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Do central banks respond timely to developments in the global economy?*

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Abstract

Our analysis suggests; they do not! We arrive at this conclusion by showing that revisions to the published interest rate path projections from the central banks in New Zealand, Norway, and Sweden can be predicted by timely and forward looking international indicators. Furthermore, using individual country and Panel VARs, identified with an external instrument method, we show that the policy surprises induced by the predictable revisions likely contain information about how the central banks assess past, current, and future economic conditions and thereby leads to a positive co-movement between the interest rate and both financial markets and the macro economy.

JEL-codes: C11, C53, C55, E58, F17

Keywords: Monetary policy, forward guidance, forecast revisions, global indicators, VAR

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I Introduction

Much applied research has shown that global developments play a large role in explaining business cycles and inflation in small and open economies, see, e.g., Kose et al. (2003), Ciccarelli and Mojon (2010), and Mumtaz et al. (2011). At the same time, the structural, small open-economy models used by many central banks to analyze and predict macroeconomic outcomes cannot account for the substantial influence of foreign-sourced disturbances identified in the numerous reduced-form studies.[1] Accordingly, model-implied cross-correlation functions between the small open economies and global economies are small, while data suggest that they are positive and large.

In this paper we hypothesize that this discrepancy matters for how monetary policy is conducted, and ultimately for how central banks make revisions to their predicted interest rate paths, i.e., their announced policy intentions. Furthermore, if policymakers make revisions to the interest rate path based on delayed responses to development about the global economy, this is consistent with central banks revealing information about their current and future view about the state of the domestic economy. After all, central banks announce their intentions to influence (i.e., give forward guidance to) the market. If central bank's policy surprises include delayed responses to international developments, these responses may also have a marked effect on the economy.

To examine these issues, we first construct a real-time data set of interest rate projections from the central banks in New Zealand (Reserve Bank of New Zealand), Norway (Norges Bank), and Sweden (Sveriges Riksbank). We focus on these three countries as they are small and open, and because they were the first three countries adopting the practice of communicating their policy intentions explicitly by publishing their forecasts of future interest rates.[2] We then examine two questions in particular: (i) whether international versus domestic indicators can predict the forecast revisions in the central bank's policy rate?, and (ii) whether fundamental variables versus forward looking variables matter? To avoid look-ahead-biases when running the predictive regressions we take care to

[1] See Justiniano and Preston (2010) and the references therein. Recent advances in the theoretical business cycle literature have tried to bridge this gap between the empirical findings and theory, with Bergholt and Sveen (2013) being one example among others.

[2] The Reserve Bank of New Zealand was the first central bank to publish own forecast of the interest rates in 1997, followed by Norges Bank in 2005, and Sveriges Riksbank in 2007. Since then, several other central banks have followed, including the Central Bank of Iceland in 2007, the Czech National Bank in 2008 and most recently, the Federal Reserve in 2012. Accordingly, the results in this paper should be of relevance for an increasing number of central banks.

use information that was actually available to the policy makers at the time of making their initial interest rate projections. That is, we use real-time data, that is data that are not revised, and data that were published prior to the publication of the initial interest rate path, and refer to them in short as timely data.

And indeed, running a battery of predictive regressions with domestic and foreign indicators we find that the forecast revisions have a high degree of persistence, and that there is a systematic role for international indicators in predicting the revisions to the policy rate. Most notably is the role of forward looking foreign indicators. In contrast, related indexes for the domestic economy tend to be of less importance or insignificant. In addition, at least for New Zealand and Sweden, there is a close correspondence between the information sets explaining inflation and output forecast revisions and those that explain the interest rate forecast revisions.

While we do find forecast revisions (errors) to be predictable by foreign variables, this is not necessarily suggesting monetary policy is inefficient or sub-optimal. In fact, there could be many reasons for our findings, like strategical considerations (Walsh (2007) and Van der Cruijsen et al. (2010)), an explicit desire for forecast smoothing (Mirkov and Natvik (2016)), or inherit uncertainties related to how international developments transmit to the domestic economies going forward and noisy economic signals, like in theories considering information rigidities (Sims (2003), Mankiw and Reis (2002))[3]. Still, an interesting question opens up: Do the central banks' forecast revisions have any effect on the macro economy?

To examine this question we analyze the joint response of key economic and financial variables, including market interest rates, to the implied monetary policy surprises using a structural vector autoregressive (SVAR) model. However, rather than relying on the standard timing restrictions that is commonly done in structural VARs, we use an external instrument variable (IV) approach (Stock (2008)). To answer the question of interest, the instruments are constructed from forecast errors based on the revisions to the published interest rate path. The total forecast error includes revisions to the interest rate path due to both new information arriving during the forecast horizon, potentially correlated with the other shocks in the SVAR, and "old" information that could be used to predict the error. Therefore, to make sure that the identified IV shocks are orthogonal to within period movements in the other variables, we use only the part of the forecast error that

[3]Using data on forecasts from professional forecasters, and surveys among households, information rigidities have been well documented empirically, see, e.g., Coibion and Gorodnichenko (2015), Dovern et al. (2015), and Dräger and Lamla (2017).

is explained (predicted) by timely foreign variables.

And yes, we do find that the central banks' forecast errors matter. In particular, following a monetary policy surprise associated with the predicable part of the forecast errors, output, inflation, and asset prices all increase. Thus, the identified component of the monetary surprise leads to a positive co-movement between the interest rate and both the macro economy and financial markets. Moreover, this pattern is generally present when we estimate separate VARs for each country, and even more pronounced and statistically strong when we pool the cross-section information and estimate Panel VAR models.

Although this finding stands in stark contrast to what one would expect following a conventional monetary policy shock, it makes clear intuitive sense in our setting, where the identified surprise is directly associated with central bank forward guidance. As already alluded to, one of the main motivations for central banks to publish their interest rate projections is exactly to help shape financial market expectations and improve macroeconomic performance, c.f. Geraats (2002), Woodford (2005) and Rudebusch and Williams (2008). If the observed revisions are consistent with the central bank revealing private information about their current assessment of the economy, we should also expect the market to respond accordingly. Moreover, using a totally different identification strategy and application, Jarocinski and Karadi (2018) document a similar response pattern following a U.S. monetary policy surprise as we find. To separate this surprise component from a conventional monetary policy shock, they suitably label it a central bank information shock. We show that, at least for the central banks considered here, part of this information shock component is likely related to the bank's current assessment of past international developments.

Our study contributes to three different strands of the literature. First, our analysis contributes to the large empirical literature documenting how economic fluctuations are closely connected across borders.[4] While the large bulk of this literature has focused on (reduced form) cross-border synchronization of real and nominal variables, we show that the synchronization patterns potentially also matter for the conduct of monetary policy.

Second, our paper relates to the literature that analyzes the efficacy of publicly commu-

[4]See, e.g., Backus et al. (1995), Kose et al. (2003), and Baxter and Kouparitsas (2005) on international business cycle synchronization, Mumtaz and Surico (2008), Monacelli and Sala (2009) and Ciccarelli and Mojon (2010) on the co-movement of inflation rates, and Canova and Marrinan (1998), Stock and Watson (2005), Eickmeier (2007), Moneta and Rüffer (2009), Mumtaz et al. (2011), Thorsrud (2013), rnland et al. (2017) and Aastveit et al. (2016) on regional and international transmissions of shocks.

nicating interest rate paths (Geraats (2002), Woodford (2005)), Swanson (2006), Mirkov and Natvik (2016)), and the loosely related literature on expectation formation and information rigidities (Coibion and Gorodnichenko (2015), Dovern et al. (2015), Dräger and Lamla (2017)). Whatever the exact reason is, i.e., a preference for forecast smoothing, noisy data, strategic behavior, etc., we provide novel evidence showing that both the central bank forecast errors and revisions can be explained by past developments in international indicators. We stress, however, that our analysis is descriptive, and not normative. For example, we can not, and do not, argue that the central bank behavior documented here is inefficient. It might be the case that not responding timely is an optimal strategy (Woodford (2003)).[5]

Finally, our analysis relates to the growing literature that more directly identifies monetary policy surprises using unconventional measures such as forward guidance, i.e., the practice of communicating the future path of the interest rates, see e.g., Kuttner (2001), Romer and Romer (2004), Gürkaynak et al. (2005) and Gertler and Karadi (2015), Jarocinski and Karadi (2018), among others. In particular, while Romer and Romer (2004) examined narrative records to infer the Federal Reserve's intentions for the federal funds rate around FOMC meetings, Kuttner (2001), Gürkaynak et al. (2005), Gertler and Karadi (2015) and Jarocinski and Karadi (2018) used high-frequency (financial) data to construct anticipated and unanticipated components of monetary policy. In contrast to some of these studies, however, we do not have to go via the narrative records of the future market to construct the central banks intentions (and the corresponding forecast errors), since we have access to the actual projected interest rate paths. Moreover, we focus on small open economies, and the contribution of international factors to the monetary policy surprises.

The remainder of the paper is structured as follows. Section II describes the real time dataset of interest rate projections and the revisions to these, while Section III describes the predictive experiment, the data used, and result obtained. Section IV discusses how

[5]For example, if the central banks strategically decide not to respond timely to negative foreign developments because they believe this will keep optimism in the domestic economy up, the extra time of optimism might outweigh the responses to a negative information shock component at a later stage when interest rates have to be revised down due to a deteriorating real economy. Still, for the three central banks considered here, we have little evidence suggesting that strategic considerations are a large component of their interest rate paths. In particular, if this was really the case, one would not expect their forecasting performance to be accurate. However, for all three countries, evidence suggest that the central banks' interest rate forecasts are relatively good compared to both model based forecast and those produced by the market, see, e.g. Sveriges Riksbank (2018) for an evaluation of Sveriges Riksbank.

we relate the central bank forecast revisions to potential monetary policy surprises in a VAR using IV identification, and reports the associated impulse responses. Section V concludes.

