty should rise over time until the next projection is published. In the variance equation above, this implies $\rho^\tau > 0$. Correspondingly, ρ^s measures the state-dependent effect of a projection on interest rate uncertainty. Following Hypothesis 2b, interest rate uncertainty increases the more interest rate expectations deviate from the central bank projection which implies that $\rho^s > 0$. However, we also expect this effect to decrease between two projection releases implying $\rho^{s,\tau} < 0$, compare Hypothesis 2c.

4.2 Empirical Results

4.2.1 Projections, market expectations, and macroeconomic news

We estimated the empirical model for the pre-crisis and the crisis period separately. Let us first summarize the results obtained for the impact of macroeconomic variables on interest rate expectations. Table 2 provides no evidence in favor of the pure time-effects

[3]More information about the controls is provided in Table 8 in the Appendix. We used bond yields with two year maturity because this captures the complete projection horizon under consideration. We also experimented with interest rates from Australia and with an economic surprise index for New Zealand provided by Citigroup but none of these variables proved to be significant.

Table 2 The response of rate expectations in New Zealand to U.S. interest rates

	j=1	j=2	j=3	j=4	j=5
pre-crisis: March 1, 2000 - Sep 12, 2008					
Δr_t^{US}	0.09***	0.21***	0.29***	0.33***	0.39***
	(0.02)	(0.03)	(0.03)	(0.03)	(0.04)
$\Delta r_t^{US} \cdot \tau_t$	0.03	-0.05	-0.06	-0.05	-0.09
	(0.04)	(0.05)	(0.05)	(0.06)	(0.07)
$\Delta r_t^{US} \cdot \lvert f-p \rvert_{t-1}$	0.51***	0.26***	0.11	0.03	-0.06
	(0.09)	(0.09)	(0.07)	(0.06)	(0.06)
$\Delta r_t^{US} \cdot \lvert f-p \rvert_{t-1} \cdot \tau_t$	-0.31**	-0.06	-0.04	-0.01	0.08
	(0.13)	(0.12)	(0.10)	(0.10)	(0.09)
crisis: Sep 15, 2008 - Feb 28, 2013					
Δr_t^{US}	0.10**	0.35***	0.30**	0.33***	0.16
	(0.05)	(0.09)	(0.12)	(0.12)	(0.11)
$\Delta r_t^{US} \cdot \tau_t$	0.04	-0.18	-0.10	-0.10	0.35*
	(0.08)	(0.16)	(0.18)	(0.19)	(0.18)
$\Delta r_t^{US} \cdot \lvert f-p \rvert_{t-1}$	-0.25**	-0.43***	-0.12	-0.09	0.15
	(0.10)	(0.13)	(0.16)	(0.16)	(0.16)
$\Delta r_t^{US} \cdot \lvert f-p \rvert_{t-1} \cdot \tau_t$	0.39***	0.62***	0.32	0.25	-0.17
	(0.14)	(0.20)	(0.21)	(0.22)	(0.22)

Notes: The table shows the time-varying and state-dependent effects of U.S. bond yields on futures rates of maturity j, see Equation (1). *** (**) [*] denotes significance at the 1 % (5 %) [10 %] level; standard errors in parentheses. For the complete set of results, see Tables 6 and 7.

emphasized in Hypothesis 1a.[4] In contrast to Ehrmann and Sondermann (2012), pure time-effects are not significant for the relative importance of macroeconomic variables for rate expectations in New Zealand. However, significant state-dependent effects are found for the influence of inflation surprises during the crisis period. In line with Hypothesis 1b, the response of rate expectations to inflation surprises is the stronger, the staler the current interest rate projection, compare the third panel in Table 3. In both sample periods, U.S. interest rates are the most important drivers for changes in New

[4]The complete set of results is provided in Table 6 and 7 in the Appendix. Tables 2 and 3 do not show the estimates obtained for the effective exchange rate because the results were economically small and statistically insignificant for all maturities and for both periods. Since GDP and inflation announcements are always made at the same point in time within a quarter, time-effects are not estimated for the corresponding surprise variables, see Table 3.

Zealand's interest rate expectations, see Table 2. Before the crisis, the results obtained for shorter maturities ($j = 1, 2$) provide strong evidence in favor of Hypotheses 1b and 1c, see the first panel of Table 2. While the impact of U.S. rates increases when the current projection becomes stale, i.e. if the spread $|f - p|$ widens, this state-dependent effect vanishes when the stale projection ages. A significant (yet, wrongly signed) state-dependent effect of U.S. rates can also be found for the crisis period. Again, in line with Hypothesis 1c, this state-dependent effect of stale projections shrinks with the age of a projection.

4.2.2 Projections and Interest Rate Uncertainty

Table 4 summarizes the estimation results on the time-varying and state-dependent effects of probably stale interest rate projections on interest rate uncertainty based on the variance equation (2).

According to Hypothesis 2a, interest rate uncertainty should increase between two releases of projections implying $\rho^{\tau} > 0$. Table 4 shows that this purely-time dependent effect is particularly important in the crisis period. In this period, an ageing projection contributes significantly to higher market uncertainty. It is worth emphasizing that this effect confirms the usefulness of projections in the crisis, since uncertainty drops in response to a fresh projection. We also find strong empirical support for a state-dependent effect of interest rate projections on uncertainty. Confirming Hypothesis 2b, we estimate that interest rate uncertainty increases significantly ($\rho^{s} > 0$) when interest rate expectations deviate from the corresponding interest rate projection. This result holds for the pre-crisis as well as the crisis period and irrespective of the projection horizon.[5] The uncertainty-increasing effects of stale projections are also found to be time dependent. Particularly for shorter horizons ($j < 5$), the distorting impact of a stale projection shrinks when the projection becomes older. Put differently, in line with Hypothesis 2c, the distorting effects of stale projections are the more severe, the longer

[5] Note that the smaller coefficients estimated for the crisis period do not necessarily imply less state-dependence since the deviations between futures rates and the central bank projections are typically more pronounced in the crisis period.

