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MEASURING THE EFFECT OF FORWARD GUIDANCE IN SMALL OPEN ECONOMIES: THE CASE OF ISRAEL

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Abstract

In this paper, I measure the effect of forward guidance in a small and open economy, using Israel as a case study. I suggest an alternative approach to the standard method of Gurkaynak *et al.* (2005) that relaxes the assumption of constant structure and estimates the effect of forward guidance (FG) separately for each shock and term to maturity. Namely, I relax the assumption that the relative effect is fixed across maturities for every FG shock, regardless of the information contained in each FG statement. This approach also controls for global shocks under the assessment that their impact may not be negligible in a small open economy. I find that while the estimates of the shocks from both methods are highly correlated, the standard method leads to imprecise identifications in cases where the FG shocks mainly affect specific terms to maturity. The results suggest that policymakers should take into consideration which term to maturity each FG statement impacts. In addition, I show that some of the main FG statements made by the Bank of Israel significantly affected yields.

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1. INTRODUCTION

The global financial crisis led many central banks (CBs) to reduce their policy rate to zero or an effective lower bound (ELB). Facing that constraint, CBs resorted to using unconventional monetary tools, including forward guidance, large-scale asset purchases, and foreign exchange intervention. This paper focuses on identifying and measuring the effects of forward guidance (FG) in a small open economy (SOE) and uses Israel as a case study. The paper argues that Gurkaynak, Sack, and Swanson's standard method (2005) (henceforth GSS) may not be suitable for an SOE and that their measure for FG partially captures the effect of global shocks. The paper also investigates the validity of an underlying implicit assumption in the GSS method: the assumption that FG affects the yield curve in a constant structure—namely, that the relative effect is fixed across maturities for every FG shock, as opposed to a differential effect along the yield curve, regardless of the information contained in each FG statement. The paper argues that this assumption can lead to imprecise identification, a problem that is not necessarily unique to an SOE.

In this paper, FG refers to communication about the future path of CB monetary interest rates: namely, all communication made by the CB which affects market expectations about the future conduct of the monetary policy, as opposed to setting the current monetary rate.[2] Accordingly, the term FG is used for communication that includes a commitment by the CB about the future path of the monetary interest rate *("Odyssean FG*"), communication that provides guidance about the likely course of monetary policy *("Delphic FG*"), and other kinds of information that lead the public to update its expectations about the interest rate path,[3] such as news that affects the public assessments about the degree of CB *"Hawkishness*" (i.e., its willingness to raise the interest rate due to an increase in inflation or a positive output gap).

Understanding the effects of FG became even more important following the financial crisis when many CBs lowered their interest rates to their ELB. Communication has become a key monetary policy instrument, which CBs use to achieve additional monetary accommodation by managing public expectations.[4] Despite its prevalence, the mechanism of this policy tool has remained unclear.

[2] A similar definition is used in Swanson (2017), which defines FG as the component of FOMC announcements that conveys information about the future path of the short-term interest rate above and beyond changes in the target federal funds rate itself.

[3] Further details about the distinction between "Odyssean" and "Delphic" forward guidance may be found in Campbell (2013).

[4] Former Federal Reserve Chair Janet Yellen, in her speech on March 3, 2017, noted that after the Federal Reserve had cut the federal funds rate to near zero in late 2008, they used new monetary tools to achieve additional accommodation, especially forward guidance and large-scale securities purchases that enabled the Federal Reserve to provide necessary additional support to the US economy by pushing down longer-term interest rates and easing financial conditions (see https://www.federalreserve.gov/newsevents/speech/yellen20170303a.htm).

The empirical literature on monetary policy has shown that FG is an effective monetary tool—on average, it affects the yield curve (e.g., GSS). However, this paper argues that it is important for policymakers to understand better the mechanism—particularly the effect of each specific FG shock—since different information is conveyed with each decision. The paper argues that GSS's standard method is unsuitable for this purpose since it imposes a restriction—that the relative effect of FG between different yields to maturity is constant across time. In particular, under the GSS structure, it is impossible that some FG shocks will affect the short part of the yield curve and others, the long part. I claim that this restriction can lead to an imprecise identification of the shock or the affected maturity. An example of why policymakers need to understand how different maturities are affected (shorter or longer maturities) can be seen from "Operation Twist", a monetary policy tool intended to cause a different effect on different maturities.[5] Furthermore, this paper argues that the standard method may not be suitable for an SOE in particular, as GSS's measure may partially capture the effect of global shocks.

This study compares FG shocks obtained from two non-structural methods.[6] The first are obtained by using the Gurkaynak *et al.* (2005) method in a similar way to that presented in Swanson (2017). This approach looks at the responses of asset prices at a high-frequency window around the CB monetary announcement and calculates the first two principal components. According to GSS and Swanson (2017), after an appropriate rotation of these factors, they could be interpreted as changes in the monetary rate and changes in FG. The GSS method is widely used, and since it was first published, numerous papers have repeated its methodology (e.g., Brand et *al.* (2010); Campbell et *al.* (2012)).

The GSS method assumes that FG is a "one-dimensional" policy tool—that various types of news shocks deriving from FGs all have the same effect on the yield curve. It assumes that each FG shock affects the yield curve on the same maturities, where the difference is only in the size or direction of the shock. As a result, the GSS method estimates the average effect on the yield curve. In case of a change in the monetary rate, it is reasonable to make this assumption. However, in the case of FG, each announcement is different from the others and,

[5] The "Operation Twist" program was first used in 1961 to decrease medium-to-long-term interest rates while maintaining or increasing shorter-term rates to stimulate the economy without worsening the balance of payments and preventing an increase in the outflow of gold, among other things. For additional details about the "Operation Twist" program, see Swanson (2011).

[6] The paper estimates FG using two non-structural methods, that are agnostic with respect to the economic model, and for several types of FG, including *Odyssean* and *Delphic FG.* This approach contrasts Ben Zeev *et al.* (2020), who identify only *Odyssean* FG shocks by applying additional structural assumptions. Specifically, they identify the shocks that maximally explain future variation in Taylor rule residuals. Campbell *et al.* (2012) use both approaches: a structural one and a high-frequency non-structural method. For further discussion on the interpretation of the monetary policy residuals as *Odyssean,* see Campbell et al. (2017).

therefore, presumably may affect the yield curve differently according to the information it contains.[7]

I use an alternative approach to examine whether different FGs have a differential effect on the yields. Similarly to GSS, it also relies on the responses of asset prices at a high-frequency window around the CB monetary announcement; however, the FG shocks are calculated separately for each monetary announcement and asset. Specifically, the change in the bond yield for each maturity is regressed on two explanatory variables— the unexpected change in the short-term monetary rate and the change in the corresponding US Treasury bond, which is an exogenous variable in SOEs.

I argue that the residuals from these regressions are suitable candidates for the FG effect estimates for different maturities. However, we must first be convinced that there was no other relevant economic news (foreign or domestic) during the event window to interpret these residuals as FG; second, that the effect cannot be attributed to another kind of monetary policy tool, and third, that the residual is not only noise.

The first could be achieved by using a narrow time window around the BOI announcement. Still, it must not be too narrow, or it would lead to an underestimation of the shock or even to an entirely incorrect estimation.[8] Furthermore, concerning the abovementioned issues, the paper uses Israel as a case study in light of several unique characteristics that make it easier to obtain more accurate estimates. First, I can use a relatively long window without concern that relevant information (domestic news shocks) was published during the event window since the Central Bureau of Statistics publishes all of its notices long after or before the interest rate decision. Second, as opposed to other CBs like the US Federal Reserve (FED), the Bank of England, and the European Central Bank (ECB), the Bank of Israel (BOI) has not had a large-scale asset purchasing program (LSAP) in the sample period. Therefore, it is easier to identify FG since there is no need to disentangle it from LSAP.[9]

In an SOE, the yields may be strongly affected by global shocks.[10] By using foreign yields as explanatory variables, I can control for those shocks. Furthermore, it is reasonable to assume that foreign yields are not affected by changes in the Israeli government yields. Hence, one can control for global shocks without being subject to endogeneity issues.

The main weakness of this alternative approach is that the estimates for the FG shocks will also include a stochastic error term that captures the effects of other factors. Therefore, I suggest that to validate the questioned assumption—whether FG has a differential effect on the yields, a residual will be identified as FG in a specific announcement only if it is statistically significant.

[7] For instance, some information may result in an update to only the short part of the yield curve, while other information may affect the long part of the curve.

[8] As in a case where the market has not yet fully comprehended the message.

[9] The BOI implemented asset purchasing programs for a short period between March 2009 and August 2009 and 2020–21, which are not included in the period investigated in this paper.

[10] For example, in case some important global publication was issued.

This alternative approach is similar to Kohn *et al.* (2003) in the sense that they both identify FG by looking at residuals. In Kohn et *al.* (2003), residuals are taken after controlling for short-term monetary surprises. However, they are calculated using daily, not intra-day, changes. Therefore, they needed to add to the regression proxies for unexpected macroeconomic developments.[11] They also didn't include any controls for global shocks.[12]

I find that on days that included a release of "new information" by the BOI, both GSS's and the alternative approach identify high and statistically significant measures for FG, which suggests that they are both informative measures. I also find that while the shock estimates from both approaches are highly correlated, around 0.9 for the medium and long maturities, in cases where the FG shocks mainly affected specific terms to maturity, according to my approach, the GSS method leads to an inaccurate understanding of the FG impact. For example, when the information embodied in the FG leads the market to reevaluate only the short-term interest rate path, using the GSS approach, these effects can mistakenly be perceived as monetary interest rate surprises. As a result, using these estimates might lead to the wrong conclusion when examining the effect of FG on other economic variables (e.g., estimating the effect of FG shocks on consumption, equities, or credit). Although necessary for evaluating the effectiveness of FG, the latter examination is beyond the scope of this article and is left for future work. I also find a statistically significant effect of US Treasury yields on the GSS measure for FG shocks. This result confirms the assessment that, at least in Israel, part of the GSS measure for FG captures global influences.

I conclude that the assumption that FG has a relative constant effect between maturities is not always valid. In some cases, policymakers may reach the wrong conclusions if it is assumed. According to the GSS method, two latent factors are enough to characterize the response of asset prices over a short window around the monetary announcement in Israel. Consequently, I infer that the GSS method estimates distinguish only a particular type of FG shock. Simply speaking, the GSS method decomposes the comovement of the yield curve for shocks that impact the short part of the yield and shocks that impact the medium-long part, rather than decomposing into conventional and FG shocks.

The remainder of the paper proceeds as follows. Section 2 lays out a general theoretical framework. Section 3 describes the data and the methodology used to estimate the effect of conventional and unconventional monetary policy. Section 4 discusses the empirical results for the FG shocks derived from the two methods. In Section 5, some robustness checks are examined, and the final section concludes.

[11] They use survey data conducted by Money Market Services to calculate the proxies for surprise macroeconomic news.

[12] It is possible that the effect of global shocks on the US yields is negligible, and therefore there is no need to control for them.

2. THEORETICAL FRAMEWORK

This section presents a general theoretical framework, similar to the one used by Kuttner (2001), to analyze the impact of conventional and unconventional monetary policies on the yield curve, with a few adjustments to the Israeli market. This framework is not limited to a specific monetary rule and does not require that the exact relationships between other economic variables (i.e., IS curve and Phillips curve) be defined. However, it does assume the expectation hypothesis.[13]

Denote R^d as the *d*—day rate. Assume a monetary rate announcement occurs on day *t*, and implementation of that rate occurs on day t + h.[14] Namely, the new monetary rate R^1_{new} is decided and announced on day t, but for the following *h* days, the actual monetary rate is still R^1_{old}. The new rate would last for *H* days (at least), so the subsequent monetary implementation is planned to be at day t + h + H.[15] According to the expectation hypothesis, and as described in Kuttner (2001), we can express R^d (d > h + H) as the average of the current monetary rate (R^1_{old}), the following new and known rate (R^1_{new}), and expected future overnight rates:

$$(1) \quad \mathrm{R}^{\mathrm{d}}_{t+} = \frac{1}{d} E_t \sum_{j=0}^{d} R^1_{t+j} = \frac{h}{d} \mathrm{R}^1_{old} + \frac{H}{d} \mathrm{R}^1_{new} + \frac{d-H-h}{d} E_t[R^{d-H-h}_{t+h+H}]$$

Where R^{d-H-h}_{t+H+h} is the forward rate from *day* $t + h + H$ for $d - H - h$ days. Therefore, the intra-day change on day *t* is:

$$(2) \quad \Delta R^d_t := R^d_{t^+} - R^d_{t^-} = \frac{H}{d}(R^1_{new} - E_t[R^1_{new}]) + \frac{d-H-h}{d}\left(E_{t^+}\left[R^{d-H-h}_{t+h+h}\right] - E_{t^-}\left[R^{d-H-h}_{t+H+h}\right]\right)$$

As Equation 2 shows, the direct effect of a change in the monetary rate comes from its unexpectedness —$R^1_{new} - E_t\ [R^1_{new}]$, which is proportional to H and therefore diminishes in d. However, the effect of a monetary interest rate surprise also comes from reevaluating the forward rate *(*$\left[R^{d-H-h}_{t+H+h}\right]$*).* Since *H* is relatively small in proportion to d, the effect on the forward rate is more significant. From this, we can conclude why the impact of FG could also be significantly large, as it can cause a reevaluation of that forward rate.

In this context, it is important to note that beyond the effect on the expected path of the monetary rate, FG can also affect the risk premium. The yields on financial assets include a risk premium that compensates for uncertainty about the future interest rate. When the CB

[13] The expectation hypothesis is assumed mainly for methodological reasons to understand the channels of influence of conventional and unconventional monetary policy.

[14] A new monetary rate implementation happens in Israel a few days after the CB announcement.

[15] Under this assumption, there is zero probability of an unplanned monetary rate decision.

takes measures that increase certainty in this area, it reduces the risk premium and thus lowers interest rates. In other words, FG affects long-term interest rates by influencing the expected risk-free interest rates and lowering risk premiums.

3. EMPIRICAL FRAMEWORK

3.1 Data

To assess the effectiveness of conventional and unconventional monetary policy in Israel, I consider dates and times of monetary policy announcements from February 2010 to December 2016. During that period, monetary rate announcements were made 12 times a year, close to the end of each month. The estimation period included 83 Bank of Israel (BOI) monetary rate meetings, 82 of which were planned, while the additional meeting was unscheduled.[16] Of the 83 monetary announcements, 75 were included in the short window regressions (further details in Section 3.2.2), and five observations were omitted because there was no trading on the Tel Aviv Stock Exchange (TASE).[17] The remaining three observations were omitted since there was no trading in the Tel Aviv Inter-Bank Offered Rate (TELBOR) market, so the monetary interest rate surprise could not be calculated.[18] Two other observations were omitted in the long window regression since there was no trading on the TASE on the day following the announcement.[19] The data set includes yields on government bonds for maturities of 1, 2, 3, 5, 7, and 10 years.[20] The data set also includes the

[16] In February 2013, the BOI Monetary Committee canceled two monetary rate meetings around major holidays, the meetings scheduled for the end of April and the end of September. As planned, the end-of-April meeting did not take place. However, on May 13, 2013, a decision was made outside the regular schedule. In August of that year, the committee resolved to return to a format of interest rate decisions 12 times per year. Accordingly, there was a meeting at the end of September.

[17] The event windows for the following monetary announcements included holidays or non-business days in Israel, and therefore there was no trade in the TASE: March 28, 2010, April 24, 2011, September 24, 2012, March 25, 2013, and May 13, 2013. As explained in the text in Section 3.2.2, before June 2014, the calculation of the 30-minute and 1-hour event windows included using bond prices of the day following the monetary announcement.

[18] For the following announcements, the monetary surprise could not be calculated since there was no trading in the TELBOR market: May 27, 2013, April 21, 2016, and December 26, 2016. Further details on how the monetary surprise is calculated are in Appendix C.

[19] The following days were holidays or non-business days in Israel; therefore, there was no trading on the stock exchange: September 24, 2015, and October 27, 2016.

[20] The data set includes government bond quotes at a one-minute frequency using the BOI stock exchange database. In the few cases where data was missing, the transactions database was used instead of the quotes database. The yield from the note or bond, which has the closest time to maturity, is used for each term to maturity. I also use end-of-day yield data for the Dynamic analysis in Section 4.6.

daily overnight interest swap (OIS) quotes from the official TELBOR interest rates, which are published every business day by Reuters.[21]

3.2 Conventional Monetary Policy

3.2.1 *Methodology*

For comparative purposes, the analysis begins with measuring the effects of conventional monetary policy in Israel and then compares it to the estimated effect of FG. The market is forward-looking and hence tends to incorporate any information about anticipated policy actions. Therefore, to study the impact of monetary policy on yields, unexpected policy changes must be isolated. For this purpose, the following regression, which has been frequently estimated in the literature, is used:

$$(3) \quad \Delta y_t = \alpha + \beta_1 surprise1_t + \varepsilon_t$$

Where Δy_t denotes the change in the government yield over an interval that includes the monetary policy announcement, $surprise1_t$ denotes the unexpected change in the monetary rate (surprise component), and ε_t is the stochastic error term that captures the effect of all other factors that influence the yield rate, including FG. Estimating Equation 3 using weekly, monthly, or quarterly data is problematic due to omitted variable bias and simultaneity. For example, the monetary policy change could respond to a macroeconomic development affecting the yields. To avoid these issues when estimating Equation 3, it is common in the literature to use a short window around the CB announcement to deduce the yield change: a one- or two-day change (as in Kuttner (2001)) or even intra-day changes (as in Bernanke and Kuttner (2005), Gurkaynak *et al.* (2005)). This paper uses both intra-day and daily windows.

To the best of my knowledge, the effect of conventional monetary policy using market-based indicators like futures contracts (such as federal funds futures contracts) has not yet been examined in Israel. The literature usually estimates the monetary interest rate surprise using futures contracts, which are not traded in Israel. As such, this paper uses the official daily TELBOR rates, which represent the quotes on the OIS contracts to deduce the monetary interest rate surprise. These rates also embody market expectations about the interest rate path but represent the prices of contracts that are traded over the counter (OTC).[22]

OIS contracts are very similar to interest rate futures contracts because both are instruments that hedge against, or speculate on, changes in short-term interest rates. Like a

[21] The official TELBOR interest rates are also published on the BOI website, www.boi.org.il/en/Markets/TelborMarket/Pages/telbor.aspx.