II Interest rate projections and forecast revisions

In the following we describe the data and explain how we construct the time series of interest rate projections and forecast revisions in the three countries. In the end we summarize the revisions series used in our analysis through a series of descriptive statistics.

Interest rate projections

The interest rate projections are collected from the Reserve Bank of New Zealand (RBNZ), Norges Bank (NB) and Sveriges Riksbank (SR) historical publication records.[6] A detailed description of how the dataset is constructed is provided in Table 6 in Appendix A, while the first row in Figure 1 illustrates how the interest rate predictions have evolved across time in RBNZ, NB and SR, respectively. For each forecast vintage we plot the predicted policy rate path up to four quarter ahead. We also report the actual outcomes. As can be clearly seen from the figures, there have at times been large revisions to the interest rate projections from one vintage to the next. We also observe that the projections are often very far off compared with the actual outcomes in all countries. The latter is maybe not that surprising given the large macroeconomic shocks that have occurred during this sample. The second row plots the short-term interest rate path revisions together with a global activity measure. The graph clearly indicates that the global activity measure is leading the interest rate revisions. This is particularly evident around the financial crisis, but also seen at the beginning of the sample for New Zealand, and towards the end of the sample for all countries.

An important issue when using these projections to construct forecast revisions and when investigating whether or not the revisions are predictable is timing, both (i) with regard to the information set available to the policy makers when making the (initial and updated) forecasts in each country, and (ii) with respect to the timing of forecasts across countries.

[6]The interest rate projections published by the RBNZ, NB and SR are the 90-bank bill rate, the key policy rate (foliorenten), and the repo rate, respectively. The sample varies, depending on when a central bank started to publish interest rate projections; 1999Q1-2017Q4 (RBNZ), 2005Q4-2017Q4 (NB) and 2007Q2-2017Q4 (SR).

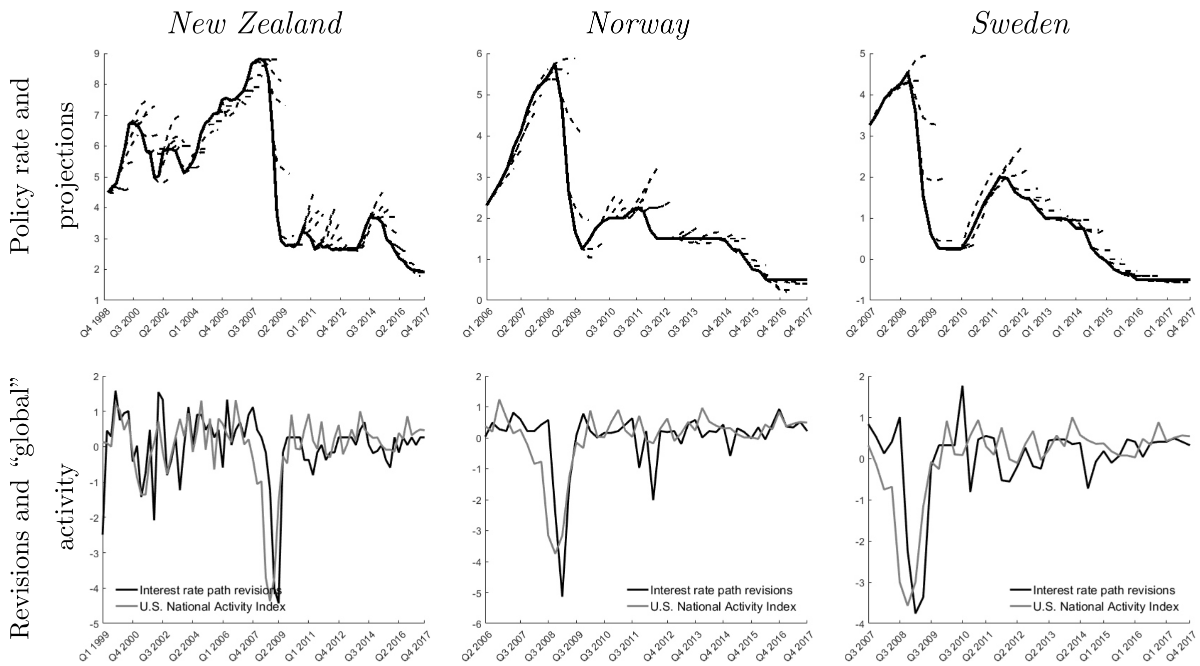


Figure 1. *The first row reports the actual policy rate together with the published interest rate path four quarters into the future. The second row reports the interest rate path revisions and one approximation for international business cycle conditions, namely the U.S. National Activity Index, lagged one quarter.*

For the first issue, we record not only the actual interest rate paths, but also the exact release day of the predictions. Subsequently, when we investigate if forecast revisions are predictable, we ensure that we do not use information that was not available to the central banks at the time they made their initial forecast.

For the second issue, we observe that for many periods, both RBNZ and NB publish their forecasts late in each quarter (March, June, September and December). Hence the timing is roughly consistent across these two countries. However, in the period prior to 2012, except 2008, NB publishes only three forecasts a year (March, June and October). To obtain comparable time series for this period and country, with four quarterly observations for each year, we construct from the October report two series of forecasts: a series of forecasts for Q4 and onwards, but stored as if it was constructed in Q3, and another set of forecast for Q1 and onwards, stored as constructed in Q4. For Sweden which publishes up to six reports within a year, we pick the reports that are published as close as possible in time to the publication cycle of the two other countries. More details on the monetary policy reports and the constructed time series are provided in Table 6 in Appendix A.

Forecast revisions

We focus our study on forecast revisions, as opposed to forecast errors, which have been studied more extensively in related literature, see e.g. Mirkov and Natvik (2016). By looking solely at forecast errors, it would have been harder to disentangle how central banks value incremental pieces of new information. In contrast, if forecast revisions are predictable using timely information it means that the central bank values this information when making it's interest rate decisions, but does not incorporate it efficiently. Still, as we show below, there is a close correspondence between the revisions and the actual forecast errors.

To construct a time series for the revisions of the projected interest rate paths (referred to in short as forecast revisions) we do the following: First, let $f_{2,t+1|I_{t-1}}$ be the two-step ahead forecast of the policy rate given information at time $t-1$, and let $f_{1t+1|I_t}$ be the one-step ahead (counterpart) forecast made one quarter later and given information up to time t, i.e., the most recent forecast of the policy rate at quarter $t+1$.[7] The forecast revisions between these two series (the one-step ahead and the two-step ahead forecast series) can then be found as: $r_{12,t+1} \equiv f_{1,t+1|I_t} - f_{2,t+1|I_{t-1}}$. Similarly, revisions between the two-step ahead and the three-step ahead counterpart forecast series, conditioning on time $t-1$ and $t-2$ respectively, can be found as $r_{23,t+1} \equiv f_{2,t+1|I_{t-1}} - f_{3,t+1|I_{t-2}}$, or more generally:

$$r_{ij,t+1} \equiv f_{i,t+1|I_{t+1-i}} - f_{j,t+1|I_{t+1-j}} \text{ where } i = j-1 \tag{1}$$

With the forecast revision definition in (1), the link between forecast revisions and actual forecast errors is simply the sum of the revisions up to the given forecast horizon h:

$$e_{h,t+1} = \sum_{j=1}^{h} r_{ij,t+1} \text{ for } h > 1 \text{ and where } i = j-1 \tag{2}$$

Naturally, the forecast error at $h=1$ is identical to the revision between the one-step ahead forecast and the outcome (i_t); $e_{1,t+1} = f_{0,t+1|I_{t+1}} - f_{1,t+1|I_t} = i_t - f_{1,t+1|I_t}$. However, in the analysis below we will not focus on these very short run revisions and errors. As reported in Mirkov and Natvik (2016), central banks in general seldom depart from their one-step ahead predictions, and the resulting revisions series will therefore feature very little variation.[8] Likewise, we restrict ourselves to evaluating only forecasts made up to four quarters ahead, i.e., $h=4$, or $r_{34,t+1}$.