Table 3 The response of rate expectations in New Zealand to surprises in inflation and GDP

	j=1	j=2	j=3	j=4	j=5
pre-crisis: March 1, 2000 - Sep 12, 2008					
	CPI surprises				
x^{CPI}	0.03***	0.04***	0.04***	0.03***	0.03**
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
$x^{CPI} \cdot \lvert f^j - p^j \rvert$	-0.01	-0.03	-0.05	-0.05	-0.04
	(0.03)	(0.02)	(0.03)	(0.04)	(0.04)
	GDP surprises				
x^{GDP}	-0.003	-0.01	0.004	0.01	0.01
	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)
$x^{GDP} \cdot \lvert f^j - p^j \rvert$	0.03	0.04	-0.01	-0.01	-0.02
	(0.05)	(0.04)	(0.03)	(0.02)	(0.03)
crisis: Sep 15, 2008 - Feb 28, 2013					
	CPI surprises				
x^{CPI}	-0.00	-0.01	-0.004	-0.01	-0.01
	(0.01)	(0.01)	(0.02)	(0.02)	(0.02)
$x^{CPI} \cdot \lvert f^j - p^j \rvert$	0.07***	0.09***	0.07***	0.07***	0.06***
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
	GDP surprises				
x^{GDP}	0.01	0.04	0.06***	0.08***	0.08***
	(0.01)	(0.02)	(0.02)	(0.03)	(0.03)
$x^{GDP} \cdot \lvert f^j - p^j \rvert$	0.13*	0.10	0.07	0.03	0.03
	(0.08)	(0.07)	(0.04)	(0.04)	(0.05)

Notes: The table shows the empirical results for the effects of CPI and GDP surprises on futures rates of maturity j from equation (1).Since those surprises occur at the same point in time in every release period, variables are only interacted with the staleness measure $|f^j - p^j|_{t-1}$. *** (**) [*] denotes significance at the 1 % (5 %) [10 %] level; standard errors in parentheses. For the complete set of results refer to Tables 6 and 7 as well as to Table 8 for an explanation of the variables.

markets have to wait for an updated projection.

The estimation results indicate that central bank interest rate projections are a helpful tool for expectations management but they could probably be used more efficiently.

Table 4 Interest rate projections and interest rate uncertainty in New Zealand

	j=1	j=2	j=3	j=4	j=5
pre-crisis: March 1, 2000 - Sep 12, 2008					
$\widehat{\rho}^{\tau}$	0.15**	-0.04	-0.07	-0.16	-0.17
	(0.07)	(0.09)	(0.12)	(0.11)	(0.11)
$\widehat{\rho}^{s}$	1.22***	0.99***	0.99***	0.50***	0.31***
	(0.16)	(0.14)	(0.16)	(0.11)	(0.10)
$\widehat{\rho}^{s,\tau}$	-0.98***	-0.62***	-0.64***	-0.28***	-0.16
	(0.21)	(0.21)	(0.22)	(0.16)	(0.15)
crisis: Sep 15, 2008 - Feb 28, 2013					
$\widehat{\rho}^{\tau}$	0.27***	0.61***	0.48***	0.17***	0.10**
	(0.05)	(0.13)	(0.12)	(0.07)	(0.05)
$\widehat{\rho}^{s}$	0.34***	0.81***	0.41***	0.11*	0.03
	(0.09)	(0.13)	(0.11)	(0.06)	(0.05)
$\widehat{\rho}^{s,\tau}$	-0.38***	-0.80***	-0.44***	-0.10	-0.02
	(0.12)	(0.18)	(0.15)	(0.09)	(0.07)

Notes: The table shows the estimates from the conditional variance equation of futures rates with maturities of *j* quarters, compare Equation (2). *** (**) [*] denotes significance at the 1 % (5 %) [10 %] level, standard errors in parentheses. For the complete set of results, refer to Tables 6 and 7 in the appendix.

First, as a consequence of the estimated time-effects, interest rate projections could be provided more frequently instead of only quarterly, with even daily updated projections as a limiting case. Alternatively, the central bank could update its projections whenever new information cast doubt on the validity of the current projection. Once market expectations and central bank projections diverge too far, the central bank could adjust its projection (if the bank follows market expectations) or reestablish the validity of the current projection (if market expectations were incorrect). In any case, interest rate uncertainty should decline as the difference between market expectations and the central bank projection ($|f - p|$) decreases.

5 Counterfactual Analysis

The results presented in the previous section suggest that the central bank could lower interest rate uncertainty by maintaining the freshness of projections. In this section, we propose a counterfactual analysis in order to evaluate the volatility effects of alternative implementation schemes for central bank projections. To that end, we consider the following implementation schemes:

(1) **Projections with daily update:** The central bank announces its interest rate projections on a daily basis. Accordingly, staleness of projections is not an issue and market expectations should be in line with projections. In the counterfactual analysis, this scenario implies that $|\widetilde{f-p}| \equiv 0$ and $\widetilde{\tau}_t \equiv 0$.

(2) **Projections with state-dependent update:** The central bank announces a new projection (or reinforces the current one) whenever $|f-p|$ rises above a certain threshold of S basis points. In this scenario, market expectations are constrained by a band of 2 S basis points around the projection. In the counterfactual analysis, this implementation scheme implies that $|\widetilde{f-p}| \leq S$. Since the central bank is paying constant attention to the information content of the current projection, time-varying effects on interest rate uncertainty should be negligible, i.e. $\widetilde{\tau}_t \equiv 0$.