[22] Alternative methods for estimating monetary surprises include the use of professional forecasters' expectations for the expected monetary change (as in Hussain (2011)), deducing the expected change from short forward rates, and inferring it using a model (such as VAR or DSGE). There are several disadvantages to these methods, as detailed in Appendix A.

futures contract, an OIS uses an overnight rate index, such as the overnight federal funds rate, as the underlying rate for its floating leg that is being exchanged for a fixed interest rate. However, there are some fundamental differences between the two. First, futures contracts are traded over stock exchanges, and changes in expectations can therefore be followed by observing the same contract at different times.

In contrast, OIS contracts are traded over the counter, so their value at the time they are issued can be observed, but their reevaluation after a monetary announcement is not observable. Therefore, to follow changes in monetary rate expectations, it is necessary to compare two contracts, one issued before the announcement and one after it. Second, while the settlement price of federal funds futures contracts is based on the average of the relevant month's effective overnight federal funds rate, the settlement price of the OIS contract is determined by either compounding the overnight rate or by taking a geometric mean over a given period. Hence, deducing the surprise component calculation is more complex using OIC contracts.

The Israeli swap market has two unique features that are appealing in trying to deduce market expectations for the interest rate path. First, compared to other benchmark interest rate markets such as LIBOR, the TELBOR market includes commitment mechanisms to carry out transactions. Therefore, the TELBOR quote faithfully represents the market value for the swap contract. Second, the TELBOR interest rate includes a relatively low risk and liquidity premium. Appendix B elaborates on the properties of the Israeli interest rate swap market, and Appendix C shows how to extract the surprise component, which is calculated similarly to how it is done with futures contracts. The necessary assumptions and approximations used are presented, and the measure of the monetary policy surprise for the current rate, the actual change, and the expected change are reported for each monetary policy announcement, as well as the surprise component in the interest rate path for the next three months.

3.2.2 *The Effect of Conventional Monetary Policy on the Yields*

Table 1 presents the results for estimating Equation 3. The dependent variable is the difference in government bonds for different maturities—1, 2, 3, 5, 7, and 10 years—and the explanatory variable is the monetary interest rate surprise for the current monetary rate. As in GSS, this paper presents results for various sizes of windows around the monetary announcement.[23] The 30-minute window is the difference in the yield after 30 minutes of

[23] At the end of my sample, the BOI announces its monetary rate decisions at 16:00, during trading hours. However, until April 2014, the announcement was at 17:30 when trading on the TASE was already closed. Until June 2013, trading on the TASE ended at 16:24-16:25 (Sunday-Thursday). Since then, trade has ended at 17:24-17:25 Monday-Thursday and at 16:24-16:25 on Sunday. As a result, until April 2014, the impact of the monetary announcement was reflected in the markets only on the day following the announcement.

trade.[24] Table 1 includes three more windows: a 1-hour trade window, a mid-day window that ends at 12:45 on the day following the announcement, and a daily window that ends at the end of the next day.[25]

As Table 1 shows, the estimated effect of conventional monetary policy is highly significant and does not differ much across the different windows. The response of the 2-year yield to a 1-percent rise in the CB monetary rate is about 30 basis points, compared with 45 basis points in GSS. The estimated effect for the long maturity (10 years) is about 15 basis points, similar to the results in GSS. As the literature already points out, I also find that the coefficients and R^2 decline with the term to maturity. GSS also reported that the R^2 declines when the window size is increased. In Israel, at the short part of the curve (1- and 2-year), the R^2 does not change significantly (around 0.5) when increasing the window's size. However, the R^2 declines for yields with longer maturities, as in GSS. Most of the decline seems to occur when the window size is increased from a half-hour to an hour.

3.3 Identifying Forward Guidance in Israel

3.3.1 *A New Approach to Deriving Forward Guidance*

In this paper, two different approaches are used to identify the effects of FG in Israel: The standard approach of GSS, in a similar way to the one presented in Swanson (2017), is explained in Section 3.3.2. The second, new approach is explained in this section.

As in the GSS method, the new approach to deriving FG shocks infers them from the responses of asset prices at a high-frequency window around the BOI monetary announcement. However, under this approach (henceforth, the residuals method), the FG shock is calculated separately for each announcement and time to maturity, which is more intuitive in the way we think about information—as "multi-dimensional" rather than "one-dimensional". For each announcement, I calculate the change in yield that is not driven by the unexpected change in the monetary rate or other known factors. To interpret the remaining change as a FG shock, we need to be sure that no other significant economic news was released during the event window. To achieve that, I use a narrow time window around the announcement, but not too narrow that it would lead to an underestimating.

[24] More precisely, 30 minutes of trading in a continuous trading phase. Until April 2014, it is calculated as the difference between the yield at the end of the continuous trading phase on the announcement day (17:13 and 16:13 on Sundays and before June 2013) and the yield at 10:00 the next day. After April 2014, it is calculated as the difference between the yield 15 minutes before and 30 minutes after the announcement, namely between 15:45 and 16:30. The pre-opening phase starts each day at 09:00. The continuous trading phase starts at 09:30.

[25] Similarly, the 1-hour window is calculated between the end of the continuous trading phase yield and 10:30 before April 2014 and 15:45 to 17:00 after that. The mid-day and daily windows are calculated similarly.

Table 1
The Response of Government Bond Yields to Changes in the BOI Rate

30-minute window						
	(1) 1 year	(2) 2 year	(3) 3 year	(4) 5 year	(5) 7 year	(6) 10 year
Surprisel	0.376*** (0.082)	0.292*** (0.061)	0.232*** (0.043)	0.228*** (0.038)	0.180*** (0.033)	0.145*** (0.026)
Constant	-0.001 (0.004)	-0.002 (0.003)	-0.005 (0.003)	-0.004* (0.002)	-0.005** (0.002)	-0.006*** (0.002)
Observations	75	75	75	75	75	75
R-squared	0.509	0.558	0.439	0.558	0.455	0.393
1-hour window						
	1 year	2 year	3 year	5 year	7 year	10 year
Surprisel	0.386*** (0.084)	0.278*** (0.058)	0.222*** (0.046)	0.197*** (0.043)	0.153*** (0.036)	0.123*** (0.030)
Constant	0.000 (0.005)	-0.002 (0.003)	-0.003 (0.003)	-0.005 (0.003)	-0.006* (0.003)	-0.007** (0.003)
Observations	75	75	75	75	75	75
R-squared	0.497	0.497	0.378	0.350	0.256	0.219
Mid-day window						
	1 year	2 year	3 year	5 year	7 year	10 year
Surprisel	0.397*** (0.097)	0.272*** (0.069)	0.218*** (0.055)	0.195*** (0.056)	0.142*** (0.049)	0.113** (0.047)
Constant	0.004 (0.005)	0.001 (0.004)	-0.001 (0.004)	-0.003 (0.005)	-0.007 (0.005)	-0.008* (0.005)
Observations	73	73	73	73	73	73
R-squared	0.497	0.421	0.290	0.191	0.113	0.090
Daily window						
	1 year	2 year	3 year	5 year	7 year	10 year
Surprisel	0.399*** (0.108)	0.290*** (0.072)	0.220*** (0.047)	0.227*** (0.053)	0.184*** (0.049)	0.156*** (0.042)
Constant	0.002 (0.004)	0.004 (0.004)	0.001 (0.004)	-0.002 (0.005)	-0.004 (0.006)	-0.005 (0.006)
Observations	73	73	73	73	73	73
R-squared	0.554	0.404	0.329	0.213	0.131	0.102

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0

Note: The table provides results for estimation of the following equation: $\Delta y_t^m = \alpha + \beta_1$ $surprise1_t + \varepsilon_t$. where: Δy_t^m is the change in the government bond yield with maturity closest to m around the monetary announcement on day t. $surprise1_t$ measures the interest rate surprises, as explained in the text.

Specifically, under this approach, I estimate Equation 4, where the dependent variables are the difference in bond yields for different maturities. The explanatory variables are surprise1 and the corresponding US Treasury bond change. The residuals resolving from these regressions, ε_t, are candidates for FG shocks.

$$(4) \quad \Delta y_t^m = \alpha + \beta_1 surprise1_t + \beta_2 \Delta r_{m,t}^{US} + \varepsilon_t$$

The first explanatory variable controls for an unexpected change in the monetary rate. The remaining change in yield (if we only controlled for that variable) could be attributed to FG or one of the following: another kind of monetary policy tool (i.e., LSAP), a domestic news shock, global shocks, or a stochastic error term. As opposed to other CBs (such as the US Federal Reserve, the Bank of England, or the ECB), the BOI has not used an asset purchasing program during the sample period. Therefore, it is easier to identify FG since there is no need to disentangle it from LSAP (for example, as in Swanson, 2017).[26] Using a narrow time window around the monetary announcement helps deal with the second and third points noted above. However, this solution is imperfect, especially when using a slightly larger window (such as to avoid an underestimation of FG shocks). In addition, the assumption that global shocks are negligible in an SOE seems unlikely. Therefore, I also control the change in the US Treasury bonds with the corresponding maturity. This solution is usually not applicable because this kind of estimation is subjected to simultaneous and endogenous issues. But since Israel is an SOE, it is reasonable to assume that foreign yields are not affected by the changes in Israeli government bond yields.

Some of the change may arise from domestic news shocks. Fortunately, in Israel, the Central Bureau of Statistics publishes all of its announcements at 1 pm.[27] So, as long as the estimating window ends before 1 pm, it is likely that no relevant information has been published. Similar to the GSS method, the FG shocks deduced from this method are orthogonal to the unexpected change in the interest rate.

The main weakness of this alternative method is that the estimates for the FG shocks may also include a stochastic error term that captures the effects of other factors. Therefore, to validate the questioned assumption, a residual should be identified as FG in a specific announcement only if it is statistically significant. I address this using two different approaches. First, in light of the view that the market is more volatile around the CB monetary announcement, I chose for reasons of conservatism to compare the residual to the sample standard error using a t-test. Second, under the assessment that this threshold level is too high (as it embodies information and not just noise), I also compare it to the noise distribution on days without interest rate decisions (further details in Section 4.2).

[26] The BOI implemented asset purchasing programs for a short period between March and August 2009 and 2020–21, which is not included in the period investigated in this paper.

[27] One exception is the publication of the Consumer Price Index, which is published later in the day. However, the BOI announcements in our sample were published at the end of each month, while the CPI is published on the 15th of every month.

This new approach is similar to the one presented in Kohn *et al.* (2003) in the sense that both try to identify FG by looking at residuals. Both methods deduce the residuals after controlling for the short-term monetary surprise. However, Kohn et *al.* (2003) calculate the residual using daily, rather than intraday, changes. As such, they use survey information to control for unexpected macroeconomic news, but they do not control for global shocks.[28,29]

US Treasury securities are traded OTC. Therefore, in principle, they are traded all day. In this paper, I use opening and end-of-day yields taken from Bloomberg.[30] For the benchmark estimation (1-hour window), I use the change between the opening and end-of-day yields for corresponding US Treasury bonds. Since the changes in the corresponding US yields do not match our 1-hour window, part of these changes should not explain the change in yield in Israel, and we suffer to some extent from measurement error. As part of the sensitivity tests, I examine whether the results are robust to different windows for the US yield using data from other sources.

Table 2 presents results for estimating Equation 4 for the 1-hour benchmark window. The response of the 3-year yield to a one percentage point increase in the corresponding US Treasury yield is 38 basis points and statistically significant. The coefficients for corresponding US Treasury yields at longer maturities are also statistically significant, with an estimated effect of 28 basis points and 24 basis points for 5-year and 10-year yields, respectively. The response of the 2-year yield to the corresponding US Treasury yield is 32 basis points, but the statistical significance is at only a 10 percent level. Also, the US 1-year coefficient is not statistically significant.

Compared to the results reported in Table 1, the R^2 in the 1-year regression does not increase after adding US yields to the estimation. However, it does increase by 2, 5, 8, 11, and 11 percentage points for 2, 3, 5, 7, and 10-year yield regressions, respectively.[31] In conclusion, these results support adding US yields as explanatory variables to the regressions, at least for the yields with maturities longer than two years. In contrast, it is unclear if adding the US yield as a control variable to the short-term regressions is worthwhile.

[28] They use survey data conducted by Money Market Services.

[29] It is possible that the effect of global shocks on the US yields is negligible, and therefore there is no need to control for these shocks.

[30] US data are the on-the-run Treasuries obtained from Bloomberg (mid-price). Bloomberg opening and end-of-day yields are defined as the yield at 20:00 (NY time) of the previous day and the yield at 17:00, respectively. In the sample, on the days when there was no trading in the US Treasury bond market (e.g., if the announcement was on a Sunday), the variable received zero value.

[31] Compared to the results reported in Table 1, the adjusted R^2 decreased by one percentage point in the 1-year regression. Also, the adjusted R^2 increases by 1, 4, 7, 10 and 11 percentage points for the 2, 3, 5, 7 and 10-year yield regressions, respectively.

Table 2
The Response of Government Bond Yields to the Changes in the BOI Rate and the Corresponding US Treasury Yields

VARIABLES	1 year	2 year	3 year	5 year	7 year	10 year
Surprisel	0.383*** (0.084)	0.276*** (0.057)	0.224*** (0.045)	0.201*** (0.042)	0.157*** (0.036)	0.123*** (0.030)
US 1 year	0.196 (0.187)					
US 2 year		0.319* (0.191)				
US 3 year			0.376** (0.168)			
US 5 year				0.278** (0.116)		
US 7 year					0.278** (0.114)	
US 10 year						0.241*** (0.088)
Constant	0.001 (0.005)	-0.001 (0.003)	-0.001 (0.003)	-0.003 (0.003)	-0.003 (0.004)	-0.004 (0.003)
Observations	75	75	75	75	75	75
R-squared	0.498	0.515	0.425	0.427	0.365	0.331

Robust standard errors in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

At this stage, the regression residuals are only suitable candidates for FG shocks.[32] To test this, I run a regression where the dependent variables are absolute values of the candidates for FG shocks on a dummy variable *(D_New_Info)* equal to one when the interest rate press release includes "new information".[33] In short, the rule classifies an interest rate decision as one that includes "new information" if there was a change in the text of the press release in one of the two relevant parts or if the interest rate decision was accompanied by a press conference regarding the monetary policy. For more details on the classification rule, see Appendix D. Of the 83 monetary rate meetings during the estimation period, 45 are identified as including "new information" according to the classification rule.[34]

[32] In light of the results in Table 2, the estimation was performed without a constant.
[33] A similar test is done in GSS where the dummy variable takes on the value one for dates on which there was an FOMC statement.
[34] Of those 45 announcements, 43 were identified because of the paragraph-based identification.

Panel A of Table 3 presents the results for the whole sample. The results verify our hypothesis about the structural interpretation of the residuals. The dummy variable is positive and statistically significant at the 5 percent level when regressed against 2-year maturity residuals. The statistical significance is even higher, 1 percent, for the 3-, 5-, 7- and 10-year regression, but is not statistically significant for the 1-year candidate.

Table 3
Estimated Effects of "New Information" Announcements on the Size of the FG Shocks Deduced Through the Residual Method

Panel A: Full sample - "New information" announcements						
VARIABLES	**Resid 1 year**	**Resid 2 year**	**Resid 3 year**	**Resid 5 year**	**Resid 7 year**	**Resid 10 year**
D_New Info	-0.001 (0.008)	0.009^{**} (0.004)	0.013^{***} (0.004)	0.013^{***} (0.004)	0.011^{***} (0.004)	0.013^{***} (0.003)
Constant	0.024^{***} (0.006)	0.015^{***} (0.002)	0.012^{***} (0.002)	0.011^{***} (0.002)	0.011^{***} (0.002)	0.010^{***} (0.001)
Observations	75	75	75	75	75	75
R-squared	0.000	0.050	0.098	0.123	0.091	0.159
Panel B: "New information" excluding the press conference held in June 2015						
VARIABLES	**Resid 1 year**	**Resid 2 year**	**Resid 3 year**	**Resid 5 year**	**Resid 7 year**	Resid 10 year
D New Info	-0.001 (0.008)	0.009^{**} (0.004)	0.012^{***} (0.004)	0.012^{***} (0.004)	0.009^{***} (0.003)	0.012^{***} (0.003)
Constant	0.024^{***} (0.006)	0.015^{***} (0.002)	0.012^{***} (0.002)	0.011^{***} (0.002)	0.011^{***} (0.002)	0.010^{***} (0.001)
Observations R-squared	74 0.000	74 0.048	74 0.089	74 0.118	74 0.086	74 0.151

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

3.3.2 *GSS Standard Approach*

According to the GSS method, asset prices are collected into a $T\ X\ n$ matrix X, with rows corresponding to monetary announcements and columns corresponding to the n different assets. Each element in X, $X_{i,j}$ reports the response of the jth asset around the ith announcement. X could be written as:

$$(5) \qquad \mathrm{X} = F\Lambda + \varepsilon$$

Where F is a $T\ X\ k$ matrix containing $k\ <\ n$ unobserved factors, Λ is a $k\ X\ n$ matrix of factor loadings, and ″ is a $T\ X\ n$ matrix of white noise residuals.

In the case that $k = 0$ means that the data is well described by white noise; in the case of $k = 1$, a single factor well describes the data (e.g., the change in monetary rate), and in the case of $k = 2$, two factors well describe the data. Similarly to Swanson (2017), the following asset responses are used to construct matrix X: the interest rate surprise, a 3-month surprise, and the 1-, 2- ,3-, 5-, 7- and 10-year government bond yields.[35, 36] In appendix E, I investigate how many latent factors are required in Israel to characterize the response of asset prices over a window around the monetary announcement. I find that when using a 1-hour trading window, two factors are required.