[7]Here for simplicity we assume that all central banks produce these forecasts at regular interval four times year; however, in practice, the frequency of publications varies among the central banks as explained in

Table 1

*Summary statistics. Panel A reports the first four moments of the revision series (using the convention where the normal distribution has a kurtosis equal to 3). Panel B reports the cross-country correlations between the revision series. The sample available for Sweden is used. Panel C reports parameters from estimating an autoregressive model. Standard errors are reported in parentheses. *, **, and ***, indicate that coefficients are statistically significant at the 10%, 5%, and 1% level, respectively. Test statistics are computed using a residual bootstrap.*

Panel A: Moments

	New Zealand			*Norway*			*Sweden*		
	$r_{12,t+1}$	$r_{23,t+1}$	$r_{34,t+1}$	$r_{12,t+1}$	$r_{23,t+1}$	$r_{34,t+1}$	$r_{12,t+1}$	$r_{23,t+1}$	$r_{34,t+1}$
Mean	-0.12	-0.14	-0.14	-0.07	-0.11	-0.14	-0.11	-0.15	-0.17
Std.	0.47	0.57	0.59	0.34	0.42	0.48	0.35	0.43	0.47
Skew	-2.19	-1.70	-1.39	-3.49	-2.62	-2.14	-2.34	-1.82	-1.55
Kurt.	9.95	7.33	6.26	16.76	11.09	8.29	9.11	7.04	6.13

Panel B: Correlations

	$r_{12,t+1}$		$r_{23,t+1}$		$r_{34,t+1}$	
	Norway	*Sweden*	*Norway*	*Sweden*	*Norway*	*Sweden*
New Zealand	0.72	0.85	0.66	0.75	0.75	0.60
Norway		0.80		0.75		0.76

Panel C: Autoregressive parameter

	New Zealand			*Norway*			*Sweden*		
	$r_{12,t+1}$	$r_{23,t+1}$	$r_{34,t+1}$	$r_{12,t+1}$	$r_{23,t+1}$	$r_{34,t+1}$	$r_{12,t+1}$	$r_{23,t+1}$	$r_{34,t+1}$
γ_{ij}	0.42***	0.39***	0.39***	0.43**	0.42**	0.38**	0.52***	0.40**	0.37**
	(0.11)	(0.11)	(0.11)	(0.14)	(0.14)	(0.14)	(0.13)	(0.14)	(0.14)
R^2_{adj}	0.16	0.14	0.14	0.17	0.16	0.12	0.26	0.15	0.12
N	73	72	71	46	45	44	43	42	41

Table 1 summarizes the revisions series used in our analysis. From Panel A we observe that the mean revision increases with the horizon for all three countries, and that it varies between -7 and -17 basis points. The negative signs indicate that over the sample considered here there has been a tendency towards downward revisions. The standard deviation of the revisions, like their mean, is very similar across countries, with perhaps New Zealand having the most volatile revisions. All series feature a negative skewness, and a substantial kurtosis. Thus, large negative revisions are not uncommon. Given the

greater detail in Appendix A.

[8]Here, the mean one-step ahead revision, or forecast error, for the three central banks considered is just -0.06, -0.01, and -0.05 for New Zealand, Norway, and Sweden, respectively. Moreover, the standard deviation in these series is only between 0.10 and 0.36.

sample available for our analysis, which includes the largest global recession since the Great Depression, this summary statistic is perhaps not that surprising.

Panel B in Table 1 reports the cross-country correlations between the revision series. All correlations are equal to or higher than 0.60, and between New Zealand and Sweden it is as high as 0.85 for the revisions between the one and two-step ahead forecasts. These high cross country correlations indicate that there might be some common forces behind the interest rate forecast revisions, a theme we will come back to below.

Finally, the statistics reported in Panel C of Table 1 show how persistent the forecast revisions are. The results are obtained by estimating simple univariate autoregressive models of order one, AR(1), and reveal that there are statistically significant evidence of autocorrelation in all countries.[9] Hence, there is predictability in the interest rate forecast revisions. Note, however, that the explanatory power is weak, as the R^2 is typically small. We also observe from the last row of the table that there are relatively few time series observations available for the Norwegian and Swedish samples, but considerably more data to work with for New Zealand. This follows naturally, since the Reserve Bank of New Zealand was also the first central bank to start publishing own forecasts of the interest rates.

III Predicting Forecast Revisions

Having established that the interest rate forecast revisions are autocorrelated, the interesting question is then; can we predict these revisions using other information that was available to the policy makers at the time of making their initial prediction? To answer this question we use various domestic and international indicators, and test if they add marginal predictive power for the interest rate forecast revisions. Our goal is to inspect whether the central banks efficiently use all available information when making their forecast. If this is true we should not expect to find any significant relationship between our candidate indicators and the forecast revisions. If, on the other hand a central bank gradually incorporates this initial information by systematically adjusting the forecast as time goes by, we would expect to see a statistically significant relationship between certain indicators and the forecast revisions.

[9] We have used various information criteria to determine the lag lengths, finding that an AR(1) in most cases is the preferred specification. For simplicity, and to make the results compatible across horizons and countries, we use this specification for country and horizon comparisons.

More formally, we run a number of simple autoregressive distributed lag (ADL) models:

$$r_{ij,t+1} = \alpha_{ij,n} + \gamma_{ij,n} r_{ij,t} + \beta_{ij,n} x_{n,t+1-j} + \varepsilon_{ij,t+1}. \tag{3}$$

where $x_{n,t+1-j}$ stands for indicator n, with $n = 1, \ldots, N$, observed at time $t+1-j$, and $r_{ij,t+1}$ is the forecast revisions as defined in the previous section. As emphasized, key to the analysis is the fact that we only include information which was available to the central banks when they made their first release of the interest rate projections, as reflected by the $t+1-j$ indexation for the indicators x_n. Based on the results obtained from the simple AR regressions, reported in Table 1, only one lag of the forecast revision itself is included in the model.

Our set of explanatory variables consists of various global and domestics indicators. Table 7 in Appendix A provides a full description. We note here that all of the indicators are available in real-time, are not subsequently revised, and could have been part of the central banks's information set when making their initial forecasts. To capture what we label as the fundamental part of central banks's information set, we include consumer prices and industrial production. We also include a set of forward looking variables, such as the term structure spread (an indicator of the future stance of monetary policy), the stock return index (reflecting the general sentiment of investors), consumer confidence indicator (which is a proxy of consumer expectation about future economic conditions), as well as various money market rates and exchange rates.[10] For all of these variables, we include in our dataset (when possible) both the domestic and the foreign counterparts, where the latter group consists of one common global country (the US) and one or two regional trading partners; for New Zealand the region is Australia; for Norway the country/regions are Sweden and the euro area; and for Sweden the country/regions are Norway and the euro area. In addition, we also include some common global indexes, such as oil prices, a volatility index and a business cycle activity index (for the U.S.).

While the interest rate forecast revisions are quarterly variables, all of the indicators in the dataset are available at a monthly frequency. Since we record the exact date at which the initial interest rate forecast was released, cf. Section II, this allows us to bridge the monthly information with the quarterly revisions without using more information than the policy makers actually had at the time. At the same time, we exploit the availability of the monthly data to ensure that our dataset is not stale relative to what the policymakers

[10] Variables such as Gross Domestic product (GDP), investment, consumption, as well as leading indicators such as the OECD's Composite Leading Indicator (CLI), are all excluded because some of the subcomponents, and then the series themselves, are subject to revisions.

actually used when forming their expectations about the future. For example, if the initial central bank prediction was released in month three of quarter $t+1-j$, we use information up to month two of the same quarter when predicting the revision to the initial forecast at time $t+1$.

Prior to estimation, all variables are made stationary. Depending on the particular series, this is done by using either monthly differences, the year-on-year growth rate of the monthly variables, or by keeping the series in levels, see Table 7 in Appendix A for details. Finally, we normalize all indicators to simplify the interpretations of the regression coefficients. Not all indicators we use are available for all three countries. Thus, the number of indicators entertained (N), will vary somewhat depending on the country studied (New Zealand, Norway, or Sweden).

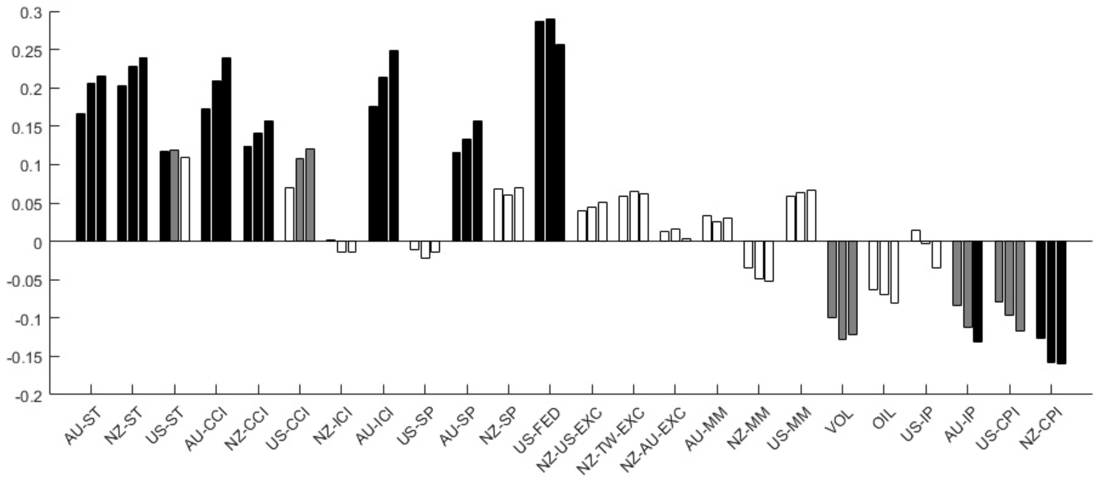
Global versus domestic indicators

Figure 2 presents a summary of the ADL regression results. That is, for each country and indicator specification, we plot the coefficients on $\beta_{ij,n}$ for the three forecast horizons r_{12}, r_{23}, and r_{34} as bars, from left to right. For ease of exposition, forward looking variables such as stock prices, consumer confidence indicators and spreads are ordered to the left in the figures, while fundamental variables such as industrial production and CPI are ordered to the right. Grey and black bar color shadings are used to indicate when coefficients are statistically significant at the 10% and 5% level, respectively. As the various indicators are standardized prior to estimation, the height of the bars is indicative of the relative strength of the relationships.