The counterfactual volatilities for the alternative schemes are derived from the EGARCH models estimated for each maturity and sample period. The counterfactual conditional volatility $\widetilde{\sigma}_t^2$ is obtained via a dynamic simulation of the estimated variance equation:

$$\begin{aligned} log(\widetilde{\sigma}_t^2) &= \hat{\omega}_o + \hat{\omega}_1 \left| \frac{\hat{\varepsilon}_{t-1}}{\hat{\sigma}_{t-1}} \right| + \hat{\omega}_2 \frac{\hat{\varepsilon}_{t-1}}{\hat{\sigma}_{t-1}} + \hat{\omega}_3 log(\widetilde{\sigma}_{t-1}^2) + \hat{\psi} D_t \\ &\quad + \hat{\rho}^{\tau} \widetilde{\tau}_t + \hat{\rho}^{s} |\widetilde{f-p}|_{t-1} + \hat{\rho}^{s,\tau} |\widetilde{f-p}|_{t-1} \widetilde{\tau}_t \end{aligned} \tag{3}$$

The counterfactual values of $|f-p|$ are defined as $|\widetilde{f-p}| \equiv min\{|f-p|, S\}$, where S defines the threshold value that triggers an update of the projection. For the scenario of daily updated projections, the threshold S equals 0. Typically, central banks change interest rates in steps of 25 or 50 basis points. Therefore, we use thresholds of 12.5 and 25 basis points for the state-dependent projection updates. Note that the size of the threshold can be interpreted as the degree of the central bank's aversion against stale projections. Finally, since the implementation schemes under consideration rule out pure time effects of projections, the original $\tau_t \in [0, 1]$ is replaced by $\widetilde{\tau}_t \equiv 0$.

Table 5 summarizes the results from the counterfactual analysis. The first row shows for each horizon the median of the conditional standard deviation of futures rates *estimated* for the current practice of quarterly projections. As expected, interest rate uncertainty increases with the projection horizon j and is larger during the financial crisis period. All remaining rows show counterfactual standard deviations resulting from the hypothetical alternative implementation schemes introduced above.

Row 2 of Table 5 presents the counterfactual interest rate volatility for the limiting case of daily projection updates. Since daily projections imply $\widetilde{|f-p|}_{t-1} \equiv 0$ and $\widetilde{\tau}_t \equiv 0$, the resulting counterfactual volatility is by construction always lower than the estimated volatility implied by quarterly projections. Therefore, the counterfactual standard deviations obtained for daily projections define a lower bound for interest rate volatility. They give a benchmark for the potential improvement that can be obtained by modifying the implementation scheme of projections. The second row implies that this gain — reflected in the difference between average volatilities obtained for projections with quarterly and daily updates — has remarkably increased both in absolute and relative terms since the outbreak of the crisis. The reductions in average standard deviations range from 0.17 to 0.58 basis points before and from 1.65 to 2.12 basis points during the crisis period. These are improvements of 5-22 % and 30-67 % respectively.

Rows 3 and 4 of Table 5 show the average counterfactual standard deviations of the state-dependent implementation schemes for central bank interest rate projections. In these scenarios, the central bank updates its projection whenever the market perceives the current projection as being too stale, i.e. whenever $|f - p|$ exceeds the threshold S. In practice, this can be accomplished by adjusting the projection to market expectations

Table 5 Counterfactual analysis of alternative projection implementation schemes

	pre-crisis period					crisis period				
Implementation scheme \ maturity	j=1	j=2	j=3	j=4	j=5	j=1	j=2	j=3	j=4	j=5
Projections with quarterly update $\hat{\sigma}(\lvert f^j - p^j \rvert)$	2.66	3.10	3.32	3.51	3.71	2.98	4.11	4.82	5.12	5.43
(1) **Projections with daily update** $\widetilde{\sigma}(\widetilde{\lvert f^j - p^j \rvert} \equiv 0, \widetilde{\tau}_t \equiv 0)$	2.08	2.62	2.79	3.20	3.54	0.99	2.16	2.70	3.30	3.78
(2a) **Projections with state-dependent update** $\widetilde{\sigma}(min\{\lvert f^j - p^j \rvert, 12.5\}, \widetilde{\tau}_t \equiv 0)$	2.35	2.90	3.05	3.41	3.72	1.40	2.44	2.88	3.41	3.83
(2b) **Projections with state-dependent update** $\widetilde{\sigma}(min\{\lvert f^j - p^j \rvert, 25\}, \widetilde{\tau}_t \equiv 0)$	2.57	3.11	3.25	3.57	3.84	1.60	2.70	3.07	3.54	3.90

Notes: The table shows the medians of the estimated standard deviations of futures rates in basis points in the first row. The corresponding counterfactual standard deviations based on Equation (3) are presented in the subjacent rows. In both subperiods, the starting date of the counterfactual analysis is the first monetary policy day with a published projection, i.e. March 15, 2000 and December 4, 2008.

or by confirming the current projection. Since the deviations of futures rates from the corresponding projections are significantly larger, the volatility dampening effects of thresholds can be expected to be more pronounced in the crisis period (cf. Table 1).

The counterfactual analysis confirms that interest rate volatility would have been significantly lower if state-dependent projections had been used during the crisis period. Even for a large threshold ($S = 25$), interest rate volatility decreases remarkably implying volatility gains close to the first best scenario of daily projections. By contrast, in the pre-crisis period, significant volatility-decreasing effects require the introduction of a small threshold of 12.5 basis points, while the volatility-reducing gains of a large threshold remain negligible. For both periods, the counterfactual exercise suggests that the efficiency of the RBNZ's interest rate projections could have been improved by a state-dependent implementation scheme that ensures a certain degree of freshness of projections.