The principal component method makes it possible to decompose the data into a set of orthogonal factors. Based on the tests in Appendix E, the first two factors are used. Although these factors explain a maximal fraction of variation, they do not have a structural interpretation (like FG or a change in the monetary rate). If F and Λ characterize the matrix X as in Equation 5 and U is an orthogonal matrix, then factors $\tilde{F} \equiv FU$ and loading $\widetilde{\Lambda} = U`\Lambda$ represent an alternative factor model with the same explanatory power as F.

Following GSS and Swanson (2017), F_1 and F_2 are rotated to yield two new factors, Z_1 and Z_2, which are still orthogonal but now have a structural interpretation. The rotation is determined such that the second factor does not affect the current monetary surprise (*surprise* 1).[37] Afterwards, Z_1 and Z_2 are rescaled so that Z_1 moves the current monetary surprise *(surprise1)* one by one, and Z_2 has the same magnitude effect as Z_1 on the 2-year bond yield.

After the transformation described above, the unexpected monetary rate change is exclusively driven by Z_1; therefore, we can regard Z_1 as the unexpected change in the monetary rate. Not surprisingly, Z_1 is highly correlated with our measure for current monetary surprise *(surprise1)*, 93 percent. However, it seems that Z_1 is even more correlated (97 percent) to our measure for the 3-month monetary surprise (m_3*_surprise)*, the change in the interest rate path expectations for the next three months.[38] One reason that Z_1 is more like *m_3_surprise* than *surprise1* is that part of the surprise component in *surprise1* is only a "timing" component,

[35] Appendix C shows how to extract the surprise components of the monetary rate and presents the necessary assumption and approximations I use.

[36] Swanson (2017) collected similar asset prices to construct matrix X. However, this paper increases the number of assets with medium-term maturities at the expense of assets with shorter maturities, under the assessment that FG might have led to a re-evaluation of market expectations of the longer-term interest rate path (longer than one year).

[37] Namely, I define $2x2$ matrix U, so the columns are normalized to have unit length and, therefore, Z_1 and Z_2 also have unit variance as F_1 and F_2. Second, I restrict Z_1 and Z_2 to remain orthogonal. Third, I restrict the element in the second row of the first column of the matrix $\widetilde{\Lambda}$, $\lambda_{2,1} = 0$ (i.e., Z_2 does not influence *surprise1).* For further details, see Gurkaynak *et al.* (2005).

[38] The correlations with *surprise1* when using the 30-minute window, the window that ends at 10:30 AM, the mid-day window, and the end-of-day window with *surprise1* are very similar: 94, 93, 92, and 91 percent, respectively. The correlations with the variable *m3_surprise* are 98, 97, 97, and 97 percent, respectively.

as suggested in Gurkaynak *et al.* (2012). Namely, some of the monetary interest rate surprises were only a surprise to the extent of the timing with which the change in monetary rate would occur (i.e., the current or next meeting).

After the transformation, the second factor represents all the other aspects that co-move the bond yields without moving the current monetary rate. This factor should represent FG, but as before, it is only a suitable candidate at this stage. Therefore, the earlier test is repeated, and I run a regression with an absolute value of Z_2 as the dependent variable on the dummy variable *D_New_Info,* defined in Section 3.3.

Table 4 presents the results for the whole sample. Results are shown for the benchmark model of the 1-hour window and other alternative windows. The results verify our hypothesis about the structural interpretation of the two factors. As expected, the dummy variable is not statistically significant for the change in the monetary rate factor (Z_1) for all window sizes. On the other hand, the dummy variable is positive and statistically significant at a 5 percent level for the FG factor (Z_2) when using the mid-day window. The statistical significance is even higher, at a 1 percent level, for the half-hour window, 1-hour window, and the window that ends at 10:30 am. However, when using the end-of-day window, the dummy variable is only statistically significant at the 10 percent level. The results strengthen the assessment regarding the structural interpretation of the two factors. Appendix *H* presents the results for the same test where the outlier observation from June 2015 is omitted. The results remain similar.

Table 4
Estimated Effects of "New Information" Announcements on the Size of the FG Factors (GSS Method)

	Absolute Value Z_1					**Absolute Value Z_2**				
VARIABLES	**30 min**	**1 hour**	**10:30**	**12:45**	**End of day**	**30 min**	**1 hour**	**10:30**	**12:45**	**End of day**
D New Info	-0.012	-0.009	-0.009	-0.011	-0.009	0.019^{***}	0.021^{***}	0.022^{***}	0.019^{**}	0.013^{*}
	(0.020)	(0.019)	(0.019)	(0.020)	(0.020)	(0.007)	(0.007)	(0.007)	(0.008)	(0.007)
Constant	0.062^{***}	0.062^{***}	0.064^{***}	0.062^{***}	0.061^{***}	0.021^{***}	0.020^{***}	0.015^{***}	0.021^{***}	0.021^{***}
	(0.017)	(0.016)	(0.016)	(0.017)	(0.017)	(0.004)	(0.003)	(0.003)	(0.004)	(0.003)
Obs.	75	75	73	73	73	75	75	73	73	73
R-squared	0.005	0.004	0.003	0.005	0.003	0.098	0.100	0.102	0.058	0.040

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

4. RESULTS

4.1 Forward Guidance Estimates Using the GSS Method

Table 5 reports the effects of the two monetary factors, Z_1 and Z_2, on government bonds for different maturities—1, 2, 3, 5, 7, and 10 years.[39] An increase in Z_1 causes an effect similar to that of *surprise1* reported in Table 1, specifically in that it diminishes at longer maturities. As opposed to the monetary rate factor *(Z_1)*, the main effect of the FG factor is on the longer yields, and the effect increases with term to maturity and until it reaches a peak at seven years.

Table 5
The Response of Government Bond Yields to the Monetary Factors Z_1 and Z_2

Variables	(1) **Surprise 1**	(2) **m3_surprise**	(3) **bond 1y**	(4) **bond 2y**	(5) **bond 3y**	(6) **bond 5y**	(7) **bond 7y**	(8) **bond 10y**
Z_1	1.000	0.73	0.52	0.35	0.27	0.22	0.16	0.13
Z_2	0.000	0.09	0.24	0.35	0.52	0.58	0.58	0.51

Figure 9 in Appendix F plots a time series of the two monetary factors. It reports the ten largest observations of the FG factor, including the change in monetary rate factor, the actual change in monetary rate, the change in the relevant paragraphs, and a specification of whether it included a press conference or a quarterly macroeconomic forecast.

At this point, it should be noted that the GSS standard method includes the implicit assumption of a constant structure across time, regardless of the information contained in each FG statement. In a sense, the GSS method assumes that FG is a "one-dimensional" policy tool and that the publication of various news has the same effect on the yield curve. In the case of an FG shock without an unexpected change in the monetary rate, it would have a broad effect on the entire yield curve in accordance with the coefficient detailed in Table 5. Precisely, in the GSS method, the factor loadings measure the average effect on each maturity, and hence, it is not possible that some news will affect only the medium-short part of the yield curve. As a result, this might lead to an imprecise identification, as the impact of bonds that were affected and ones that were not are averaged during the estimation process.

The next section presents evidence that suggests this assumption might be invalid and that each press release published by the CB affects different maturity ranges. As opposed to a change in the monetary rate, where it is reasonable to assume that the same action is repeated each time, in the case of FG, each announcement is different and, therefore, should presumably affect the yield term differently, in accordance with the information it contains.

[39] As mentioned in the text, the factor Z_1 is scaled to move the current monetary surprise one to one, and Z_2 is scaled such that it has the same magnitude effect as Z_1 on the 2-year bond yield.

4.2 Forward Guidance Estimates Using the Residual Method

As noted earlier, a residual is identified as a FG shock (in a specific announcement) if it is statistically significant. I address this using two different approaches: in the first approach, I use a t-test, and each residual is compared to the sample standard error, excluding the outlier observation on June 2015.[40] Table 6 shows the announcement days on which the FG shock on at least one maturity term is statistically significant at the 5 percent level.

The results in Table 6 strengthen the assessment that the regression residuals should be interpreted as FG shocks, as most dates that were found statistically significant included a release of new and meaningful information. In some cases, the information was embodied in the press release; in others, it came via the BOI Research Department's forecast or the press conference. However, in one statistically significant case, in March 2011, there appeared to be no release of new information. It seems more plausible that the large FG shock obtained on that date results from a large change in the interest rate and a non-linear effect that may exist.

I also use an additional approach to calculate the confidence intervals under the assessment that the previous ones, derived from days of interest rate decisions, might be too wide, as these days usually contain information. In this approach, I compare the residuals to the noise distribution on days without publications of important information. Specifically, the distribution of the difference in bond yields at the same time of the day (event window) as previously used.[41] I calculate confidence intervals for each day using percentiles derived from a sample window of 201 observations (for further details, see Appendix *G).* This approach also allows one to relax the assumption that the noise distribution is constant over time.

The results using the second approach are shown in Figure 1. Compared to the previous approach, more dates are found to be statistically significant. These results support the hypothesis that the previous confidence intervals are too conservative, at least for maturities longer than two years: 11, 6, 5, and 4 additional dates are found statistically significant for maturities 3, 5, 7, and 10 years respectively. In almost all the above occasions, "new information" was released.[42] However, on only about half of the additional occasions for the 1- and 2-year maturities (17 and 9, respectively), "new information" was released.[43]

[40] Each residual is compared to its standard deviation according to its term to maturity.

[41] For reasons of simplicity and since there is uncertainty over the coefficients' actual values, I use the difference in bond yields instead of the residuals. Furthermore, under the standard assumption that the error term is normally distributed, we obtain more conservative threshold levels.

[42] Statistically significant at a 5 percent level. "New information" according to the classification rule described in Section 3.3. While on one occasion, for the 5-year maturity, there was a publication of the Research Department's forecast, in a few, there is no evidence that new information was released: one for each of the 3- and 5-year maturities and two for the 7-year maturity.

[43] Except for one occasion, for the 1-year maturity, on which a Research Department's forecast was published, in the rest, there is no evidence of new information (8 and 4 for 1- and 2-year maturities, respectively).

Table 6
Forward Guidance Shocks Deduced from the Residuals Method

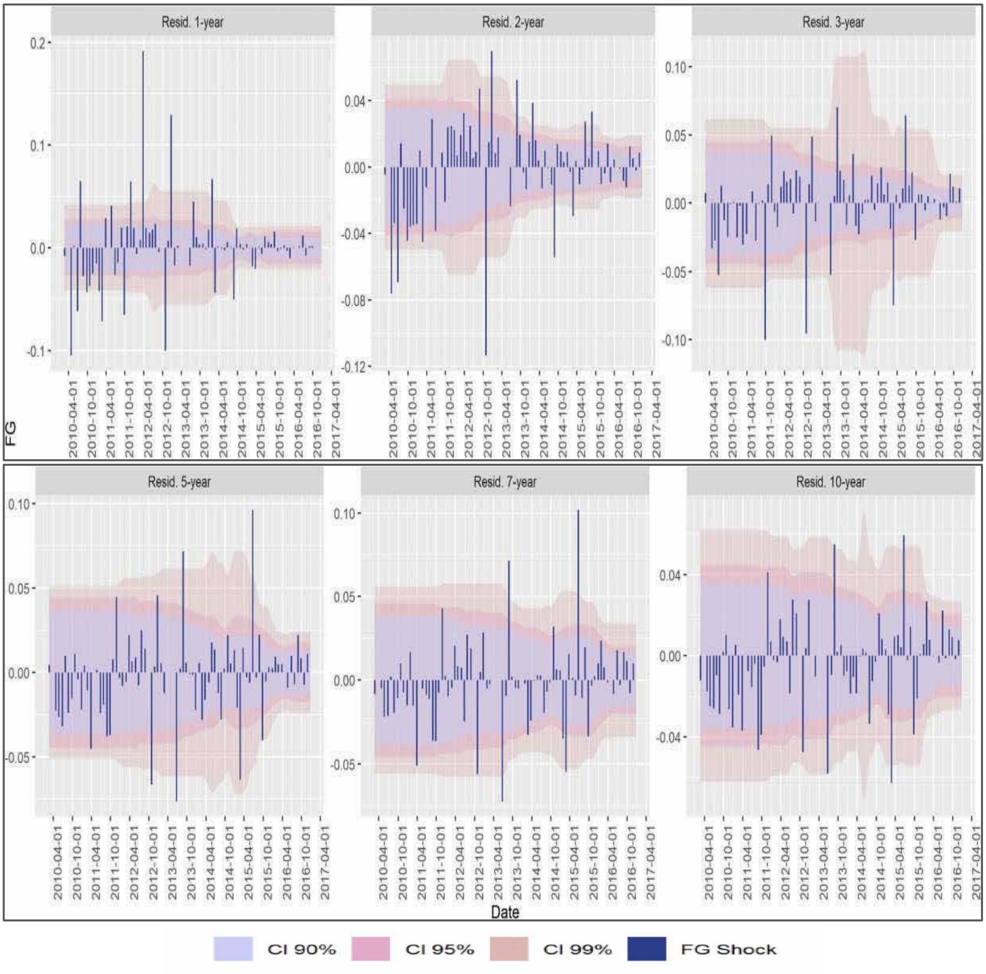
					FG shocks (Residuals)					
Date	**A description of the main "new information"**	**Staff forecast**	**Press conference**	**Monetary rate**	**1-year**	**2-year**	**3-year**	**5-year**	**7-year**	**10-year**
26-Apr-10	A statement indicated that additional factors supported an increase in the interest rate, but since the rate was increased last month, the Governor decided to leave it unchanged.				**-0.105****	**-0.076****	-0.033	-0.023	-0.005	-0.018
28-Jun-10	Statement emphasizing that the Governor has decided to leave the interest rate unchanged after considering the increased uncertainties in the global economy.				-0.062	**-0.069****	**-0.052***	-0.032	-0.021	-0.026
28-Mar-11	The monetary rate was increased by 0.5 percentage points instead of the usual 0.25 percentage points change.			+0.5	0.029	-0.012	-0.023	**-0.045***	**0.051****	**-0.037***
29-Aug-ll	After a process of gradual increases in the monetary rate, this announcement includes a statement that suggests that the future **direction** of monetary rate changes is unclear.				0.019	0.009	0.002	-0.038	-0.036	**-0.046****

					FG shocks (Residuals)					
Date	**A description of the main " new information"**	**Staff forecast**	**Press conference**	**Monetary rate**	**1-year**	**2-year**	**3-year**	**5-year**	**7-year**	**10-year**
26-Sep-11	It was the first monetary easing after a yearlong series of monetary tightening. The statement indicates that the cut is intended to minimize the negative effect on Israel's economy of the slowdown in activity and the increased level of uncertainty in the global economy.			-0.25	-0.065	-0.021	**-0.1*** **	-0.037	-0.036	**-0.039***
26 Mar-12	-	+			**0.191*** **	0.032	0.023	0.022	0.021	0.018
29-0ct-12	The Supervisor of Banks issued a directive limiting the LTV because of the increases in home prices and credit against the background of low-interest rates in the mortgage market. The announcement occurred **at the same time as the interest rate announcement.** The Monetary Committee stated that they reduced the interest rate to support economic activity, and because of the absence of inflationary pressures.			**-0.25**	**-0.1** **	**-0.113*** **	**-0.095*** **	**-0.066*** **	**-0.056** **	**-0.048** **

					FG shocks (Residuals)					
Date	**A description of the main "new information"**	**Staff forecast**	**Press conference**	**Monetary rate**	**1-year**	**2-year**	**3-year**	**5-year**	**7-year**	**10-year**
24-Dec-12	The Monetary Committee decided to reduce the interest rate to provide additional support for economic activity in the absence of inflationary pressures.	+		-0.25	**0.129*****	**0.07****	**0.049***	**0.046***	0.028	0.027
24-Jun-13	The Monetary Committee decided to keep the interest rate unchanged this month and to allow the recent steps to take effect. They further noted that they would continue to examine the impact of the steps and will act as necessary in the future.	+			-0.018	-0.024	**-0.052***	**-0.076*****	**-0.073*****	**0.058*****
26-Aug-13	The interest rate set on that date was supposed to be in effect for two months. However, the Committee announced that due to the experience accumulated, and the uncertainty in global markets, the Committee found it prudent to re-examine monetary policy at the end of the next month and resolved to return to a format of reaching interest rate decisions 12 times per year.				0.01	**0.053***	**0.07****	**0.072*****	**0.071*****	**0.055****

23-Feb-15	The Monetary Committee reduced the interest rate from 0.25 to 0.10 percent, which may be considered the effective lower bound. In addition, the committee decided to narrow the interest rate corridor in the credit window from+/-0.25 to +/-0.1 percentage points.			-0.15	-0.018	-0.03	**-0.075*****	**-0.064*****	**-0.055****	**-0.063*****
22-Jun-15	The interest rate decision included a press conference and a staff forecast, which was perceived as positive and surprising: Jonathan Katz, chief economist at Leader Capital Markets: *"We were somewhat surprised by the confidence of the Bank of Israel that the inflation Markets: "We were somewhat surprised by the confidence of the Bank of Israel that the inflation environment for one year ahead will return to the target range."* (Calalist', 22/6/2015). The press conference also included the following dramatic statement made by the Governor "... *it appears that the probability that we will be required to use unconventional tools in the near future has declined."*	+	+		0.011	0.027	**0.064****	**0.096*****	**0.102*****	**0.059*****
*** p<0.01, ** p<0.05, * p<0.1										

Figure 1
Estimated FG Shocks with Time-Varying Confidence Intervals Derived from "Days without Information"



As noted earlier, some of the significant results obtained in the short-term yields might be due to a biased estimation of the variable *surprise1*. This hypothesis is examined in Section 5.1.[44]

As shown in Figure 1, the confidence intervals had gradually decreased in the second half of the sample, in accordance with the continuing decrease of the monetary interest rate towards its ELB (See Figure 5. in Appendix C). As such, dates with significant BOI statements are now found to be statistically significant. For example, when the BOI stopped stating that the inflation rate is intended to return to within its target range *"over the next twelve months"*, (September 24, 2015), and when the BOI stopped stating that the risks to growth are high (August 24, 2016). To conclude, the empirical evidence supports the relaxation of the assumption that the noise distribution is constant over time.