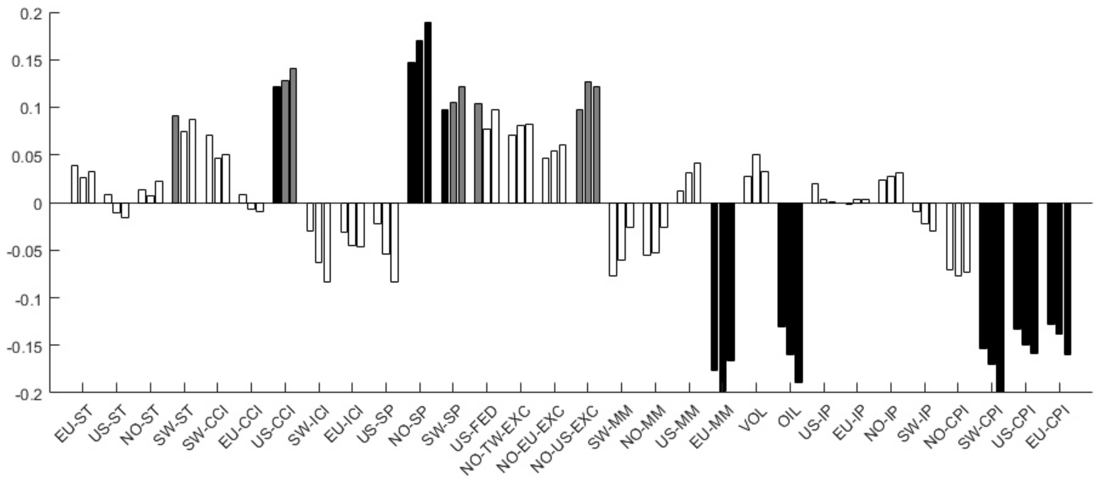
The results suggest a systematic role for typical forward looking variables in predicting the revisions to the projected policy rate path. That is, for New Zealand, Norway and Sweden, the consumer confidence index, stock returns and business cycle indicators are often significant in the predictive regressions. Furthermore, in unreported results we confirm that the autocorrelation coefficient is generally no longer significant when these variables are included in each of the regressions, and the R^2 increases substantially relatively to the pure autoregressive specification reported in Table 1. Together these findings suggest that the systematic pattern in the revisions of the policy rate is well captured by these indicators.

Turning now to the fundamental variables typically included in a central bank's policy rule, i.e., foreign and domestic inflation, industrial production (as a proxy for GDP), exchange rates and interest rates, we find fewer of these to be significant in the predictive

New Zealand



Norway



Sweden

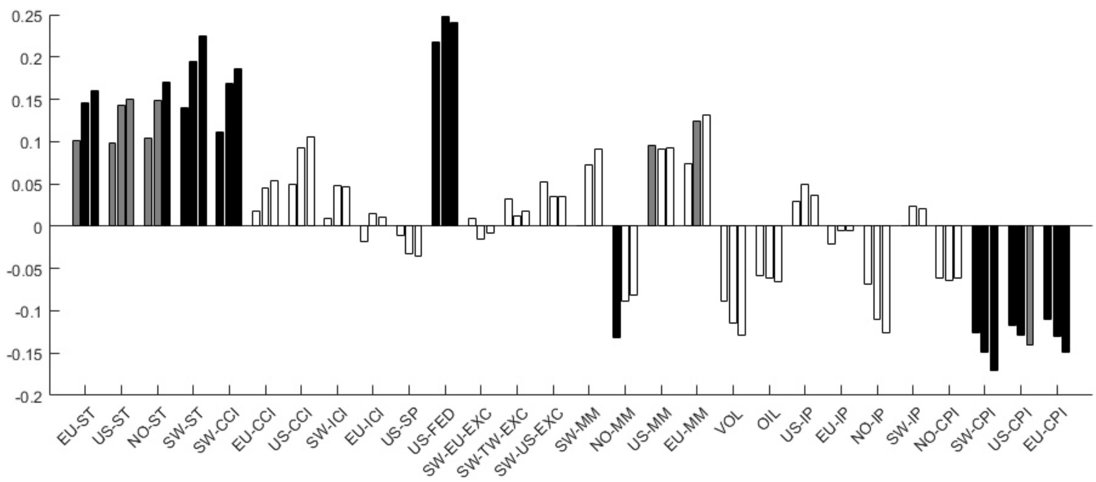


Figure 2. *Forecast revisions and ADL regression results. The figures report the coefficients on $\beta_{ij,n}$ from equation 3 for each indicator and for all the three forecast horizons r_{12}, r_{23}, and r_{34} (from left to right). The gray and black bar color shadings indicate that coefficients are statistically significant at the 10% and 5% level, respectively. No shading (white) indicates not significant. Test statistics are computed using a residual bootstrap. See Table 7 in Appendix A for a definition of the variable abbreviations.*

regressions. It is particularly interesting that almost none of the various domestic interest rate measures seem to be able to explain the forecast revisions. The exceptions are various inflation measures, which tend to have strong predictive power irrespective of whether they are international or not.

In New Zealand and Sweden, the best performing indicator, at least on the shortest horizon, is the *US FED* variable, which is a business cycle measure for the U.S. economy. Thus, international business cycles matter not only for economic developments in small open economies, but also for the revision of forecasts made by the central banks in these economies. In Norway, the most important variable is the oil price, together with foreign inflation and foreign (EU) money market rates. The finding for Norway speaks directly to studies that have documented the considerable importance of oil for the economy, see in particular Bjørnland and Thorsrud (2016).

Global versus domestic factors

Although the findings from the previous section document a large degree of predictability, many of the indicators seem equally useful for predicting the interest rate revisions. However, evaluating the indicators separately may not seem all that useful. Central banks do not typically look at only one single indicator when making their interest rate decisions, but filter large information sets. Furthermore, for some indicators it is not always clear whether it is the domestic or the international counterpart that adds the most predictive power. For instance, for New Zealand, both the Australian and the domestic stock price indexes are significant in the predictive regressions. Yet, this should come as no surprise. Typically, there is a common component in the foreign and the domestic counterpart of forward looking series, implying that they move in the same direction over the sample. This could, for instance, be due to financial integration. In particular, as agents can diversify their risk by investing in different markets, financial prices will become more synchronized through arbitrage.

To address these issues we first separate the information set used for each country into an international and domestic part, where each block of data only contains those indicators that individually added significant marginal predictive power in the regression conducted in Section . We then summarize the informational content in each dataset (foreign and domestic) by estimating factors using principal components analysis (PCA).[11] After es-

[11] As documented by, e.g., Boivin and Ng (2003), more information is not necessarily better when predicting using principal components. Hence, when constructing the datasets prior to PCA estimation,

timating the two factors, one foreign and one domestic, we include both in an extended ADL specification, and evaluate which of the two contributes the most in explaining the forecast revisions.

Summarizing the information in each data set using factor estimates has many advantages. First, as demonstrated in a number of studies, and perhaps most prominently in Bernanke et al. (2005), using factor analytical techniques can improve our understanding of the monetary policy transmission mechanism. Second, summarizing the informational content in large data sets using common factors tend to perform well in forecasting settings, see, e.g., Stock and Watson (2002), Giannone et al. (2008), and rnland et al. (2017). Third, as discussed in Section I, a large body of evidence from the international business cycle literature has found that domestic business cycles (in small open economies) are well explained by one common international and domestic factor. Lastly, by extending the ADL by two factors instead of many different (domestic and foreign) indicators we avoid running into degrees of freedom problems due to our rather limited sample availability.

Table 2 summarizes the results for the factor extended ADL results.[12] The rows indexed by γ_0 list the estimated autoregressive coefficients, and the rows indexed by β^I (β^D) lists the estimated coefficients associated with the international (domestic) factor. Panel A shows that with the exception of Sweden, the international factor contributes significantly to the predictive regressions. In Sweden, however, it is the domestic factor that seems to be the most important one.

Panel B in Table 2 reports the results from the factor extended ADL estimations when one additional extension has been implemented when extracting the factors. As stressed above, there is likely a very high correlation between many of the (forward looking) domestic and international variables used to estimate foreign and domestic factors and, as pointed out by Reichlin (2010), this might be the case because of the occurrence of general equilibrium effects in highly integrated markets. Here, ignoring this issue might lead to problems of multicollinearity when estimating the ADL specification, and might also blur the interpretation of the estimated coefficients. We therefore implement a factor rotation

we include only variables that are individually significant at the 10 percent level, which amounts to roughly half the variables, cf. Figure 2. The PCA estimator used is standard. Let X be a $T \times N$ matrix containing either the international or domestic variables, Λ the factor loadings, and F the factor. The factor estimates are then found by solving the following problem: $min_{F,\Lambda} V(\Lambda, F)$ s.t. $N^{-1}\Lambda'\Lambda = I$ and Σ_F diagonal, where $V(\Lambda, F) = \frac{1}{NT}\sum_{t=1}^{T}(X_t - \Lambda F_t)'(X_t - \Lambda F_t)$.

[12] For readability, the $r_{23,t+1}$ horizons are excluded from the table. The results from this horizon, across countries, are qualitatively the same as for those reported and can be obtained on request.