6 Concluding Remarks

The efficiency of monetary policy crucially depends on the central bank's expectations management, see Blinder et al. (2008). Following the RBNZ's lead, central banks increasingly use interest rate projections to guide market expectations about the future course of monetary policy. Typically, projections are announced and updated only once a quarter. As a consequence of this rather inflexible implementation scheme, projections can become stale when new information enters the economy and their remaining information content becomes dubious. Stale projections may even pose an obstacle to central bank expectations management to the extent they confuse markets and, thereby, increase interest rate uncertainty.

This paper uses data from New Zealand to investigate the time-varying and state-dependent impact of probably stale interest rate projections on the expectations management of central banks. Our empirical results show that the impact of inflation surprises and U.S. interest rates for rate expectations in New Zealand is the larger, the staler the projection, i.e. the more market expectations deviate from the rate projected by the central bank. In line with Ehrmann and Sondermann (2012), our results confirm a stabilizing effect of fresh central bank interest rate projections. In particular, interest rate uncertainty is found to be larger if the current projection is outdated. However, in addition to this pure time effect, this paper provides first evidence that the impact of central bank projections on market expectations and interest rate uncertainty is also state-dependent. We show that interest rate uncertainty significantly increases when market expectations deviate from the actual interest rate projection.

The distorting effects of stale projections suggest that central bank expectations management could be implemented more efficiently. In order to assess the possible gains for interest rate uncertainty, we conduct a counterfactual analysis applying alternative implementation schemes for central bank interest rate projections. Particularly, we investigate the interest rate uncertainty implied by projections that are updated whenever futures rates reveal that markets perceive the current projection as too stale. In practice, this more flexible way to implement interest rate projections can be accomplished by adjusting the projection to market expectations (if market expectations correctly anticipated the future change of projections) or by confirming the current projection (if market expectations were incorrect).

Our results suggest that the publication of interest rate projections enhances central bank communication as long as the central bank can ensure that the information content of projections remains sufficiently high. Yet, the experience of the RBNZ shows that preventing quarterly projections from becoming stale is not an easy task. In an attempt to ameliorate this problem, the Sveriges Riksbank publishes alternative scenarios for the future interest rate path in its monetary policy report, see Svensson (2013). The detailed discussion of various economic risks and their impact on the future interest rate path should help markets to assess to what extent a certain interest rate projection has become stale. Alternatively, the Bank of England and the FED recently introduced outcome-based forward guidance in order to enhance the communication of monetary policy, compare ECB (2014). In this case, future policy rates are conditioned on explicit numerical thresholds on observed or projected unemployment or inflation.

This paper suggests that central bank interest rate projections should be implemented taking into account the market's actual demand for forward guidance. Our findings support the approach adopted by the ECB because its forward guidance is renewed or adjusted in response to market developments instead of providing inflexible quarterly projections. By reassuring 'on demand' that policy rates will be kept low *for an extended period of time*, forward guidance is prevented from becoming stale.

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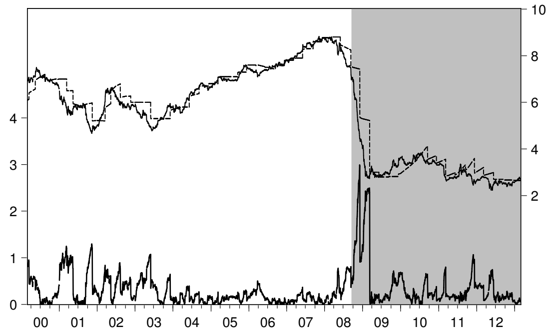
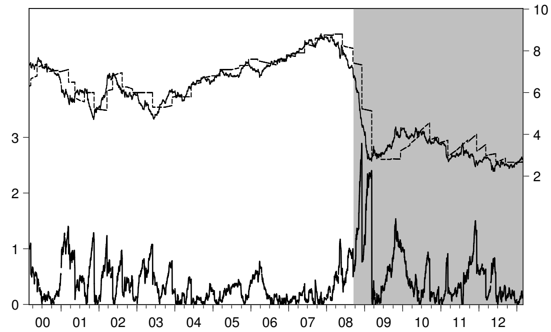
Appendix

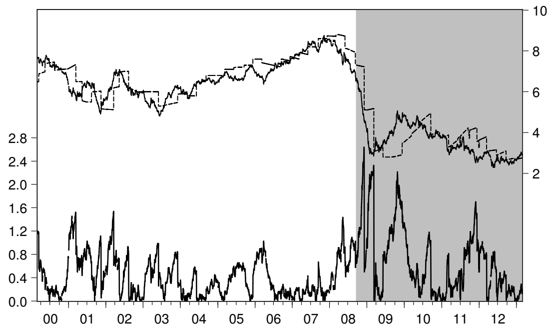
Figure 3 Interest rate projections and futures rates in New Zealand



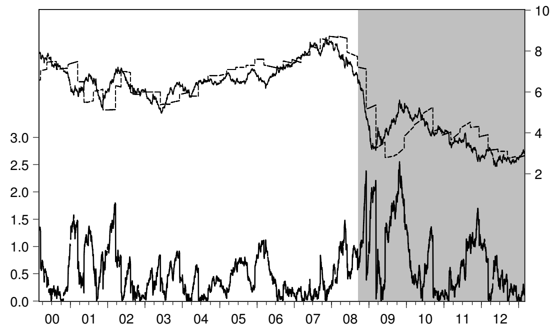
$j = 1$



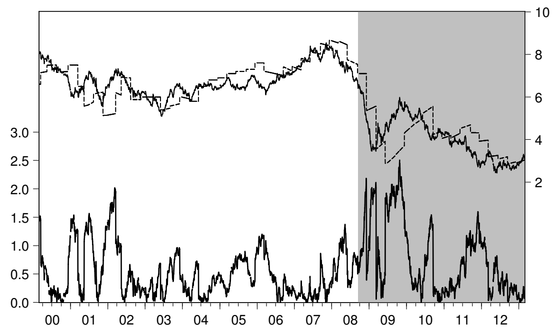
$j = 2$



$j = 3$



$j = 4$



$j = 5$

Notes: Futures rates f_t and central bank interest rate projections p_t (dashed line) in percentage points at horizons $j = 1, \ldots, 5$ as well as the absolute deviation $|f_t - p_t|$ (at the bottom, left scale) from March 2000 until February 2013. The shaded area refers to the period as of September 2008.