4.3 Comparison Between the Two Approaches

This section compares the FG shocks derived from the two approaches. Table 7 presents a correlation matrix between the FG shocks derived from the residuals method and the factors Z_1 and Z_2. The FG shocks from both approaches are highly correlated. Correlations between Z_2 and FG shocks from the residuals method for long maturities (5 years and longer) are close to 0.9. The correlation with the 3-year maturity shocks is still high (75%) but drops for shorter maturities. According to these results, I can safely determine that, on average, the shocks derived from both methods are similar. However, if I examine each interest rate decision separately, the effect of FG on the yields is not constant, as seen in Table 6.

To further emphasize this point, I focus on three interest rate decisions: April 26, 2010, October 29, 2012, and June 22, 2015.[45] Figure 2 shows the estimated effect of the two methods on these dates. For each date, the left graph presents the effect of the two factors *(*Z_1 and Z_2). The right graph presents the effect of FG under the residuals method and the effect of a monetary interest rate surprise *(surprise1)*.[46]

Using the GSS method, I do not identify any FG shocks in April 2010, as opposed to the residuals method, which identifies an FG shock on 1- and 2-year yields. Furthermore, in October 2012, the Supervisor of Banks at the BOI issued a macroprudential directive limiting the loan-to-value ratio (LTV) on mortgages. Using the residuals method, I identify negative and statistically significant FG shocks along the entire yield curve, with most of that effect

[44] It might be that some of the monetary interest rate surprises, as estimated in the variable, were only "timing" surprises related to the exact meeting in which the change in the monetary rate occurred.

[45] A description of the information published on the three dates is presented in Table 6.

[46] The plots in the left column show the predicted effect of each factor on the yields: $\beta_i^m Z_{i,t}$, $m \in \{1,2,3,5,7,10\}$, $i \in \{1,2\}$ and $t \in T$. The plots in the right column present the residuals from Equation 4 (i.e., second method FG shocks) and the predicted effect of an unexpected interest rate change as estimated by the variable $surprise1$*:* $\beta^m surpise1$, $m \in \{1,2,3,5,7,10\}$ and $t \in T$.

in the short term. Contrariwise, using the GSS method, I identify the effect only on the long-term yields, and the interest rate surprise is much larger than the one estimated by surprise1. The third case (June 2015) was a press conference that included a dramatic statement from the Governor. According to the GSS method, there were also short-term FG shocks on that date, but according to the residuals method, the shocks were solely on the medium- and long-term yields.[47]

In summary, in cases where news only affected specific terms, I estimate the FG effect incorrectly when using the GSS method, especially at the short part of the yield curve when the model sometimes perceives these effects as interest rate surprises.

Table 7
Correlation Matrix Between the FG shocks Derived From the "Residuals Method" and Factors Z1 and Z2

	Z_2	Z_1	Resid. 10-year	Resid. 7-year	Resid. 5-year	Resid. 3-year	Resid. 2-year	Resid. 1-year
Z_2	1.00							
Z_1	0.00	1.00						
Resid. 10-year	0.88	0.02	1.00					
Resid. 7-year	0.89	0.02	0.93	1.00				
Resid. 5-year	0.88	0.07	0.91	0.95	1.00			
Resid. 3-year	0.75	0.16	0.76	0.79	0.85	1.00		
Resid. 2-year	0.52	0.26	0.56	0.53	0.64	0.75	1.00	
Resid. 1-year	0.27	0.32	0.35	0.33	0.44	0.59	0.71	1.00

4.4 Examining Whether the FG Shock Captures the Effect of Global Shocks

In this section, I examine whether factor Z_2 captures additional elements beyond the effect of FG. Specifically, I examine if the GSS method estimates also partially capture the effect of global shocks. Table 8 presents the results of regression Z_2 on US Treasury yields. If Z_2 solely captures the effect of FG, the US Treasury variables should not be statistically significant. However, the result confirms the assessment that part of the FG shocks captures global influences. The US Treasury bonds with maturities of three years or longer are statistically significant at the 5 percent level, and the 2-year bond is significant at the 10 percent level.

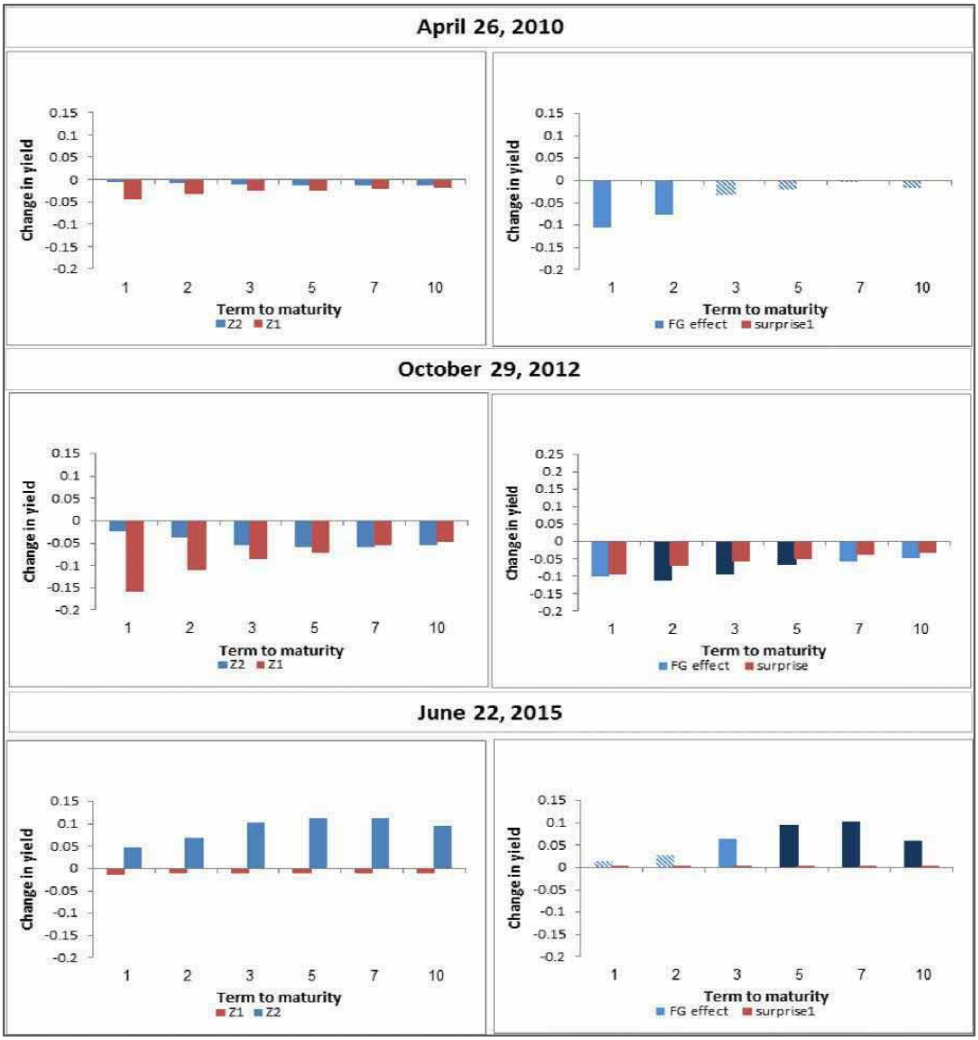
[47] The decision on that date was followed by a press conference that included a dramatic statement made by the Governor *"...it appears that the probability that we will be required to use unconventional tools in the near future has declined."*

Table 8
Estimated Effects of US Treasury Yields on the Forward Guidance Factor Derived from the GSS Method

	Z_2					
US 1 year	-0.006 (0.502)					
US 2 year		0.752* (0.387)				
US 3 year			0.718** (0.313)			
US 5 year				0.469** (0.191)		
US 7 year					0.467** (0.182)	
US 10 year						0.455** (0.184)
Constant	-0.000 (0.006)	0.001 (0.005)	0.004 (0.006)	0.004 (0.006)	0.005 (0.006)	0.004 (0.006)
Observations	75	75	75	75	75	75
R-squared	0.000	0.080	0.113	0.123	0.144	0.140

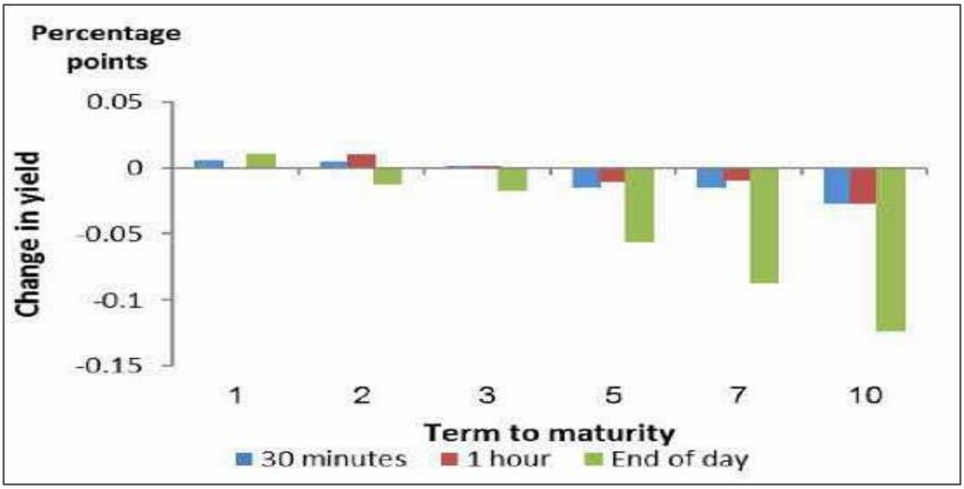
Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Figure 2
Estimated Effect of FG Shocks Derived from the Two Methods



The left graphs show the predicted effect of Z_1 and Z_2 on the yields: $\beta_i^m Z_{i,t}$, $m \in \{1, 2, 3, 5, 7, 10\}$, $i \in \{1,2\}$ and $t \in T$. The right graphs present the estimated effect from the residuals method, the striped colors represent a statistically insignificant effect, and the light and the dark blue represent 5% and 1% statistical significance levels, respectively. The right graphs also present the predicted effect of interest rate surprise, as estimated by the variable *surprise1:* $\beta^m surpise1$, $m \in \{1, 2, 3, 5, 7, 10\}$ and $t \in T$.

Figure 3
Responses of Government Bonds, October 26, 2015



4.5 Identifying FG Shocks Through Wider Windows

The financial markets fully internalize the change in the monetary rate shortly after it is announced (as also reported in Section 3.2.2). Yet, the additional information published by the CB is subject to interpretation. It takes time to fully understand the implication of the news, especially when the news is ambiguous or complex. Furthermore, the information assimilation process also depends on the behavior of other market participants. Hence, using a narrow time window around the monetary announcement might lead to underestimating the FG shocks. This section examines whether using a 1-hour window around the monetary announcement leads to underestimating the effect.

Support for this assessment can be found in the press release published by the BOI on October 26, 2015, *"The Monetary Committee's assessment is that monetary policy will remain accommodative for a considerable time."* The initial change in the yields was only moderate: 1 basis point on the 5-year yield and three basis points on the 10-year yield (see Figure 3). However, the 1-day change was significant: 6 and 12 basis points, respectively. Furthermore, our FG estimates on that announcement from both methods (and maturities) are negligible, 0-2 basis points.

Appendix *I* shows results for FG shocks using the residuals method but with a wider window—the mid-day window. As mentioned before, because the estimating window ends before 1 pm, most likely, no relevant local news had been published.[48] As before, I control global shocks using the US yields. While using the mid-day window, I identify all the

[48] The Central Bureau of Statistics publishes all of its announcements at 1 pm, except for the CPI publication on the 15th of every month.

previous dates that I found statistically significant with the 1-hour window. In addition, I identify four more dates.[49]

Except for one announcement, all others included a release of information that can affect the public's expectation of the future path of the monetary rate. Further, the press release in October 2015 had a statistically significant effect on the 10-year yield (8 basis points), as expected from such a significant statement. When the window size is increased further until the end of the business day, the impact seems even stronger: 12 and 8 basis points on the 10- and 7-year yields, which are both statistically significant.[50] These results support the assessment that using an intra-daily window would sometimes lead to a considerable underestimation of the FG shock.

4.6 The Persistence of Forward Guidance

To further examine the effectiveness of FG shocks on the yields, I analyze their dynamic effects. Specifically, I examine how persistent the impact of FG shocks on the yield curve is. Following Swanson (2017), I run a series of regressions at multiple horizons, indexed by h, of the form:

$$(6) \qquad y^m_{t-1+h} - y^m_{t-1} = \gamma_0 + \gamma_{1,h} M_t + \varepsilon^m_{t,h}$$

Where t takes on the dates of BOI announcements, t-1 denotes the business day before a BOI announcement, and y^m_τ denotes the end-of-day government bond yield at day τ with maturity m. M_t denotes the estimate for the FG shock. Each regression separately estimates the FG effect for the horizon of h days. As a result, we derive a series of coefficients $(\gamma_{1,h})$ that represent the effect of FG and vary across horizons h. $\varepsilon^m_{t,h}$ is the error term on the day t for horizon h with maturity m. The analysis is essentially the Jorda (2005) local projections method, without any additional lags on the right-hand side.[51]

Figure 4 plots the series of coefficients and illustrates the persistence of the FG estimates on the 5-year yield as a function of the horizon (h). The coefficients tend to diminish as h increases. Yet, as the horizon increases, more non-monetary news impacts the yields; thus, the confidence intervals also increase with h. The solid line in each panel represents the coefficients $(\gamma_{1,h})$ as a function of the horizon (h) . The shaded blue area is the 95-confidence interval around those points.

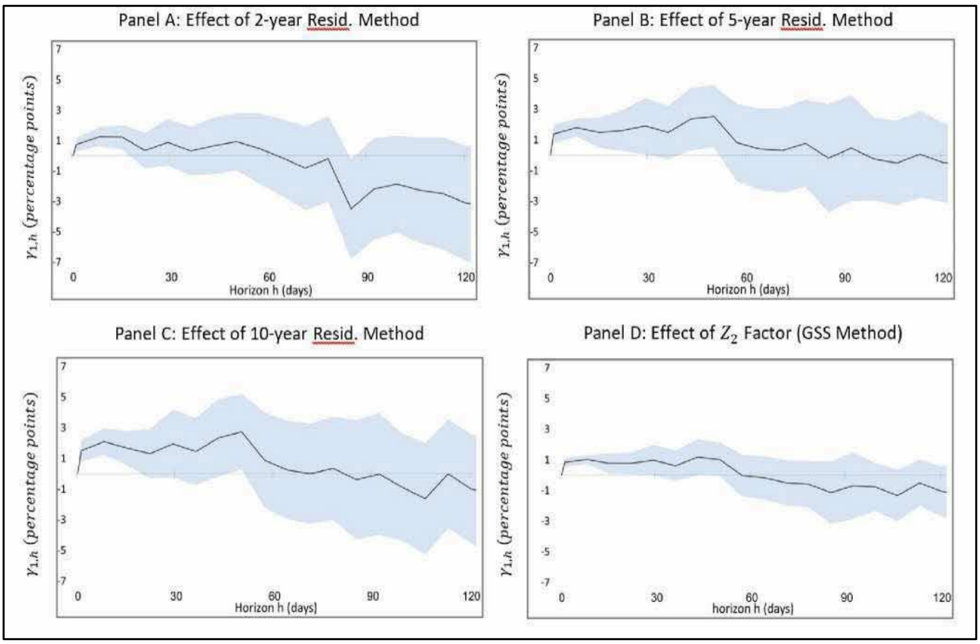
[49] November 28, 2011, August 25, 2014, August 24, 2015, and October 26, 2015.

[50] Results for the daily window are available from the author upon request.

[51] Following Swanson (2017), I impose restrictions on the analysis. Specifically, the dependent variable is the h-day change, $y_{t-1+h} - y_{t-1}$, on the factors instead of the more general specification (y_{t-1} is on the right-hand side).

The estimated effect of FG, using the GSS method, stays similar up to the horizon of around 50 days and generally remains statistically significant; after then, it diminishes toward zero (Panel D).[52] The residual method results are similar using the 5-year and 10-year FG estimates (Panel A and B, respectively); However, the 2-year FG estimate shows a much smaller persistence; it diminishes after 2-3 weeks (Panel C). Nevertheless, I cannot rule out that the persistence is similar between all FG estimates in light of the wide confidence intervals. Appendix K reports the persistence analysis for the monetary interest rate surprise for the current monetary rate.

Figure 4
Effect of FG on 5-year Government Bond Yield



* Estimated effect of FG $\gamma_{1,h}$ (solid black line) on 5-year Government bond yield for different horizons h from 1 to 120 days. The 95 confidence intervals (shaded blue area) are based on Robust standard errors. Panels A, B, and C show the dynamic effect from the residuals method, 2,5 and 10 years, respectively. Panel D shows the dynamic effect Z_2 factor (GSS).

[52] The analysis in this section focuses on the persistence and not on the effect size since the FG estimates using the GSS method are normalized.

5. ROBUSTNESS CHECKS

5.1 An Alternative Measure for a Monetary Surprise

As reported in Section 4.3, in some cases, I have identified FG shocks while using the residuals method but not the GSS method, especially when the residuals method identifies short-term FG shocks, but the GSS method partially captures them as interest rate surprises (e.g., April 2010 and October 2012; see Figure 2). This disagreement between the methods is also shown in the correlation between the short-term FG shocks and the monetary rate factor (Z_1), as shown in Table 7 (32%, 26%, and 16% with the 3-, 2- and 1-year yields).

These results raise the suspicion that I may have used imprecise estimates for the unexpected monetary rate change (i.e., surprise1). As mentioned in Section 3.3.2, Z_1 is more correlated with the 3-month monetary surprises (i.e., *m_3 _surprise)* than our current monetary surprise measure. One explanation is that part of the surprise component in *surprise1* is the "timing", as noted earlier. An alternative explanation is that the disagreement stems from the invalidity of the constant structure assumption. The alternative explanations suggest that the GSS method decomposes the co-movement of the yield curve for shocks that impact the short part of the yield and shocks that impact the medium-long part.