Table 2

*Forecast revisions and factor predictability. Standard errors in parenthesis. *, **, and ***, indicate that coefficients are statistically significant at the 10%, 5%, and 1% level, respectively. Test statistics computed using a residual bootstrap. Panel A reports the results when only variables significant at the 10% percent level, cf. Figure 2, are used to construct the respective factors. Panel B reports the results when the factors are made orthogonal to each other.*

	New Zealand		*Norway*		*Sweden*	
	$r_{12,t+1}$	$r_{34,t+1}$	$r_{12,t+1}$	$r_{34,t+1}$	$r_{12,t+1}$	$r_{34,t+1}$
Panel A: 10 significant level						
γ_0	-0.04	-0.10	0.35**	0.30**	0.24	0.07
	(0.14)	(0.14)	(0.12)	(0.13)	(0.17)	(0.16)
β^I	0.19**	0.26**	0.12*	0.15	-0.00	-0.06
	(0.08)	(0.11)	(0.07)	(0.12)	(0.09)	(0.11)
β^D	0.12	0.13	0.04	0.06	0.17**	0.30**
	(0.07)	(0.09)	(0.07)	(0.12)	(0.08)	(0.11)
R^2_{adj}	0.35	0.34	0.37	0.26	0.40	0.32
N	73	71	46	44	43	41
Panel B: 10 significant level and orthogonal factors						
γ_0	-0.04	-0.10	0.35**	0.30**	0.24	0.07
	(0.14)	(0.14)	(0.12)	(0.13)	(0.17)	(0.16)
β^I	0.28***	0.36***	0.16***	0.20***	0.14***	0.20**
	(0.06)	(0.08)	(0.04)	(0.06)	(0.06)	(0.08)
β^D	0.12*	0.13	0.04	0.06	0.17**	0.30***
	(0.07)	(0.09)	(0.07)	(0.12)	(0.08)	(0.11)
R^2_{adj}	0.35	0.34	0.37	0.26	0.40	0.32
N	73	71	46	44	43	41

prior to estimating the ADL specification. Following common practice, see, e.g., Gregory et al. (1997), Kose et al. (2003) and Thorsrud (2013), this is done under the assumption that any movements in the domestic factor that are not explained by the international factor must be purely due to domestic forces, and implemented by estimating the following equation: $F_t^D = \beta F_t^I + e_t$. Here, F_t^D and F_t^I are the estimated factors from the domestic and foreign data sets, containing variables that individually had a significant predictive power in explaining the forecast revisions (i.e., the factors used in Panel A in Table 2.). Letting the estimated residual $\hat{e}_t = \tilde{F}_t^D$, delivers a new domestic factor that is orthogonal to the international one.

As seen from the results reported in Panel B in Table 2, this additional factor rotation increases the statistical importance of the foreign factors in all countries. In fact, the foreign factor is now always significant, at the 1% level in New Zealand and Norway, and

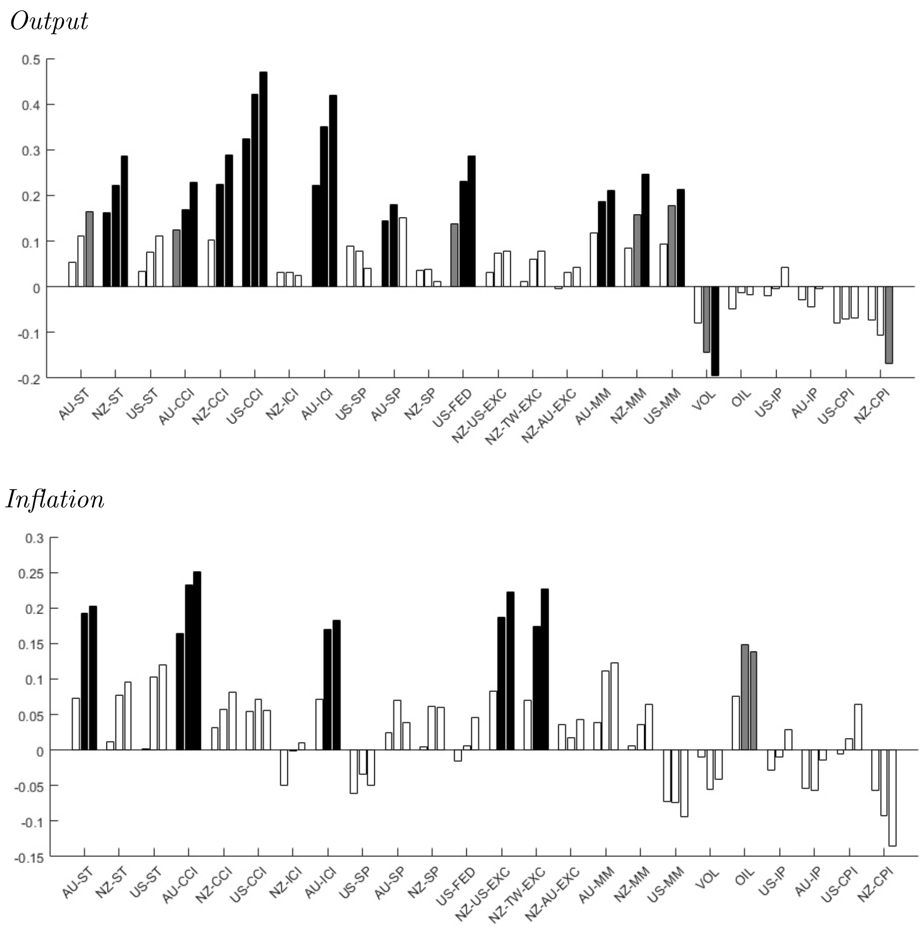


Figure 3. *Forecast revisions of inflation and output and ADL regression results in New Zealand. See Figure 2 for further explanations.*

at the 1% and 5% level in Sweden depending on the horizon. However, still, the domestic factors are significant in Sweden, suggesting they may also play a role in explaining the forecast revisions.[13]

We conclude from this analysis that most of the predictability of the central banks' interest rate revisions are due to a delayed incorporation of international developments.

GDP and inflation

Our focus so far has been on investigating whether or not forecast revisions of the interest rate paths published by central banks are predictable. However, to the extent that the central banks revise their forecasts of inflation and output in a coherent manner relative

[13]There is, as shown in equation (2), a close connection between the forecast errors and revisions. This connection is confirmed when we redo the analysis from above using the actual forecast errors instead of the revisions, see Table 8 in Appendix B. In fact, results are even stronger, as now only the foreign factor is significant at the 5% and 1% level in all countries.

to the interest rate, one would expect that also these revisions are predictable using the same information sets as when predicting interest rate forecast revisions.

To investigate this issue we construct revisions series for inflation and output in the same manner as for the interest rate, and redo the analysis described in Sections and using either output or inflation as the dependent variable. The choice of variables/transformations reflects what the central banks themselves publish. The central banks in New Zealand and Sweden predict annualized GDP growth, while the central bank in Norway predicts the output gap. For all three countries, the banks predict year-on-year CPI inflation.

The results from this additional experiment yield two main findings. First, many of the indicators that explained the interest rate revisions also explain the revisions in GDP and inflation, see Figure 3 for New Zealand and Table 3 for summary statistics for all three countries.[14] In particular, the table shows that the correlation between the indicators that explain well interest rate forecast revisions and those that explain inflation and output is very high and significant. Especially for inflation and output in Sweden and New Zealand, we find very robust relationships. In Norway, however, the correlations are substantially lower, and not significant.

Second, as shown in Tables 9 and 10 in Appendix B, when summarizing the information sets using international and domestic factors, it is the international factors that dominate in terms of explaining the inflation and output forecast revisions, although the results are less strong compared with those for the interest rate revisions.[15]

Thus, for all countries we confirm the main finding from our earlier analysis, namely that it is the informational content in international variables that can explain most of the predictability in the central banks' forecast revisions. In addition, at least for New Zealand and Sweden, there seems to be a close correspondence between the information sets explaining inflation and output revisions relative to the interest rate revisions.

[14]In the interest of preserving space, the figures for the other countries are displayed in Figures 5 and 6 in Appendix B.

[15]Note here that for some country and horizon combinations, neither international nor domestic indicators were significant at the 10% level. To alleviate this issue we first included all variables when constructing the orthogonal factors, and then, as when predicting interest rate forecast revisions, only the variables that were significant at 10% level. This latter specification results in some missing observations.

Table 3

*Spearman's rank correlation coefficients. Each entry in the table reports the correlation between the estimated β_{ij} coefficients from the ADL regressions when the dependent variable is the interest rate revisions or the inflation (output) revisions. *, **, and ***, indicate that coefficients are statistically significant at the 10%, 5%, and 1% level, respectively.*

	New Zealand			*Norway*			*Sweden*		
	β_{12}	β_{23}	β_{34}	β_{12}	β_{23}	β_{34}	β_{12}	β_{23}	β_{34}
Inflation	0.42**	0.57***	0.48**	0.09	-0.13	-0.17	0.70***	0.84***	0.85***
Output	0.79***	0.82***	0.81***	0.07	0.03	0.20	0.65***	0.88***	0.70***

IV Revision predictability and monetary policy shocks

What consequences do the findings documented about predictability have for the conduct of monetary policy, and monetary policy surprises in particular? After all, central banks publish their interest forecasts to guide public expectations about the macro economy in general and monetary policy in particular. Hence, if the policy makers revise their forecast due to, say, a delayed response to international economic developments in the past, these revisions might make public private information about how the central banks assess past, current, and future economic conditions, and thereby affect markets. On the other hand, if market participants already at the forecast origin know that the central bank would eventually have to revise their predictions, i.e., they anticipate the deviations of what the policy maker said she would do and what she actually ends up doing, then it is hard to envision that these forecast revisions should move the market. The information should already be fully incorporated in the market rates.