Table 6 The EGARCH model for futures rates: Complete results for the pre-crisis sample

$j=1$	Δf_t	α	β^{MPS}	β^{OCR}	δ	γ^{CPI}	$\gamma^{CPI,s}$	γ^{GDP}	$\gamma^{GDP,s}$	γ^{US}	$\gamma^{US,\tau}$	$\gamma^{US,s}$	$\gamma^{US,s,\tau}$	γ^{EFF}	$\gamma^{EFF,\tau}$	$\gamma^{EFF,s}$	$\gamma^{EFF,\tau,s}$
		0.001	0.20***	0.11***	0.08***	0.03***	-0.01	-0.003	0.03	0.09***	0.03	0.51***	-0.31**	0.002	-0.01	-0.02	0.03
		(0.001)	(0.08)	(0.04)	(0.02)	(0.01)	(0.03)	(0.01)	(0.05)	(0.02)	(0.04)	(0.09)	(0.13)	(0.004)	(0.01)	(0.02)	(0.03)
	$log(\sigma_t^2)$	ω_o	ω_1	ω_2	ω_3	η^{OCR}	η^{MPS}	ρ_τ	ρ_s	$\rho_{s,\tau}$	η^{CPI}	$\eta^{CPI,s}$	η^{GDP}	$\eta^{GDP,s}$			
		-4.02***	0.38***	-0.04**	0.52***	1.94***	0.29	0.15**	1.22***	-0.98***	0.12	1.04	0.36	0.25			
		(0.23)	(0.04)	(0.02)	(0.03)	(0.14)	(0.27)	(0.07)	(0.16)	(0.21)	(0.41)	(1.38)	(0.44)	(1.36)			
$j=2$	Δf_t	α	β^{MPS}	β^{OCR}	δ	γ^{CPI}	$\gamma^{CPI,s}$	γ^{GDP}	$\gamma^{GDP,s}$	γ^{US}	$\gamma^{US,\tau}$	$\gamma^{US,s}$	$\gamma^{US,s,\tau}$	γ^{EFF}	$\gamma^{EFF,\tau}$	$\gamma^{EFF,s}$	$\gamma^{EFF,\tau,s}$
		0.001	0.16**	0.12***	0.11***	0.04***	-0.03	-0.01	0.04	0.21***	-0.05	0.26***	-0.06	0.01	-0.01	-0.04*	0.04
		(0.001)	(0.06)	(0.04)	(0.02)	(0.01)	(0.02)	(0.01)	(0.04)	(0.03)	(0.05)	(0.09)	(0.12)	(0.01)	(0.01)	(0.02)	(0.03)
	$log(\sigma_t^2)$	ω_o	ω_1	ω_2	ω_3	η^{OCR}	η^{MPS}	ρ_τ	ρ_s	$\rho_{s,\tau}$	η^{CPI}	$\eta^{CPI,s}$	η^{GDP}	$\eta^{GDP,s}$			
		-4.43***	0.36***	0.001	0.43***	1.67***	0.42	-0.04	0.995***	-0.62***	0.22	0.63	-0.08	2.08**			
		(0.35)	(0.04)	(0.02)	(0.05)	(0.22)	(0.35)	(0.09)	(0.14)	(0.21)	(0.43)	(1.26)	(0.43)	(1.02)			
$j=3$	Δf_t	α	β^{MPS}	β^{OCR}	δ	γ^{CPI}	$\gamma^{CPI,s}$	γ^{GDP}	$\gamma^{GDP,s}$	γ^{US}	$\gamma^{US,\tau}$	$\gamma^{US,s}$	$\gamma^{US,s,\tau}$	γ^{EFF}	$\gamma^{EFF,\tau}$	$\gamma^{EFF,s}$	$\gamma^{EFF,\tau,s}$
		0.001	0.11*	0.11***	0.10***	0.04***	-0.05	0.004	-0.01	0.29***	-0.06	0.11	-0.04	-0.0001	-0.001	-0.01	0.01
		(0.001)	(0.06)	(0.04)	(0.02)	(0.01)	(0.03)	(0.01)	(0.03)	(0.03)	(0.05)	(0.07)	(0.10)	(0.01)	(0.01)	(0.02)	(0.02)
	$log(\sigma_t^2)$	ω_o	ω_1	ω_2	ω_3	η^{OCR}	η^{MPS}	ρ_τ	ρ_s	$\rho_{s,\tau}$	η^{CPI}	$\eta^{CPI,s}$	η^{GDP}	$\eta^{GDP,s}$			
		-5.20***	0.36***	0.05**	0.31***	1.57***	0.51	-0.07	0.99***	-0.64***	0.50	0.17	-0.66	3.03***			
		(0.35)	(0.04)	(0.03)	(0.05)	(0.26)	(0.40)	(0.12)	(0.16)	(0.22)	(0.59)	(1.36)	(0.55)	(1.13)			
$j=4$	Δf_t	α	β^{MPS}	β^{OCR}	δ	γ^{CPI}	$\gamma^{CPI,s}$	γ^{GDP}	$\gamma^{GDP,s}$	γ^{US}	$\gamma^{US,\tau}$	$\gamma^{US,s}$	$\gamma^{US,s,\tau}$	γ^{EFF}	$\gamma^{EFF,\tau}$	$\gamma^{EFF,s}$	$\gamma^{EFF,\tau,s}$
		0.001	0.08*	0.13***	0.10***	0.03***	-0.05	0.01	-0.01	0.33***	-0.05	0.03	-0.01	-0.004	0.004	0.005	-0.01
		(0.001)	(0.04)	(0.04)	(0.02)	(0.01)	(0.04)	(0.01)	(0.02)	(0.03)	(0.06)	(0.06)	(0.10)	(0.01)	(0.01)	(0.01)	(0.02)
	$log(\sigma_t^2)$	ω_o	ω_1	ω_2	ω_3	η^{OCR}	η^{MPS}	ρ_τ	ρ_s	$\rho_{s,\tau}$	η^{CPI}	$\eta^{CPI,s}$	η^{GDP}	$\eta^{GDP,s}$			
		-4.12***	0.41***	0.06**	0.44***	1.25***	0.67*	-0.16	0.50***	-0.28*	0.32	0.68	-1.06**	3.09***			
		(0.32)	(0.04)	(0.02)	(0.05)	(0.23)	(0.35)	(0.11)	(0.11)	(0.16)	(0.38)	(0.72)	(0.48)	(0.88)			
$j=5$	Δf_t	α	β^{MPS}	β^{OCR}	δ	γ^{CPI}	$\gamma^{CPI,s}$	γ^{GDP}	$\gamma^{GDP,s}$	γ^{US}	$\gamma^{US,\tau}$	$\gamma^{US,s}$	$\gamma^{US,s,\tau}$	γ^{EFF}	$\gamma^{EFF,\tau}$	$\gamma^{EFF,s}$	$\gamma^{EFF,\tau,s}$
		0.001	0.07**	0.12***	0.08***	0.03**	-0.04	0.01	-0.02	0.39***	-0.09	-0.06	0.08	-0.005	0.004	0.01	-0.02
		(0.001)	(0.03)	(0.03)	(0.02)	(0.01)	(0.04)	(0.02)	(0.03)	(0.04)	(0.07)	(0.06)	(0.09)	(0.01)	(0.01)	(0.01)	(0.02)
	$log(\sigma_t^2)$	ω_o	ω_1	ω_2	ω_3	η^{OCR}	η^{MPS}	ρ_τ	ρ_s	$\rho_{s,\tau}$	η^{CPI}	$\eta^{CPI,s}$	η^{GDP}	$\eta^{GDP,s}$			
		-3.80***	0.46***	0.06**	0.48***	1.05***	0.81**	-0.17	0.31***	-0.16	0.38	0.61	-0.89*	2.48***			
		(0.30)	(0.04)	(0.02)	(0.04)	(0.22)	(0.33)	(0.11)	(0.10)	(0.15)	(0.30)	(0.53)	(0.49)	(0.73)			