To confirm our results, I repeat the analysis to identify FG shocks using the residuals method, only this time, instead of using the current monetary surprise, I use the change in expectation for the next three months (m_3*_surprise).*

Table 9 shows the results for estimating Equation 4 (without a constant) for the 1-hour benchmark window with the variable *m_3_surprise* instead of *surprise1*. Compared to the results reported in Table 2, the R^2 is higher for all terms, primarily the short-term yields: 16 and 13 percentage points for 1- and 2-year yields, respectively.

Appendix J shows the FG shocks on days that were found to be statistically significant. All the announcements that were found to be statistically significant using surprise1 (as described in Table 6) remained statistically significant. In addition, I identify two more statistically significant announcements: June 25, 2012, and September 24, 2015, both of which seem to include news that had a potent effect on public expectations.

Results obtained in this way are similar to the previous ones. However, as expected, the estimated effect of short-term FG shocks is now smaller since news about the short-term interest rate path is now partially included in the variable *m_3_surprise.* Hence, even if there was some bias in our measure for unexpected monetary rate change, it does not affect the main conclusion regarding the validity of the assumption.

Table 9
The Response of Government Bond Yields to the Change in 3-month Monetary Rate Expectations and the Corresponding US Treasury Yields

Var.	1-year	2-year	3-year	5-year	7-year	10-year
m3_surprise	0.629*** (0.055)	0.442*** (0.065)	0.350*** (0.061)	0.309*** (0.057)	0.237*** (0.055)	0.190*** (0.046)
US 1-year	0.082 (0.165)					
US 2-year		0.288* (0.172)				
US 3-year			0.363** (0.142)			
US 5-year				0.277*** (0.099)		
US 7-year					0.281*** (0.095)	
US 10-year						0.264*** (0.081)
Obs.	75	75	75	75	75	75
R-squared	0.660	0.646	0.509	0.495	0.413	0.383

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

5.2 Alternative Measures for Global Shocks

Under the empirical methodology of the residuals method, I controlled for global shocks by using the change in the corresponding US Treasury bond. As noted, I use the change in the corresponding US yields between opening and end-of-day, taken from Bloomberg.[53] Bloomberg's opening and end-of-day yields are taken at 20:00 NY time of the previous day (03:00 Tel Aviv time) and at 17:00 NY time (00:00 Tel Aviv), respectively.[54] Since the changes in the corresponding US yields do not match our 1-hour window, some of these changes are irrelevant in explaining the change in yield in Israel, and we suffer to some extent from measurement error.

This section examines whether the results are robust using a different-sized window for the US yields. In particular, I use a narrower time window around the time of the monetary announcement in Israel, using opening and end-of-day data from Yahoo Finance, which uses

[53] US data are the on-the-run Treasuries obtained from Bloomberg (mid-price).
[54] The hours according to Tel Aviv time, excluding differences due to the exact date of the beginning and end of daylight savings time.

a different time convention. The opening and end-of-day yields are taken at 08:20 NY time (15:20 Tel Aviv time) and the yield at 15:00 NY time (22:00 Tel Aviv time).[55]

Table 10 shows the results of estimating Equation 4 without a constant (i.e., $\beta_0 = 0$) for five-year and ten-year yields.[56] Columns 1 and 2 show the results using Bloomberg data, and Columns 3 and 4 show the results using Yahoo Finance data. Results are similar with both data sources, although the 5-year US Treasury yield coefficient is slightly higher using Yahoo Finance data.

Table 10
The Response of Government Bond Yields to the Changes in the BOI Rate and the Corresponding US Treasury Yields, Bloomberg and Yahoo Finance

	(1)	(2)	(3)	(4)
	Bloomberg		**Yahoo Finance**	
	5-year	**10-year**	**5-year**	**10-year**
surprise1	0.203^{***}	0.125^{***}	0.195^{***}	0.123^{***}
	(0.042)	(0.031)	(0.043)	(0.031)
US 5-year	0.297^{***}		0.352^{**}	
	(0.105)		(0.140)	
US 10-year		0.268^{***}		0.279^{**}
		(0.083)		(0.130)
Obs.	75	75	75	75
R-squared	0.440	0.355	0.432	0.316

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, *p <0. 1

Results for the FG shocks from the two data sources are similar, with a few exceptions (Table 11). Although there are some differences on some of the dates, they do not affect our conclusion regarding the validity of the assumption in question. It also seems that FG estimates found to be statistically significant using the Yahoo Finance data seem more reasonable (as expected ex-ante).

[55] Yahoo Finance data are the on-the-run Bid price.
[56] Because Yahoo data are available only for these maturities.

Table 11
Comparison Between the FG Shocks Using Bloomberg and Yahoo Finance Data

					FG shocks (Residuals)			
					Bloomberg		Yahoo Finance	
Date	**A description of the main "new information"**	**Staff forecast**	**Press conference**	**Monetary rate**	**5-year**	**10-year**	**5-year**	**10-year**
24-May-10	The Supervisor of Banks issued draft guidelines to exercise strict checks on housing credit and limiting the LTV because of the increases in home prices and credit against the background of low interest rates in the mortgage market. The announcement occurred at the same time as the interest rate announcement.				-0.026	-0.025	**-0.051****	**-0.046****
29-Aug-11	After a process of gradual increases in the monetary rate, this announcement includes a statement that suggests that the future **direction** of monetary rate changes is unclear.				-0.038	**-0.046****	-0.033	**-0.042***
28-Nov-11	The Monetary Committee stated that the reduction in the interest rate, together with the weakening of the exchange rate are expected to help Israel s economy deal with the difficulties confronting it.				**0.045***	**0.041***	**0.060****	**0.058*****
24-June-13	The Monetary Committee decided to keep the interest rate unchanged this month and to allow the recent steps to take effect. They further noted that they would continue to examine the impact of the steps and will act as necessary in the future.	+			**-0.076*****	**-0.058*****	-0.037	-0.27
24-Sep-15	The Monetary Committee omitted the time framework that stated the expected duration that the inflation rate would return to within the price stability target range of 1-3 percent a year.	+	+		**-0.040***	**-0.038***	**-0.046***	**-0.046****

6. CONCLUSIONS

In this paper, I examine the effect of FG conducted in Israel on the yield curve. I find that the assumption of constant structure effect across time, regardless of the information contained in each FG statement, at least in Israel, is not always fulfilled.

The paper compares the FG shocks derived from the standard method of GSS with an alternative approach that is more intuitive in the way we think about information— as "multi-dimensional" rather than "one-dimensional". I find that on days that included a release of "new information" by the BOI, both methods identify high and statistically significant measures of FG, which suggests that both are informative. Furthermore, the FG shocks from both methods are highly correlated. Correlations between the standard and the new approaches for medium-long maturities (5 years and longer) are close to 0.9. According to these results, I determine that, on average, the shocks derived from both methods are similar. However, if we examine each interest rate decision separately, the relative effect of FG on the yield curve is not constant across time. Consequently, in some cases, the standard method derives imprecise shocks, especially when that news only affects specific terms. For example, if the information leads to updating only the short part of the yield curve, these effects are sometimes perceived by the standard approach as interest rate surprises.

In addition, I find that part of the GSS measure for FG, when implemented in Israel, captures global influences. I infer that, at least in Israel, the FG shocks from the GSS method distinguish only certain FG shocks. Simply speaking, the GSS method decomposes the co-movement of the yield curve to shocks that impact the short part of the yield and shocks that impact the medium-long part, and not to conventional monetary rate shocks and FG shocks.

These findings have important implications for measuring FG in SOEs and for the conduct of FG. Policymakers need to understand the mechanism — particularly the effect of each specific FG shock—since different information is conveyed with each decision. Furthermore, policymakers need to be aware of which maturities are affected.

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APPENDICES

A. Alternative Methods to Estimate Monetary Interest rate surprises

There are alternative methods to estimate monetary interest rate surprises that do not use futures contracts: Professional forecasters' expectations (e.g., Hussain (2011)),[57] deduce the expected change from short forward rates, or infer from a model (e.g., DSGE).

There are serval disadvantages to these other approaches. The literature has shown that forward rates are poor measures of policy expectation (Gurkaynak *et al.* (2012)).[58] If we use the average of the professional forecasters' expectations, there is a limitation on the window's size around the monetary announcement, from which we derive the interest rate surprise. Therefore, the surprise estimator might include an anticipated component.[59] Another problem is that each forecaster estimates the mode, as their forecasts are in increments of the possible changes in monetary interest rate (0.25%). As a result, the surprise measure would be imprecise. For example, if all forecasters predict a 51% likelihood that the monetary rate will not change and a 49% likelihood that it will rise, then according to the estimator, there is no expectation for an interest rate increase. However, the yields incorporate the assessment of a high probability for a change. In other words, if the expected event of not raising the monetary rate happens, the yields would change significantly, but it would mistakenly not be attributed to a monetary surprise.

When inferring a monetary shock from a model, there are risks of incorrectly choosing the model or the information input. There are also risks in using revised data or data unavailable at the time of the decision. I identify the surprise component in the paper using the daily official TELBOR rates. These rates represent quotes on OIS contracts. Further details are explained in Appendices B, and C.

B. The Israeli Swap Market (TELBOR)

To support the development of the TELBOR market, the BOI established an inter-organizational committee, *"The TELBOR Interest Rate Committee"*, in early 2007. The main goal of the TELBOR Committee is to ensure that the contributing commercial banks operate reliably and transparently in the interbank market. To that end, the TELBOR Committee determines the definitions, the contributors, and the rules for calculating and publishing the

[57] Hussain (2011) uses professional forecasters' expectations from the Bloomberg World Economic Calendar and calculates the surprise component as the standardized difference between the expected the actual changes.

[58] This measure would be even more problematic in Israel since yields are determined from a price that can be quoted by up to only two decimal points. Also, to forecast the upcoming monetary rate, bonds with short maturities must be used, and the estimator would be noisy and imprecise.

[59] For example, the Bloomberg surveys are conducted over the week before each announcement and can be updated by participants until the night before the release.

TELBOR interest rates.[60]

The Tel Aviv Inter-Bank Offered Rate (TELBOR) is based on interest rate quotes by several commercial banks.[61] It is published daily by Reuters. The algorithm for fixing the TELBOR for each term to maturity averages the banks' quotes after excluding outliers. The interest rates are quoted for one business day, one month, three months, six months, nine months, and one year. The contributors report the rates continuously, in percentage points to an accuracy of three digits after the decimal point in annual terms, on Monday through Thursday from 10:00 until 17:00 and on Friday from 10:00 until 13:00. The official TELBOR rates are calculated each day as the average quotes at a random time between 11:45 and 11:55. These rates are the references for interest rate derivatives. For example, the 1-month TELBOR is the fixing leg for the 1-month OIS contract.

As opposed to other benchmark interest rate markets (e.g., LIBOR market), the TELBOR market includes a commitment mechanism to carry out transactions according to the banks' quotes between 11:00 and 12:00. The commitment about the over-night rate quote is for loans at the reported quote, or deposits at the reported quote minus four basis points for an amount of at least NIS 50 million. There are obligations for making transactions relative to all the contributor's reported quotes between 11:00 and 12:00. Each reported quote is linked to some interest rate derivative. For example, there is a commitment for making transactions for 1-month and 3-month OIS contracts in obligatory rates of ±2 basis points from the quoted rate for 1 or 3 months, respectively, for an amount of NIS 100 million.

Stein (2017) argues that the TELBOR market has two unique features: *"The commitment to execute transactions based on quotes creates an anchor for setting the Telbor rate so that it reflects the actual interest rate every day*." In addition, the benchmark In addition, the benchmark rates, determined based on citations, include a relatively low risk and liquid-ity premium. These two characteristics are appealing when trying to deduce the market expectation of the future monetary rate.

Until 2007, there was no commitment mechanism. The commitment to the overnight quote began in 2007. The obligation regarding the three-month quote (3-month OIS) and the one-month quote (1-month OIS) started in June 2010 and in May 2013, respectively.[62]

[60] The information on the TELBOR market is based on Bank of Israel publications found at http://www.boi.org.il/en/Markets/TelborMarket/Pages/Default.aspx

[61] The quotations are received from the five major banking groups in Israel: Bank Hapoalim, Bank Leumi, Israel Discount Bank, Mizrachi-Tefahot, and First International Bank. In the past, several foreign banks, including Barclays Capital, Citibank, HSBC, and Deutsche Bank, were also contributors.

[62] For further details, see: http://www.boi.org.il/en/Markets/TelborMarket/Documents/telbordef_eng.pdf.

C. Deducing Monetary Surprises via OIS Contracts

Optimally, to avoid omitted variable bias, it is vital to take a small window around the monetary announcement (e.g., an hour), during which we deduce the monetary interest rate surprise. Unfortunately, in practice, the contributors do not update their quotes after 12:00 since there are no obligations after that hour. Therefore, I decided to set the size of the window for deducing the monetary interest rate surprise at 24 hours—the frequency of change in the official TELBOR rate.

I calculate the surprise component for the current month relative to the official 1month TELBOR rate (1-month OIS), namely, the rate on the announcement day, which is calculated around 12:00, 4 hours before the announcement (5.5 2hours prior to 2014), and the rate at 12:00 on the day following the announcement.[63]

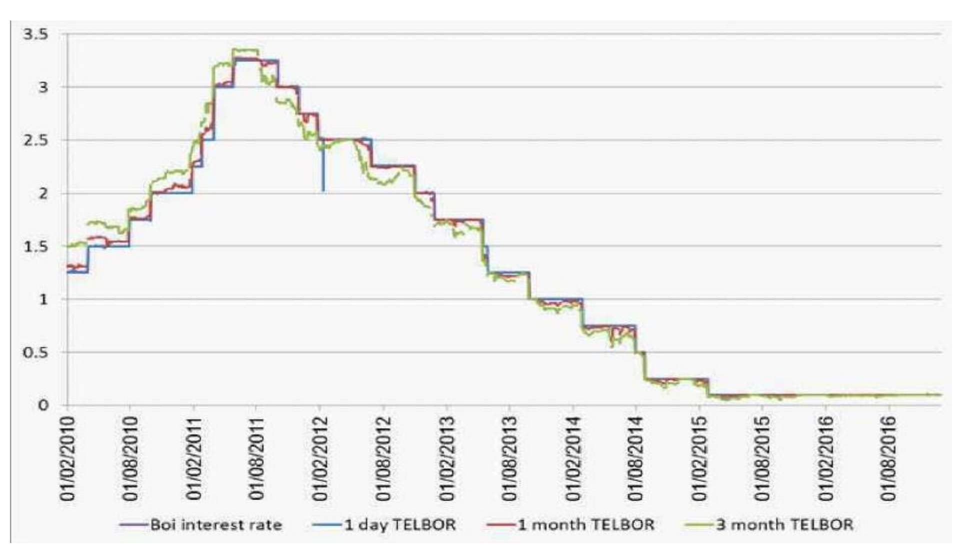
Ideally, we would have preferred to shrink the window's size. However, in practice, there are no quote updates after 12:00. In principle, we could still shrink the window's size as some banks start reporting at 08:00. However, only a small number of banks do so, and using these early quotes could lead to bias.

The underlying assumption in taking a 24-hour window is that the only relevant information that was revealed to the public during the window is the BOI announcement, which seems plausible, since we are estimating the unexpected monetary rate for a very short horizon—the next month.

An OIS transaction in Israel is based on the 1- or 3-month TELBOR interest rates and the overnight TELBOR (O/N TELBOR) interest rate. Figure 5 shows the development of the BOI monetary rate and the TELBOR rates for 1-day, 1-month, and 3-months over our sample period, February 2010 to December 2016.

[63] For five monetary announcements, I calculated the monetary interest rate surprise using longer windows: March 23, 2010 - from two days before the announcement to a day after. April 24, 2011 - from two days before the announcement to two days after. September 24, 2012 - from the day of the announcement to two days after. December 24, 2012 - from the announcement day to three days after. March 24, 2013 - from two days before the announcement to one day after. However, I used the longer window only once in my sample, on December 24, 2012. The other dates are not being used since there was no trading on TASE.

Figure 5
BOI Interest Rate, and 1-Day, 1-Month and 3-Month TELBOR Rates, February 2010 to December 2016 (Percentage Points, Daily Data)



The structure of the transaction payment is dependent on the difference between a fixed interest rate (f^s) and the geometric average of O/N TELBOR interest rates for the relevant period, according to the following equation:

$$\left[\prod_{i=t^*}^{d_0(t)}\left(1+\frac{r_i^{O/N}}{365}\cdot n_i\right)-1\right]\frac{365}{m_t^*}$$

where $r_i^{O/N}$ is the O/N TELBOR rate for one business day i, t^* is the day the floating interest rate starts (in Israel, it is two business days), d_0 is the number of business days in the relevant calculation period, n_i is the number of calendar days on which the rate is $r_i^{O/N}$,[64] and m^* is the number of calendar days in the relevant calculation period (for a contract that is issued at day t).