What should we expect? Using the results from the analysis in Section III, a reasonable expectation is that market participants do not anticipate the interest rate revisions. That is, we showed that domestic money market rates did not add any value added in predicting the revisions to the policy rate, suggesting they do not contain independent information about policy revisions. A similar view is obtained if one looks at simple correlations between revisions in the policy rate and contemporaneous changes in money market rates. For example, the correlations between the $r_{12,t+1}$ forecast revisions and the quarterly change in various market interest rate measures are strong, positive, and generally significant in all three countries, see Table 11 in Appendix B. Of course, these correlations might not necessarily be due to the central banks lack of timely response to foreign shocks, but rather new information arriving after the forecast origin.

To investigate more formally the potential implications of our findings documented in

Section III, we specify a standard monetary vector autoregression (VAR):

$$A(L)y_t = \eta_t \tag{4}$$

where an intercept is dropped for notational simplicity. The $n \times 1$ vector y_t includes the output gap, inflation, the real exchange rate, stock prices, and the change in the market interest rate, and Appendix provides a more detailed description about how the data are collected and transformed. To answer the question of interest, instead of identifying a monetary policy surprise using standard structural VAR methods, see e.g. Christiano et al. (1999), Eichenbaum and Evans (1995) and Bjørnland and Halvorsen (2014), we use an external instrument variable (IV) approach, where the instruments are constructed from the part of the actual forecast errors that can be predicted/explained by foreign indicators.

Instrument variable identification

The use of instrument variables (IV) to identify shocks in a VAR was introduced by Stock (2008), and have later been used in, e.g., Stock and Watson (2012), Mertens and Ravn (2013), and Gertler and Karadi (2015). As in conventional structural VAR analysis, the object of interest is the structural shocks ϵ_t, and its dynamic responses. These objects can be recovered from the reduced form residuals η_t through:

$$\eta_t = H\epsilon_t \tag{5}$$

where H is the structural impact matrix, and the structural shocks are assumed to be uncorrelated. The challenge for all studies is then to find a plausible identification scheme to recover H and ϵ_t. When the interest is single shock identification, the general idea with the method proposed by Stock (2008) is to use an exogenous instrument, Z_t, to achieve this.[16]

Assume without loss of generality that the market interest rate is ordered first in the VAR system, and let $\epsilon_{MP,t}$ denote the structural shock of interest. Then, as with standard IV estimation, two important assumptions need to be fulfilled for valid identification, namely the well known relevance and exogeneity assumptions:

$$E(\epsilon_{MP,t} Z_t') = \alpha' \neq 0 \tag{6}$$

[16]Note here that the instrument is called external because it is not included in the VAR, and that although more than one instrument can be used, we restrict ourselves to only one in this analysis. See Stock and Watson (2016) for an overview of the methodology, and further references.

$$E(\epsilon_{j,t}Z_t') = 0, j = 2, \ldots, n \tag{7}$$

Following the notation in Stock and Watson (2016), and assuming that the instrument used is valid, i.e., that (6) and (7) hold, the estimator of the relevant part of H can be obtained by combining (5)-(7) such that:

$$\begin{bmatrix} E(\eta_{1,t}Z_t') \\ E(\eta_{\bullet,t}Z_t') \end{bmatrix} = \begin{bmatrix} H_{11} & H_{1\bullet} \\ H_{\bullet 1} & H_{\bullet\bullet} \end{bmatrix} \begin{bmatrix} E(\epsilon_{MP,t}Z_t') \\ E(\epsilon_{\bullet,t}Z_t') \end{bmatrix} = \begin{bmatrix} \alpha' \\ H_{\bullet 1}\alpha' \end{bmatrix} \tag{8}$$

where H_{11} and $H_{\bullet 1}$ are the first and subsequent elements in the first column of H respectively, and $\eta_{\bullet,t}$ the remaining $n-1$ elements of η_t. The last equality uses an unit effect normalization imposed, $H_{11} = 1$, together with (6) and (7).

Then, from the first and last term in (8) we obtain the IV estimator:

$$H_{\bullet 1} = \frac{E(\eta_{\bullet,t}Z_t)}{E(\eta_{1,t}Z_t)} \tag{9}$$

from which dynamic responses (impulse responses) can be computed using standard methods.

As already stated, we use the part of the actual forecast errors that can be explained by foreign variables as an external instrument.[17] Is this a good instrument? Equation (6) can be tested, and we do so below in the next section. Essentially, if the instrument is weak, it likely means that the predictable part of the forecast error does not move the market because the agents in the economy know about the forecast errors the central banks tend to make and incorporate that information efficiently. On the other hand, if the predictable part of the forecast error is a strong instrument for the monetary policy error, it will be a valid instrument and potentially capture important structural aspects of the monetary policy surprise.

Equation (7) can not be tested. Still, as our instrument variable, Z_t, is the predictable part of the forecast error, it is very likely that it is fulfilled. Recall that to predict the forecast errors we used information that was available to the policy maker at least two quarters prior to the forecast horizon. Is seems unlikely that this information set should be correlated with future values of the structural VAR shocks (other than the structural

[17] Recall from the discussion above, and as shown in equation (2), there is a close connection between the forecast errors and revisions. See also results in Table 8 in Appendix B, where we have redone the analysis from Section , using the actual forecast errors instead of the revisions. We focus on the forecast errors here because they capture the sum of revisions, i.e., a larger part of the central bank's updates. We have, however, also done the analysis using the predictable part of the forecast revisions as instruments. Qualitatively, the results shown below are similar, but the instruments are weaker.

monetary policy surprise). In contrast, if we had used the unexplained part of the forecast errors from the predictive regressions as an instrument, it would potentially have included all new information arriving between the forecast origin and horizon, and therefore also potentially been correlated with the other structural VAR shocks. A similar argument applies against using the whole forecast error, since this measure then likely includes both an exogenous and endogenous part.

Given our framework, we believe the IV approach has three advantages compared with more traditional identification schemes used to identify a (potential) monetary policy surprise: First, we do not need to take a stand on any timing assumptions. For example, in many empirical studies, output and inflation are typically restricted from responding on impact to unexpected changes in the interest rate. Using the IV approach, all variables are allowed, but not restricted to, respond contemporaneously to the shock of interest, see equation (9). Second, compared with studies that typically include the forecast errors as a direct measure of the shock of interest directly into the VAR, i.e., Kuttner (2001), Hamilton (2003), and Romer and Romer (2004), we do not have to assume that this measure captures the entirety of the structural shock. As argued in Stock and Watson (2016), such an assumption can be questionable, lead to errors-in-variables biases, but be alleviated through the use of IV identification. Third, and on a more practical note, we do not have a long enough sample to include the forecast errors directly into the VAR system. However, by using the IV identification scheme, H can be estimated on a sub-sample, for which the forecast errors are available, relative to the sample the VAR is estimated on.

Individual country VAR results

We start by estimating the VAR model in (4) individually for each of the three economies already considered; New Zealand, Norway, and Sweden. For New Zealand we let the estimation period start in 1997. For Norway and Sweden we start in 1999. These dates correspond to time periods where all three countries had either adopted inflation targeting, or were about to do so. For all three countries we end the estimation sample in 2017.[18]

For each country we consider six different VAR specifications. In particular, we estimate the VARs using three different market interest rates. As discussed in Gertler and Karadi (2015), because we wish to include shocks to future interest rates in the measure of the policy innovation, we use a policy indicator with a longer maturity than the

[18]The lag lengths used in the VAR are determined by the AIC information criterion, and suggest that either 1 or 2 lags are appropriate. Parameter uncertainty is simulated using a residual bootstrap.

Table 4

First stage TSLS regressions. The results are obtained by estimating the various money market rate VAR residuals on the instrument. In Panel A the instruments are constructed by choosing the best performing single indicator in terms of predicting the central bank's forecast revisions. In Panel B the instruments are constructed using the orthogonal factors derived in Section . For both sets of instruments we use the fitted values from predicting the forecast error at the two-step ahead horizon.

	New Zealand			*Norway*			*Sweden*		
	3 month	1 year	2 year	3 month	3 year	5 year	3 month	2 year	5 year
Panel A: Single Indicator									
F-stat	5.60	0.00	0.91	16.84	0.59	0.09	5.63	0.04	1.40
R^2	0.07	0.00	0.01	0.28	0.01	0.00	0.12	0.00	0.03
N	73	73	73	44	44	44	41	41	41
Panel B: Factors									
F-stat	6.41	0.16	0.62	13.77	0.75	0.10	7.36	0.65	0.35
R^2	0.08	0.00	0.01	0.24	0.02	0.00	0.16	0.02	0.01
N	73	73	73	44	44	44	41	41	41

short-term rates. Accordingly, we estimate the VAR using either the three month money market rate, or two measures of longer-term government bond yields.[19]

For each country we also consider two different instruments. The first set of instruments is constructed by choosing the best performing single indicator in terms of predicting the forecast revisions, cf. Section . For New Zealand and Sweden, the indicator used is the *US FED* variable, while it is the *OIL* variable for Norway. The second set of instruments is constructed by using the orthogonal factors derived in Section . For both sets of instruments we use the fitted values from predicting the forecast error at the two-step ahead horizon.

Table 4 reports the results of regressing the various VAR interest rate residuals on the two proposed instruments. With the exception of Norway, for most instrument and interest rate combinations, the instruments have a F-statistic below 10, and appear to be weak. This may indicate that the agents in the economy have already incorporated the inefficiencies in the central banks interest rate projections, or might simply be a result of the rather short sample available for estimation. In the next section we explore the

[19] The exact maturities and type of instruments we use varies somewhat between the countries due to data availability. For New Zealand we use the 90-day bank bill yield, and the 1 and 5 year secondary market government bond yields. For Norway we use the 3 month-NIBOR, and 3 and 5-year government bond yields. For Sweden, we use the 3 month STIBOR, and 2 and 5-year government bond yields. All statistics are collected from the Reserve Bank of New Zealand, Norges Bank and Sveriges Riksbank, respectively.

effect of pooling information across all three countries when estimating both the VAR and testing the instrument validity. First, however, we note that it is the combination of using the foreign factor together with the 3-month interest rate that tends to yield the highest F-statistic.