Notes: The table shows the empirical results from equations (1) and (4):

$$\Delta f_t^j = \alpha^j + \delta^j \Delta f_{t-1}^j + \beta^{MPS,j} D_t^{MPS}(p_t^j - f_{t-1}^j) + \beta^{OCR,j} D_t^{OCR}(r_t^{OCR} - r_{t-1}^{30}) + \sum_k \gamma^{k,j} s_t^k + \sum_k \gamma^{k,\tau,j} s_t^k \tau_t + \sum_k \gamma^{k,s,j} s_t^k \cdot |f^j - p^j|_{t-1} + \sum_k \gamma^{k,s,\tau,j} s_t^k \cdot |f^j - p^j|_{t-1}\tau + \varepsilon_t^j$$

$$log(\sigma_t^{2,j}) = \omega_o^j + \omega_1^j \cdot \left|\frac{\varepsilon_{t-1}^j}{\sigma_{t-1}^j}\right| + \omega_2^j \cdot \frac{\varepsilon_{t-1}^j}{\sigma_{t-1}^j} + \omega_3^j \cdot log(\sigma_{t-1}^{2,j}) + \eta^{OCR,j} D_t^{OCR} + \eta^{MPS,j} D_t^{MPS} + \eta^{CPI,j} D_t^{CPI} + \eta^{CPI,s,j} D_t^{CPI} |f^j - p^j|_{t-1} + \eta^{GDP,j} D_t^{GDP} +$$
$$\eta^{GDP,s,j} D_t^{GDP} |f^j - p^j|_{t-1} + \sum_k \lambda^{k,j} D_t^k + \sum_k \lambda^{k,s,j} D_t^k |f^j - p^j|_{t-1} + \rho_\tau^j \tau_t + \rho_s^j |f^j - p^j|_{t-1} + \rho_{s,\tau}^j |f^j - p^j|_{t-1} \tau_t$$

For an explanation of the variables refer to Table 8. The sample covers business days from February 24, 2000 until September 12, 2008. *** (**) [*] denotes significance at the 1 % (5 %) [10 %] level; standard errors in parentheses.