As shown in Equation C.1, the floating leg is the average over all the calendar days within the period, but the interest rate is compounded only on business days. From a no-arbitrage argument:

[64] For example, on a regular business day, n_i equals 1; on Fridays, it equals three since there is no trading in the TELBOR market until Monday.

$$1+\frac{m_t^*\cdot f_t^s}{365}=\mathrm{E}_t\left[\prod_{i=t^*}^{d_0(t)}\left(1+\frac{r_i^{O/N}}{365}\cdot n_i\right)\right]\cdot\left(1+\frac{m_t^*\mu_t}{365}\right)$$

The term μ_t^s represents a risk, liquidity, or any other premium. I Denote η_t as the daily gap between the O/N TELBOR and the BOI monetary rate (r_t^f) and denote x_t^* as the number of days the current monetary rate is known. For reasons of simplicity, I assume at this point that there is only one shock over the contract period:

$$1+\frac{m_t^*\cdot f_t^s}{365}=\prod_{i=t^*}^{known\, r^f}\left(1+\frac{r_0^f}{365}\cdot n_i\right)$$
$$\cdot\ \mathrm{E}_t\left[\left\{\prod_{unknown\, r^f}^{m_t^*}\left(1+\frac{r_1^f}{365}\cdot n_i\right)\right\}\overline{\left(1+\frac{\eta}{365}\right)^{x_t^*}}_{t^*\le t<t^*+x_t^*}\right.$$
$$\left.\cdot\overline{\left(1+\frac{\eta}{365}\right)^{m_t^*-x_t^*}}_{t^*+x_t^*\le t\le t^*+m_t^*}\right]\cdot\left(1+\frac{m_t^*\mu_t}{365}\right)$$

Assuming the expected average gap is independent before and after the announcement and of expected r_1^f:

$$1+\frac{m_t^*\cdot f_t^{1m}}{365}=\prod_{i=t^*}^{known\, r^f}\left(1+\frac{r_0^f n_i}{365}\right)\mathrm{E}_t\left[\prod_{unknown\, r^f}^{m_t^*}\left(1+\frac{r_1^f n_i}{365}\right)\right]$$

$$\cdot E_t\left[\overline{\left(1+\frac{\eta}{365}\right)}_{t^*\le t<t^*+x_t^*}^{x_t^*}\right]E_t\left[\cdot\overline{\left(1+\frac{\eta}{365}\right)}_{t^*+x_t^*\le t\le t^*+m_t^*}^{m_t^*-x_t^*}\right]\cdot\left(1+\frac{m_t^*\mu_t}{365}\right)$$

Applying the logarithm function and using first order Taylor approximations, we derive:[65]

$$m_t^*\cdot f_t^{1m}=x_t^*r_0^f+(m_t^*-x_t^*)E\left[r_1^f\right]+x_t^*E_t[\bar{\eta}_{t^*\le t<t^*+x_t^*}]+(m_t^*-x_t^*)E_t[\bar{\eta}_{t^*+x_t^*\le t\le t^*+m_t^*}]+m_t^*\mu_t$$

[65] Using second order Taylor approximation of $log(x)$ around $E(x)$:
$\log(x)\approx\log(E[x])+\frac{1}{E[x]}(x-E[x])-\frac{1}{2E^2[x]}(x-E[x])^2\overset{E[\cdot]}{\Longrightarrow}$
$Elog(x)\approx\log(E[x])-\frac{var(x)}{2E[x^2]}$. IF we use the first order approximation we get, $Elog(x)\approx\log(E[x])$.

We derive that the contract rate (f_t^{1m}) equals a weighted average of the current and expected interest rates and three more terms. The sum of the first two is a weighted average of the average gap between the BOI monetary rate and the O/N TELBOR rate, and the last term is a risk premium. Similarly, f_j^{1m}, the contract rate issued on day *j*, after the monetary announcement, equals the following[66]:

$$m_t^* \cdot f_j^{1m} = x_j^* r_0^f + \left(m_j^* - x_j^*\right) r_1^f + x_j^* E_j[\bar{\eta}_{j^* \le t < j^* + x_t^*}] + \left(m_j^* - x_j^*\right) E_t[\bar{\eta}_{j^* + x_j^* \le t \le j^* + m_j^*}] + m_j^* \mu_j \Rightarrow$$

$$surprise \coloneqq \left(r_1^f - E_t\left[r_1^f\right]\right) = \frac{m_j^* \cdot f_j^{1m} - m_t^* \cdot f_t^{1m}}{m_t^* - x_t^*} + \frac{x_t^* - x_j^*}{m_t^* - x_t^*} r_0^f + \frac{\left\{\left(m_j^* - m_t^*\right) + \left(x_t^* - x_j^*\right)\right\}}{m_t^* - x_t^*} r_1^f + $$

$$- \frac{x_j^*}{m_t^* - x_t^*}\left(E_j[\bar{\eta}_{j^* \le t < j^* + x_j^*}] - E_t[\bar{\eta}_{t^* \le t < t^* + x_t^*}]\right) - \left(E_j[\bar{\eta}_{j^* + x_j^* \le t \le j^* + m_j^*}] - E_t[\bar{\eta}_{t^* + x_t^* \le t \le t^* + m_t^*}]\right) +$$

$$- \frac{x_t^* - x_j^*}{m_t^* - x_t^*}\left(E_j[\bar{\eta}_{j^* + x_j^* \le t \le j^* + m_j^*}] - E_t[\bar{\eta}_{t^* \le t < t^* + x_t^*}]\right) - \frac{m_j^* - m_t^*}{m_t^* - x_t^*}\left(E_j[\bar{\eta}_{j^* + x_j^* \le t \le j^* + m_j^*}]\right) - \frac{m_j^* \mu_j - m_t^* \mu_t}{m_t^* - x_t^*}$$

Namely, the surprise component equals a scaled difference of the rates of two contracts, a contract issued before and after the CB announcement, and some corrections due to (possibly) different amounts of days of current and future monetary rates. In addition, to extract the surprise component, the following assumptions are sufficient:

$$E_j[\bar{\eta}_{j^* \le t < j^* + x_j^*}] = E_t[\bar{\eta}_{t^* \le t < t^* + x_t^*}]$$

$$E_j[\bar{\eta}_{j^* + x_j^* \le t \le j^* + m_j^*}] = E_t[\bar{\eta}_{t^* + x_t^* \le t \le t^* + m_t^*}]$$

$$E_j[\bar{\eta}_{j^* + x_j^* \le t \le j^* + m_j^*}] = E_t[\bar{\eta}_{t^* \le t < t^* + x_t^*}]$$

$$\frac{m_j^* - m_t^*}{m_t^* - x_t^*}\left(E_j[\bar{\eta}_{j^* + x_j^* \le t \le j^* + m_j^*}]\right) = 0$$

$$\frac{m_j^* \mu_j - m_t^* \mu_t}{m_t^* - x_t^*} = 0$$

[66] When we assume no other monetary announcements are in the relevant period.

The first two assumptions require that the expected average gap does not change after the monetary announcement. The third assumption requires that the expected average gap in time t for the period until the implementation of the new rate equals the expected gap in time j for the period after the implementation. The fourth assumption would be satisfied if the number of calendar days relevant for calculating the floating leg is the same (the number of days in the month) or if the expected gap is zero. The last assumption would be valid if the term premium does not change after the announcement. Sufficient assumptions instead of the first four assumptions are that the expected sum of the four factors would be zero.

I have checked the realization of the sum of the four elements (equations 1-4) for a longer period than the paper's sample. It is almost always zero (except for two cases, once in September 2007 and once in April 2009). The result is not surprising since the average gap between the O/N TELBOR rate and the monetary rate is close to zero, and hence the gap differences are also. Additionally, usually, it is the case that $j^* = t^* + 1$ and that $m_j^* = m_t^*$, so the error terms are very small. The more problematic assumption is the last one, a similar version of which is also assumed when calculating the surprise component with futures contracts. However, since the term premium is relatively small, the term premium difference is probably even smaller.

For example, in the case where $j^* = t^* + 1$, $m_j^* = m_i^*$ and under the assumptions above, we derive a similar expression to the surprise component that is derived from futures contracts plus a slight adjustment:

$$surprise := \left(r_1^f - E_t\left[r_1^f\right]\right) = \frac{m_t^*(f_{t+1}^{1m} - f_t^{1m}) \cdot}{m_t^* - x_t^*} + \frac{1}{m_t^* - x_t^*} r_0^f - \frac{1}{m_t^* - x_t^*} r_1^f$$

Under similar assumptions, in a case where there is more than one monetary announcement over the contract period, we derive the following expression:

$$\frac{m_t^* \cdot f_j^{1m} - m_t^* \cdot f_t^{1m}}{m_t^* - x_t^*} + \frac{x_t^* - x_j^*}{m_t^* - x_t^*} r_0^f + \frac{\left\{\left(m_j^* - m_t^*\right) + \left(x_t^* - x_j^*\right)\right\}}{m_t^* - x_t^*} r_1^f =$$

$$\frac{\left(x_{2,t}^* - x_t^*\right)\left(r_1^f - E_t\left[r_1^f\right]\right) + \left(m_t^* - x_{2,t}^*\right)\left(E_j[r_2^f] - E_t\left[r_2^f\right]\right)}{m_t^* - x_t^*}$$

$$+ \frac{\left(m_j^* - m_t^*\right) + \left(x_{2,t}^* - x_{2,j}^*\right)}{m_t^* - x_t^*}\left(E_j[r_2^f] - r_1^f\right)$$

where $x_{2,t}^*$ is the number of days until the second monetary interest rate is implemented. Namely, in the case of more than one interest rate decision, our surprise measure equals a weighted average between the monetary surprise of this month, the change in expectation for the following monetary announcement, and an error term. Since the number of days for which the second monetary interest rate is relevant to the contract is usually small, the weighted average would be very close to the actual current surprise. The error term is also small since the numerator $(\{(m_j^* - m_t^*) + (x_{2,t}^* - x_{2,j}^*)\})$ is close to zero and, in many cases, $E_j[r_2^f] = r_1^f$.

Using the 3-month OIS contract, we can derive the change in expectation of the interest rate path for the next three months using similar calculations:

$$surprise\_3M := \frac{m_j^{3m*} \cdot f_j^{3m} - m_t^{3m*} \cdot f_t^{3m}}{m_t^{3m*} - x_{1,t}^{3m*}} + \frac{x_{1,t}^{3m*} - x_{1,j}^{3m*}}{m_t^{3m*} - x_{1,t}^{3m*}} r_0^f + \frac{\{(m_j^{3m*} - m_t^{3m*}) + (x_{1,t}^{3m*} - x_{1,j}^{3m*})\}}{m_t^{3m*} - x_{1,t}^{3m*}} r_1^f$$

where m_t^{3m*} is the number of calendar days in the relevant calculation period for a contract issued at day t. $x_{i,t}^{3m*}$ is the number of days the next i monetary rate is relevant for the contract (e.g., $x_{1,t}^{3m*}$ is the number of days for the next monetary rate). Under similar assumptions as in the 1-month OIS contract:

$$surprise_{3M} = \frac{1}{m_t^{3m*} - x_{1,t}^{3m*}} \sum_i \{(x_{i+1,t}^{3m*} - x_{i,t}^{3m*})(E_j[r_i^f] - E_t[r_i^f])\} + \frac{\{(m_j^{3m*} - m_t^{3m*}) + (x_{2,t}^{3m*} - x_{2,j}^{3m*})\}}{m_t^{3m*} - x_{1,t}^{3m*}} (E_j[r_{last}^f] - r_1^f)$$

Our measure for the 3-month surprise is equal to a weighted average of the changes in expectation of the interest rate path and an error term due to our assumption that $E_j[r_{last}^f] = r_1^f$. However, as explained before, the error term is quite negligible since:

$$\frac{\{(m_j^{3m*} - m_t^{3m*}) + (x_{2,t}^{3m*} - x_{2,j}^{3m*})\}}{m_t^{3m*} - x_{1,t}^{3m*}} \approx \frac{1}{90}$$

Table 12
Descriptive Statistics, Monetary Interest Rate Surprise for Current and 3-Month Rate, February 2010-December 2016

Variable	***Obs.***	***Mean***	***S.D.***	***Min***	***Max***	***Median***
Surprise	80	-0.01	0.11	-0.44	0.35	0.00
3m_surprise	80	0.00	0.08	-0.27	0.28	0.00

Figure 6 shows the monetary interest rate surprises in Israel for the current rate, according to the methodology presented in this appendix. Table 12 presents descriptive statistics, and Figure 7 shows a histogram of the monetary surprises. Table 13 describes the actual, expected, and unexpected changes in the Bank of Israel rate and my measure for the 3-month surprise.

Figure 6
Monetary Interest Rate Surprises, February 2010-December 2016

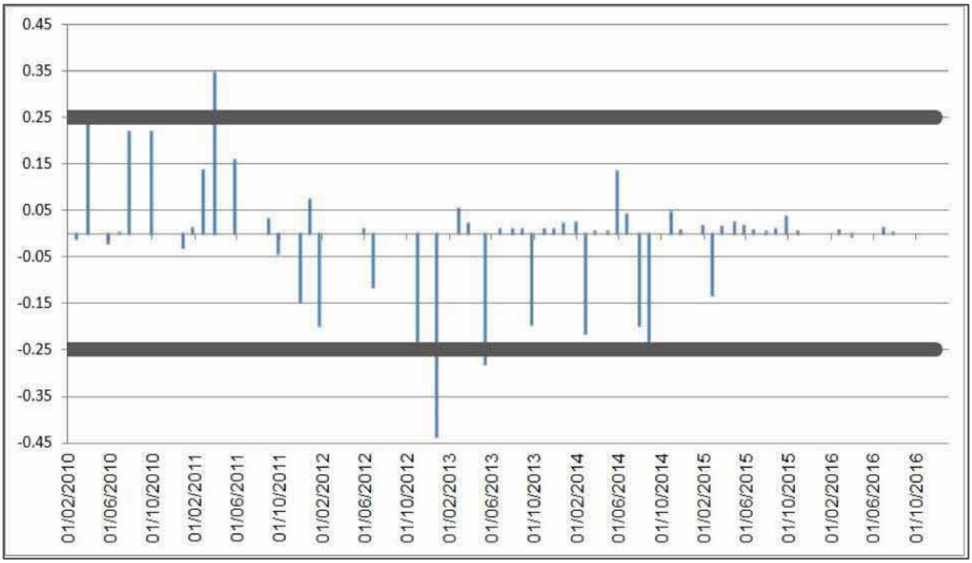


Figure 7
Histogram of Monetary Interest Rate Surprises, February 2010-December 2016

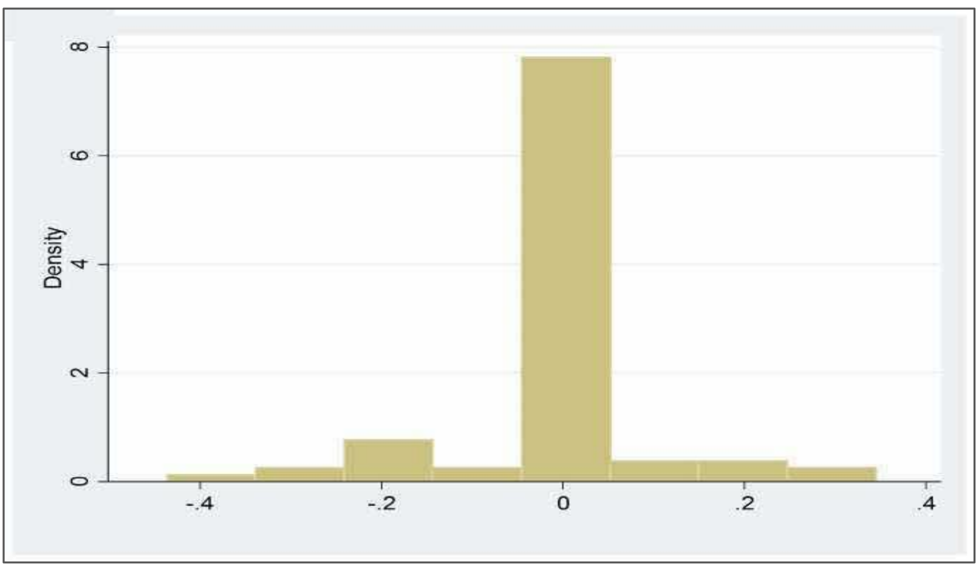


Table 13
Actual, Expected and Unexpected Changes in the Bank of Israel Rate and the 3-Month Surprise

Date		Actual change	surprise	expected	m3_surprise
2010	25/01	0.00	0.00	0.00	0.00
	22/02	0.00	-0.01	0.01	0.01
	28/03	0.25	0.25	0.00	0.18
	26/04	0.00	0.00	0.00	-0.01
	24/05	0.00	-0.02	0. 02	-0.01
	28/06	0.00	0.00	0. 00	-0.04
	26/07	0. 25	0.22	0. 03	0.20
	23/08	0. 00	0.00	0.00	0.00
	27/09	0. 25	0.22	0.03	0.12
	25/10	0.00	0.00	0.00	0.00
	22/11	0.00	0.00	0.00	-0. 01
	27/12	0.00	-0. 03	0.03	0. 01
2011	24/01	0.25	0. 01	0.24	0. 01
	21/02	0.25	0. 14	0.11	0. 03
	28/03	0.50	0. 35	0.16	0.28
	24/04	0.00	0. 00	0.00	-0.02
	23/05	0.25	0.16	0.09	0.16
	27/06	0.00	0.00	0.00	0.01
	25/07	0.00	0.00	0.00	0.00
	29/08	0.00	0.03	-0. 03	0.04
	26/09	-0.25	-0.04	-0. 21	-0.03
	24/10	0.00	0.00	0. 00	0.01
	28/11	-0. 25	-0.15	-0.10	-0.05
	26/12	0. 00	0.07	-0.07	0.07
2012	23/01	-0. 25	-0.20	-0.05	-0.12
	27/02	0. 00	0.00	0.00	0.01
	26/03	0.00	0.00	0.00	0.01
	23/04	0.00	0.00	0.00	0. 00
	28/05	0.00	0.01	-0.01	0. 03
	25/06	-0.25	-0. 12	-0.13	-0. 02
	23/07	0.00	0. 00	0.00	0.00
	27/08	0.00	0. 00	0.00	0.02
	24/09	0.00	0.00	0.00	0.00
	29/ 10	-0.25	-0.25	0.00	-0.20
	26/ 11	0.00	0.00	0.00	0.00
	24/12	-0.25	-0.44	0.19	-0.17

Date		Actual change	surprise	expected	m3_surprise
2013	28/01	0.00	0.00	0.00	0.01
	25/02	0.00	0.05	-0. 05	0.04
	24/03	0.00	0.02	-0. 02	0.08
	13/05	-0. 25	-0.28	0. 03	-0.27
	27/05	-0. 25	-	-	-
	24/06	0. 00	0.01	-0.01	-0.01
	29/07	0. 00	0.01	-0.01	0.00
	26/08	0.00	0.01	-0.01	0.00
	23/09	-0.25	-0. 20	-0.05	-0. 19
	28/10	0.00	0.01	-0.01	0. 01
	25/11	0.00	0. 01	-0.01	0. 00
	23/12	0.00	0. 02	-0.02	0.01
2014	27/01	0.00	0. 02	-0.02	0.02
	24/02	-0.25	-0.22	-0.03	-0.17
	24/03	0.00	0.00	0.00	0.01
	28/04	0.00	0.00	0.00	0.01
	26/05	0.00	0.13	-0. 13	0.09
	23/06	0.00	0.04	-0. 04	0.01
	28/07	-0.25	-0.20	-0. 05	-0.13
	25/08	-0. 25	-0.23	-0. 02	-0.21
	22/09	0. 00	0.00	0. 00	0.00
	27/10	0. 00	0.05	-0.05	0.04
	24/11	0. 00	0.01	-0.01	0.01
	29/12	0. 00	0.00	0.00	0.00
2015	26/01	0.00	0.02	-0.02	0. 00
	23/02	-0.15	-0. 13	-0.02	-0. 11
	23/03	0.00	0. 01	-0.01	0. 01
	27/04	0.00	0. 02	-0.02	0. 02
	25/05	0.00	0. 02	-0.02	0.02
	22/06	0.00	0. 01	-0.01	0.02
	27/07	0.00	0.00	0.00	0.00
	24/08	0.00	0.01	-0. 01	0.02
	24/09	0.00	0.04	-0. 04	0.04
	26/10	0.00	0.00	0.00	0.01
	23/11	0.00	0.00	0.00	0.00
	28/12	0.00	0.00	0. 00	0.00

Date		Actual change	surprise	expected	m3_surprise
2016	25/01	0.00	0.00	0. 00	0.00
	22/02	0. 00	0.01	-0.01	0.00
	28/03	0. 00	-0.01	0.01	-0.01
	21/04	0. 00	-	-	-
	23/05	0.00	0.00	0.00	0.00
	27/06	0.00	0.01	-0.01	0. 01
	25/07	0.00	0.00	0.00	0. 00
	29/08	0.00	0. 00	0.00	0. 00
	26/09	0.00	0. 00	0.00	0.00
	27/ 10	0.00	0. 00	0.00	0.00
	28/ 11	0.00	0.00	0.00	0.00
	26/ 12	0.00	-	-	-

D. Classification Rule for Monetary Decisions that Included New Information

During our sample period, the interest rate press release followed a relatively standard structure, separated into two parts. The first part is the “background conditions”, a summary of recent economic developments divided into various topics (inflation data, real economic activity, labor market, etc.). The information in this section was already published and known to the public at the time of the press release. The second part of the press release includes the considerations behind the decision. It is comprised of three sub-sections: an opening paragraph, the main considerations underlying the decision, and a concluding paragraph. The second sub-section, despite its title, does not include any new informa-tion and is only a brief repetition of the "background conditions".