Accordingly, Figure 7, in Appendix B, reports the impulse responses derived for each country using the foreign factor as instrument and the 3-month interest rate to identify the shock. Following the initial shock, normalized to increase the interest rate with one percentage point on impact, we observe that output and inflation increases in all countries, returns tend to increase on impact, while the exchange rate response is insignificant.

Although these results are all very uncertain and should be interpreted with care, they indicate that the identified shock is far from a conventional monetary policy shock. Instead, the estimated effects suggest that the surprise component we capture leads to co-movement between the variables. We return to this discussion in the next section.

Panel VAR results

Estimating the VAR model (4) individually for each country yields weak instruments, and very uncertain impulse responses. In this section we pool information from all three countries, and estimate a Panel VAR model where shock identification is achieved using the external instrument method. In the current setting, this has two potential benefits. First, pooling information across countries might lower the uncertainty associated with the estimated VAR parameters, and, second, gives us a substantial larger amount of observation for estimating the first stage IV regressions.

Based on the results presented in the previous section, we include in the Panel VAR the 3-month interest rate, and use the foreign factor as the preferred instrument. When estimating the Panel VAR we assume that the slope parameters and the error covariance matrix is homogeneous across countries, while the intercepts are country specific (fixed effects). Although these are rather strong assumptions, they restrict the number of parameters to be estimated considerably.

Table 5 reports the first-stage IV results. Three findings stand out. First, when using the full sample to estimate the relationship between the Panel VAR residuals and the instruments, we find that the instruments are relevant with a F-statistic around 30. Moreover, this finding is robust to estimating the relationship with simple OLS, or allowing for a panel structure with fixed-effects. Thus, pooling information across the three countries indicates that the weak instrument property found in the previous section was mostly a sample size issue.

Second, as one of the main hypothesis in this article is that the central banks do not respond in a timely fashion to developments in the global economy, we should expect an even stronger relationship between the Panel VAR residuals and the instruments during periods of large swings in international business cycles. And, looking at the columns under (B) in Table 5, this is exactly what we find. When only including time periods associated with the aftermath of the Asian financial crisis, the boom and bust of the dot-com bubble and the US recession in the early 2000s, the Global financial crisis, and lastly, the change in global business cycles towards the end of the sample, the estimated first-stage IV coefficient becomes substantially larger (in absolute value). Compared to the full sample results reported in the columns under (A) we also observe a noticeable increase in the R^2. However, due to the reduced sample size, the F-statistics fall from around 30 to 20, but the instruments are still considered to be strong.

Third, the period during the Global financial crisis is of course important for this result: It is by far the best example of a period with large swings in international business cycles the two last decades. Accordingly, when estimating the first-stage IV regressions and only considering the financial crisis years, see the columns under (C) in Table 5, the predictive relationship strengthens further. Compared to the results reported under (A) and (B), both the coefficients (in absolute value) and the R^2 statistics increase substantially, but, with only 27 observations available for estimation, the F-statistics indicate that the instruments are barely relevant.

The left column in Figure 4 reports the impulse responses associated with the first-stage IV regressions in Table 5. Treating the *Full sample* results as the benchmark model, we confirm the impression obtained from running the VARs individually for each country. That is, after a monetary policy surprise, normalized to increase the short-term interest rate with 1 percentage point, output, inflation, and stock returns all rise. The output and inflation responses are significantly different from zero at the 10 percent level after roughly one and one to six quarters, respectively. The stock market response is more uncertain, but close to significant at the 10 percent level on impact. Finally, the median exchange rate response is negative, suggesting a depreciation, but the response is not significant at any horizons.[20]

[20] Figure 8, in Appendix B, shows that these results are robust to using a simple mean-group estimator (Pesaran and Smith (1995)). In unreported results we also observe that the results hold when estimating the pooled Panel VAR model using Bayesian inference. Likewise, these findings are robust to using the single indicators used in Table 4 as instruments. See Table 13 and Figure 9 in Appendix B.

Table 5

Panel VAR and first stage TSLS regressions. With reference to Table 4, the Panel VAR includes the 3 month interest rate, and the foreign factors are used as external instruments. In the table, two estimators are considered, simple OLS, or a fixed effect regression. For the OLS regression, standard errors are clustered on the group (country) level. Three different estimation samples are considered: (A) The Full sample (1999-2017); (B) Only observations associated with important international business cycle "events", i.e., the Asian financial crisis, the boom and bust of the dot-com bubble and the US recession in the early 2000s, the Global financial crisis, and lastly, the change in global business cycles towards the end of the sample (1999-2003, 2008-2010, and 2015-2017); (C) Only observations associated with the Global financial crisis (2008-2010).

	(A) Full sample		*(B) Volatile international periods*		*(C) Financial crisis*	
	OLS	Fixed effect	OLS	Fixed effect	OLS	Fixed effect
Coefficient	-0.41	-0.41	-0.49	-0.51	-0.62	-0.62
F-stat	29.54	32.42	19.25	18.32	11.08	9.73
R^2	0.17	0.17	0.25	0.26	0.31	0.30
N	158	158	56	56	27	27

The black dotted and marked lines in the left column of Figure 4 reports the median impulse responses when the Panel VAR impact matrix is estimated using the first-stage IV regressions in columns market (B), i.e., 'Volatile international periods' and (C) 'Financial crisis' in Table 5. There are no significant differences between these responses and the ones discussed above. This suggests, as expected, that the periods that drive our results are those that are associated with large swings in international business cycle developments. Or, in other words, periods in which international developments might be of particular relevance for small and open economies like New Zealand, Norway, and Sweden.

For comparison, the right column of Figure 4 reports the results when identifying the monetary policy innovations using the more conventional recursive ordering (Cholesky identification).[21] Now, a one percentage point increase in the interest rate leads to a drop in output and stock returns, an appreciation of the exchange rate, and an increase in the inflation rate. Thus, although we get the usual prize puzzle using this type of identification, the responses in the other variables are all in line with what we would expect following a conventional monetary policy shock.

The difference between the IV and Cholesky identification schemes are striking. While the latter has a conventional interpretation, the surprise we identify through our IV scheme resembles more what the more recent monetary policy literature has labeled an informa-

[21] To allow the exchange rate and the stock market to respond on impact to monetary policy surprises, we use the following ordering: output gap, inflation, interest rate, exchange rate, stock returns.