Table 7 The EGARCH model for futures rates: Complete results for the crisis sample

$j=1$	Δf_t	α	β^{MPS}	β^{OCR}	δ	γ^{CPI}	$\gamma^{CPI,s}$	γ^{GDP}	$\gamma^{GDP,s}$	γ^{US}	$\gamma^{US,\tau}$	$\gamma^{US,s}$	$\gamma^{US,s,\tau}$	γ^{EFF}	$\gamma^{EFF,\tau}$	$\gamma^{EFF,s}$	$\gamma^{EFF,\tau,s}$
		0.002*	-0.05	0.08***	0.08**	-0.00	0.07***	0.01	0.13*	0.10**	0.04	-0.25**	0.39***	0.001	0.001	0.01	-0.01
		(0.001)	(0.04)	(0.03)	(0.04)	(0.01)	(0.02)	(0.01)	(0.08)	(0.05)	(0.08)	(0.10)	(0.14)	(0.01)	(0.01)	(0.02)	(0.03)
	$log(\sigma_t^2)$	ω_o	ω_1	ω_2	ω_3	η^{OCR}	η^{MPS}	ρ_τ	ρ_s	$\rho_{s,\tau}$	η^{CPI}	$\eta^{CPI,s}$	η^{GDP}	$\eta^{GDP,s}$			
		-1.02***	0.31***	-0.02	0.92***	1.45***	-0.59**	0.27***	0.34***	-0.38***	1.22***	-0.82	0.09	0.65			
		(0.11)	(0.03)	(0.02)	(0.01)	(0.21)	(0.27)	(0.05)	(0.09)	(0.12)	(0.25)	(0.67)	(0.32)	(0.97)			
$j=2$	Δf_t	α	β^{MPS}	β^{OCR}	δ	γ^{CPI}	$\gamma^{CPI,s}$	γ^{GDP}	$\gamma^{GDP,s}$	γ^{US}	$\gamma^{US,\tau}$	$\gamma^{US,s}$	$\gamma^{US,s,\tau}$	γ^{EFF}	$\gamma^{EFF,\tau}$	$\gamma^{EFF,s}$	$\gamma^{EFF,\tau,s}$
		0.003*	-0.05*	0.05	0.08**	-0.01	0.09***	0.04	0.10	0.35***	-0.18	-0.43***	0.62***	0.01	-0.004	-0.002	0.02
		(0.002)	(0.02)	(0.03)	(0.03)	(0.01)	(0.02)	(0.02)	(0.07)	(0.09)	(0.16)	(0.13)	(0.20)	(0.01)	(0.02)	(0.02)	(0.03)
	$log(\sigma_t^2)$	ω_o	ω_1	ω_2	ω_3	η^{OCR}	η^{MPS}	ρ_τ	ρ_s	$\rho_{s,\tau}$	η^{CPI}	$\eta^{CPI,s}$	η^{GDP}	$\eta^{GDP,s}$			
		-0.59***	0.17***	-0.02	0.95***	1.29***	-0.76***	0.10***	0.07	-0.05	0.57**	-0.02	0.08	1.17			
		(0.10)	(0.02)	(0.02)	(0.01)	(0.18)	(0.23)	(0.04)	(0.05)	(0.07)	(0.29)	(0.45)	(0.32)	(0.83)			
$j=3$	Δf_t	α	β^{MPS}	β^{OCR}	δ	γ^{CPI}	$\gamma^{CPI,s}$	γ^{GDP}	$\gamma^{GDP,s}$	γ^{US}	$\gamma^{US,\tau}$	$\gamma^{US,s}$	$\gamma^{US,s,\tau}$	γ^{EFF}	$\gamma^{EFF,\tau}$	$\gamma^{EFF,s}$	$\gamma^{EFF,\tau,s}$
		0.002	-0.04	0.09	0.09**	-0.004	0.07***	0.06***	0.07	0.30**	-0.10	-0.12	0.32	0.01	-0.003	-0.004	0.01
		(0.002)	(0.04)	(0.07)	(0.04)	(0.02)	(0.02)	(0.02)	(0.04)	(0.12)	(0.18)	(0.16)	(0.21)	(0.01)	(0.02)	(0.01)	(0.02)
	$log(\sigma_t^2)$	ω_o	ω_1	ω_2	ω_3	η^{OCR}	η^{MPS}	ρ_τ	ρ_s	$\rho_{s,\tau}$	η^{CPI}	$\eta^{CPI,s}$	η^{GDP}	$\eta^{GDP,s}$			
		-2.50***	0.30***	0.04	0.69***	1.32***	-0.37	0.48***	0.41***	-0.44***	-0.03	0.35	0.38	-0.25			
		(0.41)	(0.05)	(0.03)	(0.05)	(0.34)	(0.55)	(0.12)	(0.11)	(0.15)	(0.53)	(0.76)	(0.63)	(1.21)			
$j=4$	Δf_t	α	β^{MPS}	β^{OCR}	δ	γ^{CPI}	$\gamma^{CPI,s}$	γ^{GDP}	$\gamma^{GDP,s}$	γ^{US}	$\gamma^{US,\tau}$	$\gamma^{US,s}$	$\gamma^{US,s,\tau}$	γ^{EFF}	$\gamma^{EFF,\tau}$	$\gamma^{EFF,s}$	$\gamma^{EFF,\tau,s}$
		0.002	-0.06***	0.11**	0.09**	-0.01	0.07***	0.08***	0.03	0.33***	-0.10	-0.09	0.25	0.01	0.004	-0.003	0.01
		(0.002)	(0.02)	(0.05)	(0.04)	(0.02)	(0.02)	(0.03)	(0.04)	(0.12)	(0.19)	(0.16)	(0.22)	(0.01)	(0.02)	(0.01)	(0.02)
	$log(\sigma_t^2)$	ω_o	ω_1	ω_2	ω_3	η^{OCR}	η^{MPS}	ρ_τ	ρ_s	$\rho_{s,\tau}$	η^{CPI}	$\eta^{CPI,s}$	η^{GDP}	$\eta^{GDP,s}$			
		-1.35***	0.29***	0.01	0.84***	1.18***	-0.38	0.17**	0.11*	-0.10	-0.04	0.26	0.13	0.23			
		(0.23)	(0.04)	(0.02)	(0.03)	(0.25)	(0.36)	(0.07)	(0.06)	(0.09)	(0.51)	(0.63)	(0.64)	(0.97)			
$j=5$	Δf_t	α	β^{MPS}	β^{OCR}	δ	γ^{CPI}	$\gamma^{CPI,s}$	γ^{GDP}	$\gamma^{GDP,s}$	γ^{US}	$\gamma^{US,\tau}$	$\gamma^{US,s}$	$\gamma^{US,s,\tau}$	γ^{EFF}	$\gamma^{EFF,\tau}$	$\gamma^{EFF,s}$	$\gamma^{EFF,\tau,s}$
		0.003	-0.06***	0.09**	0.06*	-0.01	0.06***	0.08***	0.03	0.16	0.35*	0.15	-0.17	0.01	0.01	-0.003	0.01
		(0.002)	(0.01)	(0.04)	(0.03)	(0.02)	(0.02)	(0.03)	(0.05)	(0.11)	(0.18)	(0.16)	(0.22)	(0.01)	(0.02)	(0.01)	(0.02)
	$log(\sigma_t^2)$	ω_o	ω_1	ω_2	ω_3	η^{OCR}	η^{MPS}	ρ_τ	ρ_s	$\rho_{s,\tau}$	η^{CPI}	$\eta^{CPI,s}$	η^{GDP}	$\eta^{GDP,s}$			
		-0.88***	0.23***	0.03*	0.89***	1.04***	-0.47	0.10*	0.02	-0.01	-0.16	0.41	-0.07	0.68			
		(0.19)	(0.04)	(0.02)	(0.03)	(0.20)	(0.28)	(0.05)	(0.05)	(0.07)	(0.36)	(0.45)	(0.58)	(0.80)			