In conclusion, only the opening and concluding paragraphs of the second part of the press release might include “new information”, but they are usually quite similar to the versions in previous press releases. Most formulations in those two paragraphs do not vary significantly between press releases. As part of the opening and concluding paragraphs, the Monetary Committee includes statements regarding the future course of the interest rate path, reasons for determining the interest rate, and assessments regarding the extent of risks to achieving the inflation target and growth.

I classified a monetary announcement as one that included “new information” if a non-trivial/semantic change was made in the opening or concluding paragraph relative to the previous press release. This type of classification involves some level of subjectivity. Still, since I only check for changes in the text and do not presume to determine whether the change is meaningful or the direction of impact, I argue this classification is reasonable. It is important to emphasize that even a significant change in the formulations might not affect the yield term if it does not lead to a change in public expectations, while even a lack of change in the text might lead to a change in expectations. However, since the purpose of this classification is only to determine if our estimators capture the FG shocks, it seems there is no serious harm in using the above proxy for announcement days with new information, which is probably true in general.

In June 2015, the BOI began holding regular press conferences regarding monetary policy every three months, following the publication of the interest rate decision at the end of each quarter.[67] Seven press conferences were held during our estimation period; six are included in our sample.[68] I also decided to classify these seven monetary announcements also as ones that included "new information".

Table 14 presents all of the announcements identified as ones that included new information, describes the change in monetary rate, and specifies whether it included a press conference or a quarterly macroeconomic forecast.[69]

[67] The briefings occur shortly after the interest rate decision and the Research Department's quarterly macroeconomic forecast are published. During these briefings, the Governor presents the background conditions under which policy operated during the quarter and the main considerations underlying the decision and answers questions from the press.

[68] The press conference held on December 26, 2016, is not included in the sample since there was no trading in the TELBOR market, and the monetary interest rate surprise could not be calculated.

[69] Since December 2011, the Research Department's staff forecast has been published quarterly together with the publication of the interest rate press release. Also, since June 2015 interest rate decisions that are published with an updated staff forecast are accompanied by a press conference (on a quarterly basis).

Table 14
Classification of "New Information" Monetary Announcements

Date	Monetary Rate	Change in press release	Staff forecast	Press conference
February 22, 2010	0.00	+		
March 28, 2010	0.25	+		
April 26, 2010	0.00	+		
May 24, 2010	0.00	+		
June 28, 2010	0.00	+		
August 23, 2010	0.00	+		
September 27, 2010	0.25	+		
October 25, 2010	0.00	+		
November 22, 2010	0.00	+		
December 27, 2010	0.00	+		
June 27, 2011	0.00	+		
August 29, 2011	0.00	+		
September 26, 2011	-0.25	+		
October 24, 2011	0.00	+		
November 28, 2011	-0.25	+		
December 26, 2011	0.00	+	+	
January 23, 2012	-0.25	+		
May 28, 2012	0.00	+		
June 25, 2012	-0.25	+	+	
July 23, 2012	0.00	+		
October 29, 2012	-0.25	+		
December 24, 2012	-0.25	+	+	
May 13, 2013	-0.25	+		
June 24, 2013	0.00	+	+	
August 26, 2013	-0.25	+		
May 26, 2014	0.00	+		
June 23, 2014	0.00	+	+	
July 28, 2014	0.00	+		
September 22, 2014	0.00	+	+	
October 27, 2014	0.00	+		
December 29, 2014	0.00	+	+	

February 23, 2015	0.15	+		
June 22, 2015	0.00		+	+
August 24, 2015	0.00	+		
September 24, 2015	0.00	+	+	+
October 26, 2015	0.00	+		
December 28, 2015	0.00	+	+	+
January 25, 2016	0.00	+		
March 28, 2016	0.00	+	+	+
May 23, 2016	0.00	+		
June 27, 2016	0.00	+	+	+
August 29, 2016	0.00	+		
September 26, 2016	0.00	+	+	+
November 28, 2016	0.00	+		
December 26, 2016	0.00		+	+

E. Testing the Number of Dimensions of the Monetary Policy Announcement

This appendix investigates how many latent factors are required to characterize the response of asset prices over a window around the monetary announcement, particularly how many are sufficient to describe matrix X. I investigate two short windows, a 30-minute trading window and a 1-hour trading window, and three longer windows, which end at 10:30 am, 12:45 pm (mid-day window) and at the end of the following day (daily window).

Table 15 presents the first through fourth eigenvalues for each of the various sizes of windows, derived from the principal components analysis (PCA) and the amount of variation each factor explains.[70] When using the 30-minute window, the first factor explains 81 percent of the variation, and the eigenvalue of the second factor is less than 1. Therefore, according to Kaiser's stopping rule, we cannot reject the hypothesis that the variation could be explained by only one factor (such as a change in the monetary interest rate).[71] This assessment is supported by a scree test analysis, as shown in Figure 8.[72] However, when using a 1-hour window, it seems that we can reject the hypothesis that the variation could be explained by only one factor, as the second eigenvalue is 1.1. The results suggest that there are exactly two dimensions that are needed to explain the response of asset prices. We reach the same conclusion from the scree plot test, as seen in Figure 8. The results for the longer

[70] By construction, the amount of variation of each factor explained in PCA is a descending series. It should also be noted that factors from different-sized windows are not necessarily the same; they might have different loading.

[71] According to Kaiser's stopping rule, only factors with eigenvalues higher than 1 should be considered in the analysis.

[72] According to a Scree plot test analysis, all components after the turning point, where the graph is clearly level, should be dropped (including the turning point).

windows are similar.

Because we are interested in deducing the effect of FG, it seems that, as opposed to GSS and Swanson (2017), we need to use a larger window than 30 minutes of trading. Therefore, a 1-hour window is used in the benchmark analysis since it is the shortest window for which we need more than one factor to explain the asset price variation.[73]

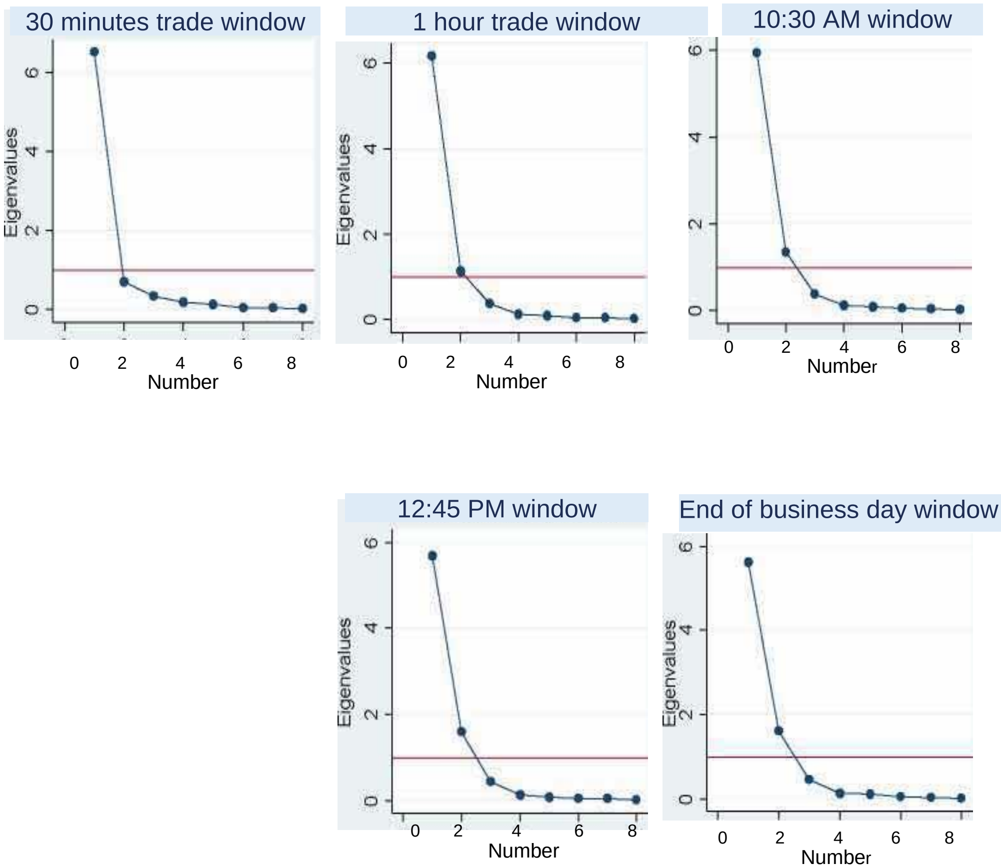
Table 15
First through Fourth Eigenvalues Derived from the Principal Components Analysis, and the Amount of Variation each Factor Explains

Size of window	First comp.		Second comp.		Third comp.		Forth comp.	
	Eigenvalue	Variation (%)	Eigenvalue	Variation (%)	Eigenvalue	Variation (%)	Eigenvalue	Variation (%)
30-min	6.51	81%	0.71	9%	0.35	4%	0.19	2%
1-hour	6.15	77%	1.14	14%	0.37	5%	0.13	2%
Until 10:30	5.94	74%	1.35	17%	0.38	5%	0.13	2%
Until 12:45	5.68	71%	1.58	20%	0.43	5%	0.13	2%
Until End of day	5.61	70%	1.60	20%	0.45	6%	0.13	2%

A 1-hour trading window is relatively close to the 30-minute benchmark window used in GSS and Swanson (2017) and is narrow enough that it is likely that no additional relevant information was published. Moreover, a 1-hour window is similar to the one used in other papers in the literature, such as Bernanke *et al.* (2004).

[73] GSS also reported some evidence that the financial market may take longer than 30 minutes to internalize the FOMC statements about the policy and economic outlook. However, according to them, most of the information is incorporated within 30 minutes, and a narrow window helps reduce the noise, thereby increasing the precision of the estimators.

Figure 8
Scree Plots Tests



*Scree plot for various windows sizes, the graphs present the relationships between the relative magnitude of eigenvalues and the number of factors.

F. Empirical Estimates of GSS's Monetary Factors (In Israel)

In this appendix, I report the ten largest observations of the FG factor derived using the GSS method, including the change in the monetary rate factor, the actual change in the monetary rate, and the change in the relevant paragraphs. I specify whether it included a press conference or a quarterly macroeconomic forecast by the BOI Research Department (Table 16).

In addition, Figure 9 plots a time series of GSS's two monetary factors over the sample period: the monetary rate factor (Z_1) and the FG factor (Z_2).

Figure 9
Monetary Rate Factor (Z_1) and FG Factor (Z_2), February 2010-December 2016

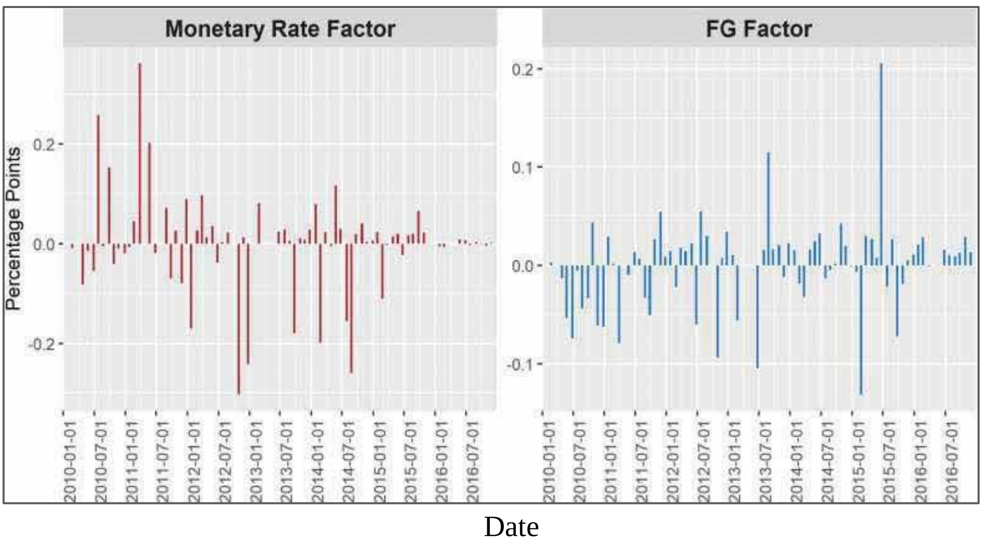


Table 16
Ten Largest Observations of the FG Factor

Date	**A description of the main "new information"**	Z_2	**Staff forecast**	**Press conference**	**Monetary rate**
22-Jun-15	The interest rate decision included a press conference and a staff forecast, which was perceived as positive and surprising: Jonathan Katz, chief economist at Leader Capital Markets: *"We were somewhat surprised by the confidence of the Bank of Israel that the inflation environment for one year ahead will return to the target range."* ('Calcalist', 22/6/2015). The press conference also included the following dramatic statement by the Governor*"... it appears that the probability that we will be required to use unconventional tools in the near future has declined."*	0.21	+	+	
23-Feb-15	The Monetary Committee reduced the interest rate from 0.25 to 0.10 percent, which may be considered the effective lower bound. In addition, the committee decided to narrow the interest rate corridor in the credit window from +/-0.25 to +/-0.1 – percentage points.	0.13			-0.15
26-Aug-13	The interest rate set on that date was supposed to be in effect for two months. However, the Committee announced that due to the experience accumulated, and the uncertainty in global markets, the Committee found it prudent to re-examine monetary policy at the end of next month and resolved to return to a format of reaching interest rate decisions 12 times per year.	0.12			
24-Jun-13	The Monetary Committee decided to keep the interest rate unchanged this month and to allow the recent steps to take effect. They further noted that they would continue to examine the impact of the steps and will act as necessary in the future.	0.10	+		

29-Oct-12	The Supervisor of Banks issued a directive limiting the LTV because of the increases in home prices and credit against the background of low-interest rates in the mortgage market. The announcement occurred **at the same time as the interest rate announcement.** The Monetary Committee stated that they reduced the interest rate to support economic activity and because of the absence of inflationary pressures.	0.09			-0.25
28-Mar-11	The monetary rate was increased by 0.5 percentage points instead of the usual 0.25 percentage points change.	0.08			+0.5
28-Jun-10	Statement emphasizing that the Governor has decided to leave the interest rate unchanged after considering the increased uncertainties in the global economy.	0.07			
24-Sep-15	The Monetary Committee omitted the time framework that stated the expected duration that the inflation rate would return to within the price stability target range of 1-3 percent a year.	0.07			
27-Dec-10	The BOI stated that it would continue to keep a close watch on developments in the asset market, and especially in the housing market (the previous version referred only to the housing market).	0.06			
22-Nov-10	As part of normalizing monetary policy, the BOI has decided to widen the interest rate corridor around its interest rate in the credit window from +/-0.25 percent to +/-0.5 percent.	0.06			

G. Confidence Intervals Derived from the Noise Distribution on Days without "Information"

Under the assessment that the confidence intervals derived from the t-test on days of interest rate decisions might be too high, as these days usually contain information, I also compare the residuals to the noise distribution on days without interest rate decisions or publication of other important information.[74] Specifically, the distribution of the difference in bond yields at the same time of the day previously used (i.e., the same 1-hour window).[75]

The confidence intervals are calculated directly: the 90th, 95th, and 99th percentiles of the absolute values of the bond yield differences to avoid bias due to outliers. For each day, the percentiles are calculated using a sample window of 201 observations (i.e., 100 business days before and 100 business days after).[76] This approach also allows us to relax the assumption that the noise distribution is constant over the seven years of the sample.

After calculating the "raw" confidence intervals, I use a local linear regression smoothing on days with sharp jumps. This is done separately for each confidence level and time-to-maturity combination, using a Gaussian kernel.[77] As shown in figure 10, the procedure affects only sharp transitory changes.