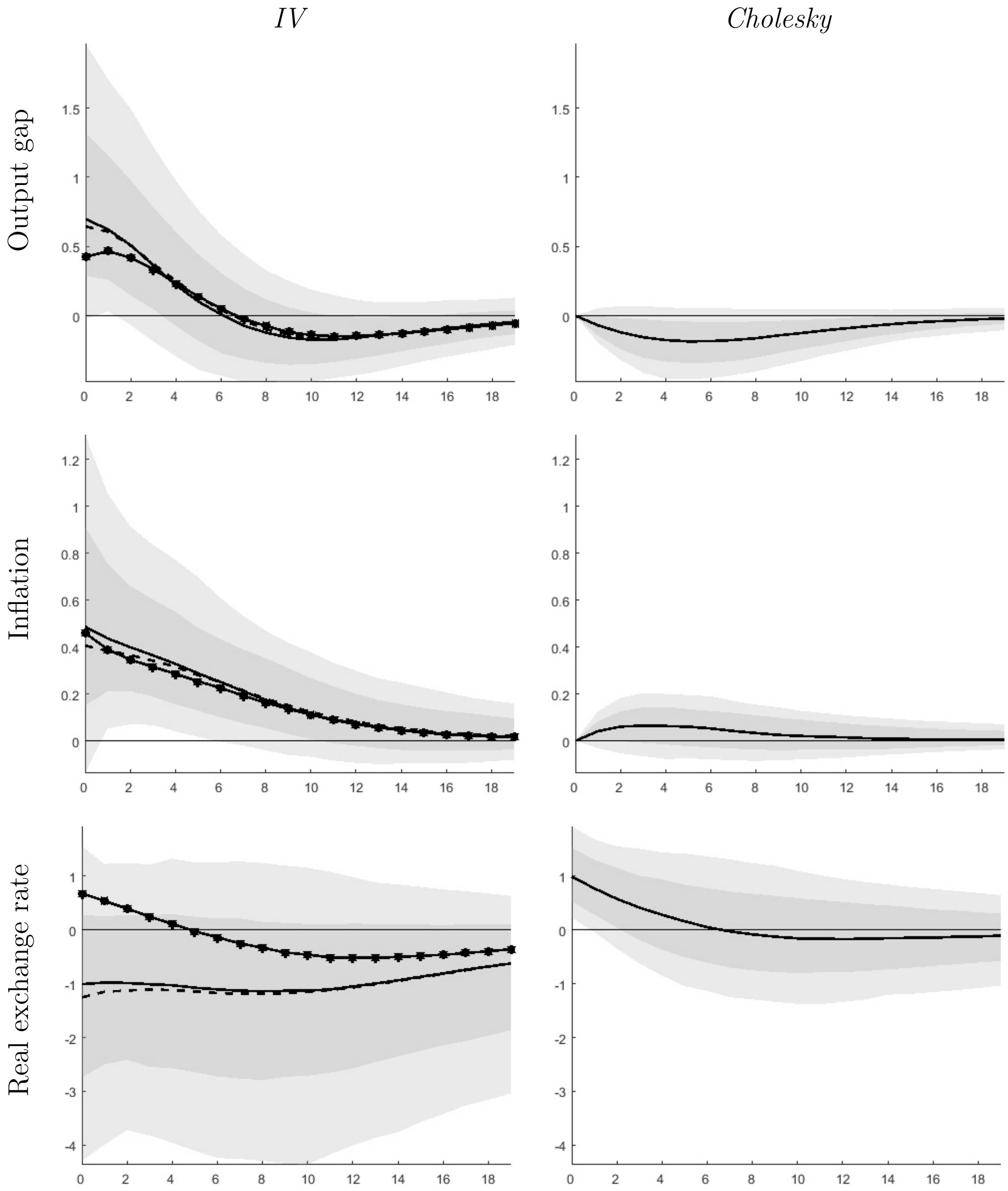


Figure 4. *Panel VARs and impulse responses to a monetary policy shock identified using the external instruments (IV), or a lower triangular ordering (Cholesky). The black solid line is the median estimate based on the Fixed effect column in (A) of Table 5. The gray shaded areas correspond to the 90 and 64 percent quantiles. The black dotted lines are the median impulse responses based on the Fixed effect column in (B) of Table 5. The black dotted lines with markers are the median impulse responses based on the Fixed effect column in (C) of Table 5. The x-axis reports the response horizons (in quarters). The initial shock is normalized to a 1% monetary policy tightening. The figure continues on the next page...*

tion shock component. In, e.g., Jarocinski and Karadi (2018) this shock is identified under the assumption that stock market valuations and monetary policy innovations co-move. The reason is that when the central bank changes the interest rates, they typically also

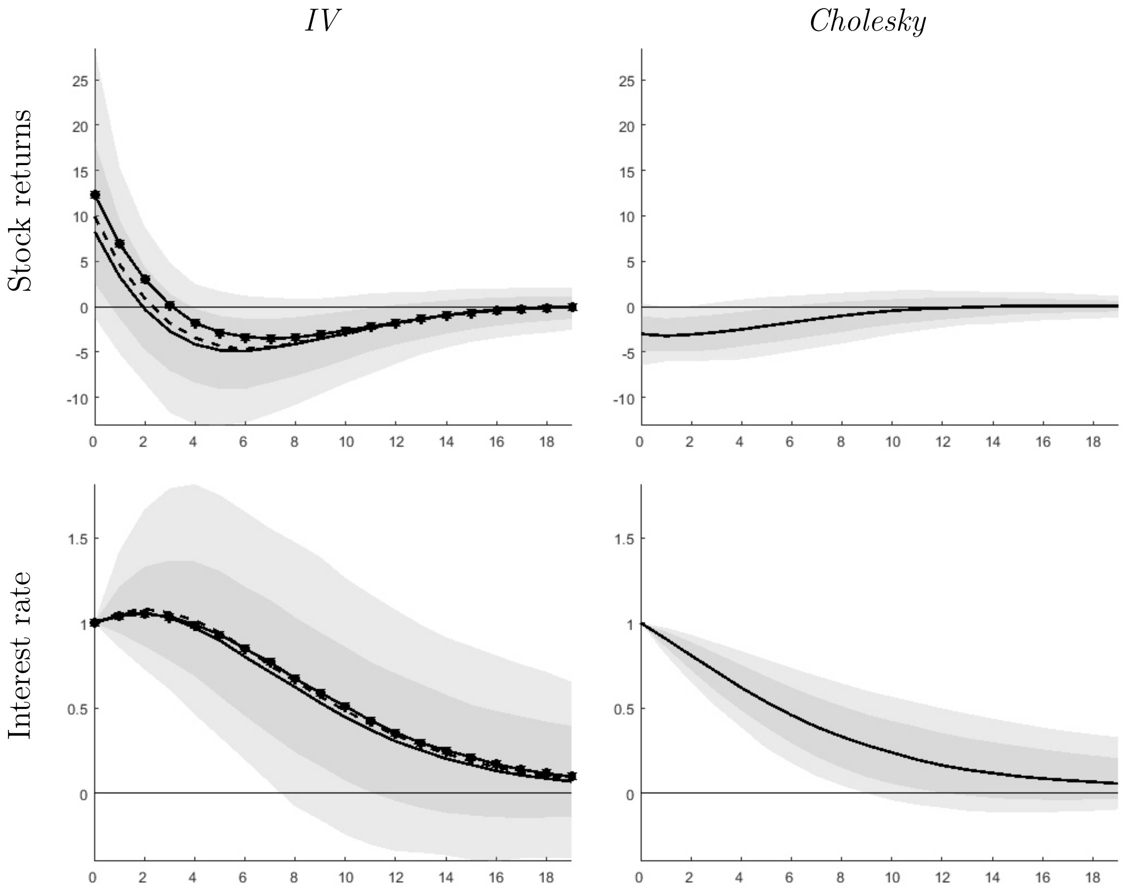


Figure 4. *...continued from previous page.*

reveal private information about current and future economic conditions. Under the assumption that central bank communication affects the market (is effective), a revelation of positive information should then, all else equal, increase returns, interest rates, and the general economic outlook. And, this is indeed what we find, although using a very different methodology than in Jarocinski and Karadi (2018).[22]

In our setting, the information component interpretation is not only in line with our empirical estimates, but also makes intuitive sense. First, it is certainly true that the publication of the interest rate path is an important part of the communication strategy for the central banks considered here. Moreover, while all market participants, including the central banks, can observe historical international developments, there might be uncertainties related to how such developments transmit to the domestic economies going forward. Thus, when the central banks eventually revise their interest rate projections

[22] Another implication of this is that a monetary policy surprise, identified using the more standard recursive ordering, potentially contains both a conventional monetary policy shock and the information component. As the responses following these two shocks are very different, this might be one reason for why one often get a "price puzzle" using the recursive identification scheme, cf. Figure 4.

up or down, this serves as a signal to the market about how to interpret international developments, and thereby reveals information about current economic conditions that are typically not available in real time. The fact that we find a high correlation between those variables that predict interest rate path revisions, and those that predict revisions in output and inflation forecasts, confer Table 3, strengthens this interpretation. After all, revising, e.g., up the interest rate path, but down the output projections, would indicate a more conventional monetary policy shock.[23]

It might be tempting to argue that we capture the information effect channel of a monetary policy surprise because the VAR modeling framework misses how the central banks systematically responds to international developments. However, we have already shown in Section III that we can predict, with historically available international factors, how the central bank's revise their future forecasts. And, importantly, it is exactly this predicable part of the forecast errors we use as instruments in the VAR framework. Thus, if indeed the central banks systematically, and fully, responded to international developments, the international factor should not have been predicting future forecast errors, nor serve as relevant instruments. We find, however, that they serve both as good predictors and relevant instrument.

In sum, although our results are somewhat uncertain, they all point to an important lesson, namely that the part of the central bank's forecast errors that can be explained by international factors lead to surprises in the market. In turn, these surprises cause economic aggregates to co-move with the interest rate, in line with an informational component interpretation. This component amplifies the cyclical fluctuations rather than reducing them. By responding in a more timely fashion to news about international developments, these surprises could in principle have been avoided.

However, we stress that our analysis is descriptive, and can not be normative. As discussed in the introduction, there could be many reasons for why the central banks do not respond in a timely fashion to global developments, like strategical considerations, an explicit desire for forecast smoothing or noisy economic signals. In particular, inertia in monetary policy has some potential benefits, and might, for example, be optimal when

[23] Relatedly, and to the extent that the information component of the monetary policy surprise dominates in times of important international developments, we find that the unconditional correlations between interest rate path revisions, and revisions in output and inflation forecasts, are significant, positive, and roughly 30 percent higher in times of international turmoil than on average. In more normal times, the correlations are insignificant and up to 70 percent lower than on average, indicating that the revisions more often move in opposite directions, see Table 12 in Appendix B.

policymakers are uncertain about the quantitative effects of foreign shocks (due to, e.g., modeling inefficiencies). Sticking to their announced intentions might also give policy makers more control over long-term interest rates via the expectations channel, which again can reduce financial sector instability, cf. Woodford (2003).

V Conclusion

We provide novel evidence that inertia in monetary policy actions is an important component of the decision-making process by policy makers in small and open economies, and that an important source explaining this inertia is a delayed monetary policy response to news about foreign variables. Furthermore, we show that the delayed responses matter for the dynamics of key economic and financial variables. This evidence is obtained by using the published real time interest rate projections from the central banks in New Zealand, Norway and Sweden, which were the first three central banks to publish their interest rate forecasts. In particular, we run a battery of predictive regressions using domestic and foreign real-time indicators to explain interest rate forecast revisions and show that, for all three countries, there is a systematic role for international indicators in predicting the revisions to the policy rate. Most notably is the role of forward looking global indicators. In contrast, using related indexes for the domestic economy yields more or less insignificant results.

Then, to examine the implication of these forecast revisions, we analyze the joint response of key economic and financial variables, including market interest rates, to implied monetary policy surprises using a structural VAR model. We use an external instrument approach for identification, where the instruments are constructed from the part of the forecast errors that can be predicted/explained by foreign indicators. We show that the identified component of the monetary surprise leads to a positive co-movement between the interest rate and both the macro economy and financial markets. We interpret the identified surprise as directly associated with central bank forward guidance. If the observed revisions are consistent with the central bank revealing private information about their current assessment of the economy, we should also expect the market to respond accordingly.

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