Notes: The table shows the empirical results from equations (1) and (4):

$$\Delta f_t^j = \alpha^j + \delta^j \Delta f_{t-1}^j + \beta^{MPS,j} D_t^{MPS}(p_t^j - f_{t-1}^j) + \beta^{OCR,j} D_t^{OCR}(r_t^{OCR} - r_{t-1}^{30}) + \textstyle\sum_k \gamma^{k,j} s_t^k + \sum_k \gamma^{k,\tau,j} s_t^k \tau_t + \sum_k \gamma^{k,s,j} s_t^k \cdot |f^j - p^j|_{t-1} + \sum_k \gamma^{k,s,\tau,j} s_t^k \cdot |f^j - p^j|_{t-1}\tau + \varepsilon_t^j$$

$$log(\sigma_t^{2,j}) = \omega_o^j + \omega_1^j \cdot \left|\frac{\varepsilon_{t-1}^j}{\sigma_{t-1}^j}\right| + \omega_2^j \cdot \frac{\varepsilon_{t-1}^j}{\sigma_{t-1}^j} + \omega_3^j \cdot log(\sigma_{t-1}^{2,j}) + \eta^{OCR,j} D_t^{OCR} + \eta^{MPS,j} D_t^{MPS} + \eta^{CPI,j} D_t^{CPI} + \eta^{CPI,s,j} D_t^{CPI} |f^j - p^j|_{t-1} + \eta^{GDP,j} D_t^{GDP} +$$
$$\eta^{GDP,s,j} D_t^{GDP} |f^j - p^j|_{t-1} + \sum_k \lambda^{k,j} D_t^k + \sum_k \lambda^{k,s,j} D_t^k |f^j - p^j|_{t-1} + \rho_\tau^j \tau_t + \rho_s^j |f^j - p^j|_{t-1} + \rho_{s,\tau}^j |f^j - p^j|_{t-1} \tau_t$$

For an explanation of the variables refer to Table 8. The sample covers business days from September 15, 2008 until February 28, 2013. *** (**) [*] denotes significance at the 1 % (5 %) [10 %] level; standard errors in parentheses.

Table 8 List of variables

f_t^j	futures rate for the 90-day rate j quarters ahead, maturity-adjusted [Source: Bloomberg L.P. / Code: ZBj Comdty]
	[*Futures rates are calculated by 100 minus the contract price from 90-day Bank Bill Futures traded at the Sydney Futures Exchange.*]
p_t^j	central bank interest rate projection of the 90-day rate j quarters ahead, maturity-adjusted [Source: RBNZ]
τ_t	time measure for the age of the current interest rate projection
	[$0 \leq \tau_t \leq 1$ *is the number of days since the last release divided by the total number of days between the preceding and the subsequent release of RBNZ's interest rate projections:* $\tau_t = 0$ *on the announcement day;* $\tau_t = 1$ *on the day before the subsequent announcement*]
Δr_t^{US}	change in the U.S. two-year government bond yield [Bloomberg L.P. / USGG2YR Index]
Δe_t	change in the New Zealand effective exchange rate [Bloomberg L.P. / NZTW Index]
x_t^{CPI}	CPI surprises for New Zealand [RBNZ, Statistics NZ]
x_t^{GDP}	GDP surprises for New Zealand [RBNZ, Statistics NZ]
	[*CPI and GDP surprises are calculated as the difference between the expectation [RBNZ Survey of Expectations] and the actual value on the announcement days (once a quarter).*]
D_t^{CPI}	impulse dummy that equals one on CPI announcement days
D_t^{GDP}	impulse dummy that equals one on GDP announcement days
D_t^{MPS}	impulse dummy that equals one on projection publication days
D_t^{OCR}	impulse dummy that equals one on OCR announcement days
r_t^{OCR}	Official Cash Rate [RBNZ]
r_t^{30}	New Zealand 30-day bank bill yields [RBNZ]
$D_t^{MPS}(p_t^j - f_{t-1}^j)$	monetary policy surprise in current projection
$D_t^{OCR}(r_t^{OCR} - r_{t-1}^{30})$	monetary policy surprise in OCR rate

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This research was supported by the Deutsche Forschungsgemeinschaft through the SFB 649 "Economic Risk".

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This research was supported by the Deutsche Forschungsgemeinschaft through the SFB 649 "Economic Risk".