In practice, I only use specific points of these series, the days of interest rate decisions.

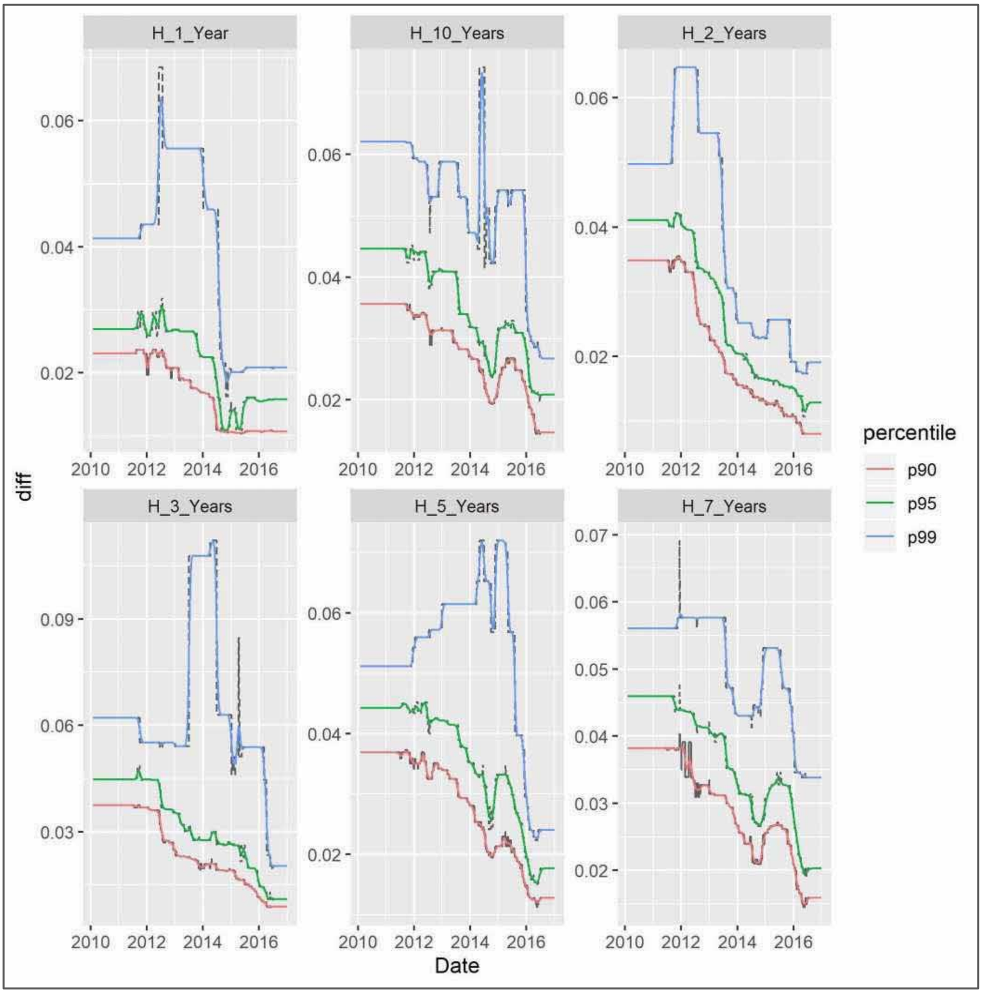
[74] I omit days on which the CPI publications happened during our event window and days on which the BOI had made FX intervention. Some additional days were omitted in light of problems in the BOI government bond quote database.

[75] The comparison is to the distribution of bond yield differences instead of the regressions' residuals for simplicity, and also since I only estimate the coefficients and do not know their actual values. Furthermore, we obtain more conservative threshold levels under the additional standard assumption that the error term is normally distributed.

[76] The sample used to calculate the percentiles starts from February 2010 to December 2016. The number of observations is fixed over each window (i.e., 201). At the beginning and end of the sample, when I did not have enough observations on one side, I added observations using the other side to reach the window's size.

[77] To eliminate the sharp jumps, the bandwidths are selected by leave-one-out cross-validation minimizing the Akaike criterion and then inflated. This produced bandwidths of approximately 2 to 3 weeks.

Figure 10
Quantiles With and Without Smoothing - 1-Hour Window



* The confidence intervals are calculated directly from the percentiles of the absolute values of the bond yield differences. The "raw" confidence intervals are smoothed using local linear regression. See the text for more details.

H. Estimated Effects of "New Information" Announcements on the Size of the FG Factors - Excluding the Press Conference Held in June 2015

Table 17

	Absolute Value of Z_1					Absolute Value of Z_2				
Var.	30-min	1-hour	10:30	12:45	End of day	30-min	1-hour	10:30	12:45	End of day
D New Info	-0.011	-0.009	-0.008	-0.011	-0.008	0.018***	0.017***	0.016***	0.013**	0.008
	(0.020)	(0.019)	(0.020)	(0.020)	(0.020)	(0.006)	(0.006)	(0.004)	(0.006)	(0.005)
Constant	0.062***	0.062***	0.064***	0.062***	0.061***	0.021***	0.020***	0.015***	0.021***	0.021***
	(0.017)	(0.016)	(0.016)	(0.017)	(0.017)	(0.004)	(0.003)	(0.003)	(0.004)	(0.003)
Obs.	74	74	72	72	72	74	74	72	72	72
R-squared	0.004	0.003	0.003	0.004	0.002	0.089	0.101	0.166	0.061	0.035

I. Results Using the Residuals Method with a Wider Window

The following table shows days the FG shock is found statistically significant at the 5 percent level on at least one term to maturity. The confidence intervals are derived from a t-test using days of interest rate decisions. Each residual is compared to the sample standard error, excluding the outlier observation in June 2015, according to its term to maturity.

					FG shocks (Residuals)					
Date	**A description of the main " new information"**	**Staff forecast**	**Press conference**	**Monetary rate**	**1-year**	**2-year**	**3-year**	**5-year**	**7-year**	**10-year**
26-Apr-10	A statement indicated that additional factors supported an increase in the interest rate, but since the rate was increased last month, the Governor decided to leave it unchanged.				-0.08*	-0.071**	-0.036	-0.03	-0.012	-0.011
28-Jun-10	Statement emphasizing that the Governor has decided to leave the interest rate unchanged after considering the increased uncertainties in the global economy.				-0.067	-0.095**	-0.067***	-0.053	-0.037	-0.039
28-Mar-ll	The monetary rate was increased by 0.5 percentage points instead of the usual 0.25 percentage points change.			+0.5	0.087**	-0.012	-0.027	-0.061*	-0.081**	-0.078**
29-Aug-ll	After a process of gradual increases in the monetary rate, this announcement includes a statement that suggests that the future **direction** of monetary rate changes is unclear.				0.007	0.032	0.029	-0.092***	-0.093***	-0.084***
26-Sep-ll	It was the first monetary easing after a yearlong series of monetary tightening. The statement indicates that the cut is intended to minimize the negative effect on Israel's economy of the slowdown in activity and the increased level of uncertainty in the global economy.			-0.25	-0.054	-0.026	-0.099***	-0.055*	-0.052	-0.06*
28-Nov-ll	The Monetary Committee stated that the interest rate reduction and the exchange rate's weakening are expected to help Israel s economy deal with the difficulties confronting it.			-0.25	0.065	0.068**	0.062*	0.038	0.022	0.023
26-Mar-12	-				0.191***	0.044	0.045	0.042	0.026	0.021

*** p<0.01, **p<0.05, *p<0.1

					FG shocks (Residuals)					
Date	**A description of the main " new information"**	**Staff forecast**	**Press conference**	**Monetary rate**	**1-year**	**2-year**	**3-year**	**5-year**	**7-year**	**10-year**
29-Oct-12	The Supervisor of Banks issued a directive limiting the LTV because of the increases in home prices and credit against the background of low-interest rates in the mortgage market. **The announcement occurred at the same time as the interest rate announcement.** The Monetary Committee stated that they reduced the interest rate to support economic activity, and because of the absence of inflationary pressures.			-0.25	**-0.087****	**-0.102*****	**-0.071****	-0.048	-0.043	-0.025
24-Dec-12	The Monetary Committee decided to reduce the interest rate to provide additional support for economic activity in the absence of inflationary pressures.	+		-0.25	**0.144*****	**0.091*****	**0.075****	**0.068****	0.043	0.038
24-Jun-13	The Monetary Committee decided to keep the interest rate unchanged this month and to allow the recent steps to take effect. They further noted that they would continue to examine the impact of the steps and will act as necessary in the future.	+			0.009	-0.01	-0.026	**-0.084****	**-0.101*****	**-0.078****
26-Aug-13	The interest rate set on that date was supposed to be in effect for two months. However, the Committee announced that due to the experience accumulated, and the uncertainty in global markets, the Committee found it prudent to re-examine monetary policy at the end of the next month and resolved to return to a format of reaching interest rate decisions 12 times per year.				0.02	**0.056***	**0.084****	**0.079****	**0.077****	**0.061***

*** $p<0.01$, ** $p<0.05$, * $p<0.1$

					FG shocks (Residuals)					
Date	**A description of the main " new information"**	**Staff forecast**	**Press conference**	**Monetary rate**	**1-year**	**2-year**	**3-year**	**5-year**	**7-year**	**10-year**
25-Aug-14	-			-0.25	**-0.08***	**-0.081****	**-0.058***	**-0.067****	-0.049	**-0.058***
23-Feb-15	The Monetary Committee reduced the interest rate from 0.25 to 0.10 percent, which may be considered the effective lower bound. In addition, the committee decided to narrow the interest rate corridor in the credit window from+/-0.25 to +/-0.1 percentage points.			-0.15	-0.016	-0.021	-0.049	-0.051	-0.052	**-0.068****
22-Jun-15	The interest rate decision included a press conference and a staff forecast, which was perceived as positive and surprising: Jonathan Katz, chief economist at Leader Capital Markets: *"We were somewhat surprised by the confidence of the Bank of Israel that the inflation Markets: We were somewhat surprised by the confidence of the Bank of Israel that the inflation environment for one year ahead will return to the target range."* (Calalist', 22/6/2015). The press conference also included the following dramatic statement made by the Governor "... it appears that the probability that we will be required to use unconventional tools in the near future has declined."	+	+		0.027	**0.06***	**0.126*****	**0.211*****	**0.199*****	**0.147*****
24-Aug-15	The Monetary Committee stated that the risks to attaining the inflation target and growth have increased.				0.01	0.052	**0.072****	**0.074****	**0.078****	**0.074****
26-Oct-15	The Monetary Committee's published assessment that monetary policy will remain accommodative for a considerable time. They also noted that they are of the opinion that the risks to achieving the inflation target remain high, and the risks to growth have increased.				0.007	0.002	-0.012	-0.031	-0.053	**-0.075****

*** $p<0.01$, $^{**}p<0.05$, $^{*}p<0.1$

J. Results Using the Residuals Method with a 3-month Surprise

					FG shocks (Residuals)					
Date	**A description of the main "new information"**	**Staff forecast**	**Press conference**	**Monetary rate**	**1-year**	**2-year**	**3-year**	**5-year**	**7-year**	**10-year**
26-Apr-10	A statement indicated that additional factors supported an increase in the interest rate, but since the rate was increased last month, the Governor decided to leave it unchanged.				**-0.099*** **	**-0.072*** **	-0.031	-0.022	-0.004	-0.016
28-Jun-10	Statement emphasizing that the Governor has decided to leave the interest rate unchanged after considering the increased uncertainties in the global economy.				-0.036	**-0.053** **	**-0.043** *	-0.026	-0.02	-0.023
28-Mar-ll	The monetary rate was increased by 0.5 percentage points instead of the usual 0.25 percentage points change.			+0.5	-0.013	-0.039	-0.041	**-0.059*** **	**-0.061*** **	**-0.046** **
29-Aug-ll	After a process of gradual increases in the monetary rate, this announcement includes a statement that suggests that the future **direction** of monetary rate changes is unclear.				0.005	0.000	-0.004	**-0.04** *	-0.035	**-0.047** **
26-Sep-ll	It was the first monetary easing after a yearlong series of monetary tightening. The statement indicates that the cut is intended to minimize the negative effect on Israel's economy of the slowdown in activity and the increased level of uncertainty in the global economy.			-0.25	**-0.061** *	-0.018	**-0.098*** **	-0.035	-0.033	**-0.036** *
26-Mar-12	-	+			**0.185*** **	0.027	0.018	0.017	0.017	0.016
25-Jun-12	The BOI emphasized that the interest rate reduction will strengthen the Israeli economy's ability to deal with the impact of potential negative consequences from the global economy.	+			-0.016	-0.019	-0.029	-0.029	**-0.044** **	-0.033

** p<0.01, **p<0.05, *p<0.1

					FG shocks (Residuals)					
Date	**A description of the main "new information"**	**Staff forecast**	**Press conference**	**Monetary rate**	**1-year**	**2-year**	**3-year**	**5-year**	**7-year**	**10-year**
29-Oct-12	The Supervisor of Banks issued a directive limiting the LTV because of the increases in home prices and credit against the background of low-interest rates in the mortgage market. **The announcement occurred at the same time as the interest rate announcement.** The Monetary Committee stated that they reduced the interest rate to support economic activity, and because of the absence of inflationary pressures.			-0.25	**-0.071****	**-0.095*****	**-0.083*****	**-0.058****	**-0.051****	**-0.043****
24-Dec-12	The Monetary Committee decided to reduce the interest rate to provide additional support for economic activity in the absence of inflationary pressures.	+		-0.25	**0.067****	0.024	0.009	0.01	-0.001	0.003
24-Jun-13	The Monetary Committee decided to keep the interest rate unchanged this month and to allow the recent steps to take effect. They further noted that they would continue to examine the impact of the steps and will act as necessary in the future.	+			-0.007	-0.015	**-0.046***	**-0.07*****	**-0.067*****	**-0.055*****
26-Aug-13	The interest rate set was supposed to be in effect for two months. However, the Committee announced that due to the accumulated experience, and the uncertainty in global markets, it is prudent to re-examine monetary policy at the end of the next month and resolve to return to a format of reaching interest rate decisions 12 times per year.				0.014	**0.055****	**0.071*****	**0.07*****	**0.069*****	**0.054****

*** $p<0.01$, $^{**}p<0.05$, $^{*}p<0.1$

					FG shocks (Residuals)					
Date	**A description of the main "new information"**	**Staff forecast**	**Press conference**	**Monetary rate**	**1-year**	**2-year**	**3-year**	**5-year**	**7-year**	**10-year**
22-Feb-15	The Monetary Committee reduced the interest rate from 0.25 to 0.10 percent, which may be considered the effective lower bound. Also, the committee decided to narrow the interest rate corridor in the credit window from+/-0.25 to +/-0.1 pp.			-0.15	0.001	-0.02	**-0.07*****	**-0.061*****	**-0.055****	**-0.061*****
22-Jun-15	The interest rate decision included a press conference and a staff forecast, which was perceived as positive and surprising: Jonathan Katz, chief economist at Leader Capital Markets: *"We were somewhat surprised by the confidence of the Bank of Israel that the inflation Markets: "We were somewhat surprised by the confidence of the Bank of Israel that the inflation environment for one year ahead will return to the target range."* (Calalist', 22/6/2015). The press conference also included the following dramatic statement made by the Governor "... *it appears that the probability that we will be required to use unconventional tools in the near future has declined."*	+	+		0.001	0.021	**0.063****	**0.098*****	**0.106*****	**0.061*****
24-Sep-15	The Monetary Committee dropped the time framework that stated the duration in which it is intended to return the inflation rate to within the price stability target range of 1-3 percent a year.	+	+		0.004	-0.008	-0.033	**-0.046****	**-0.038***	**-0.042****

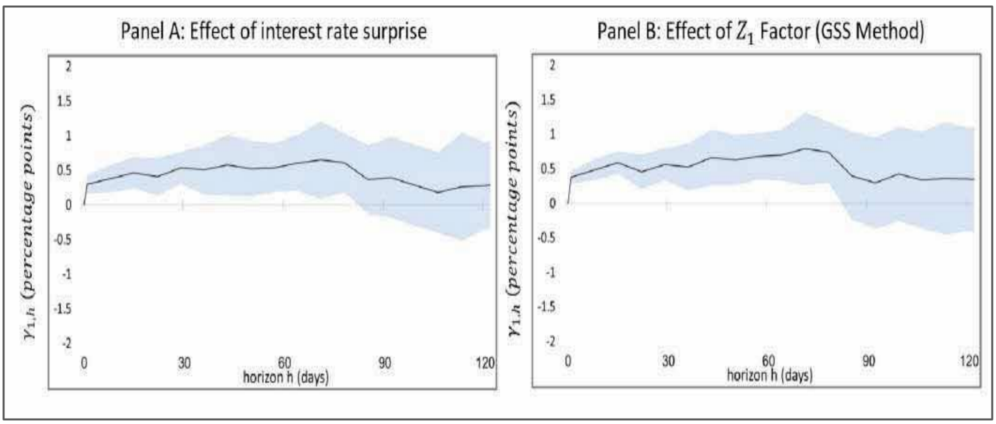
** p<0.01, **p<0.05, *p<0.1

K. The Persistence of Monetary Interest Rate

This appendix presents the dynamic effects of monetary interest rate surprise on the yields, as explained in Section 4.6. Figures 12 (13) plot the $\gamma_{1,h}$ coefficients for the monetary interest rate surprise as a function of the horizon h on the two-year (5-year) yield. The solid line in each panel plots the point estimates, and the shaded blue area is the 95% confidence interval around those points.

Using both methods, the estimated effect of monetary interest rate stays similar up to the horizon of around 80-90 days and generally remains statistically significant; after that, it decreases toward zero and no longer remains statistically significant.[78] Results on the 5-year yield are similar; however, the standard errors are larger. Specifically, the results using *suprise1* are no longer statistically significant beyond the horizon of 2-3 weeks. Nevertheless, we cannot rule out that the persistence is similar.

Figure 12
Effect of Monetary Interest Rate on 2-year Government Bond Yield



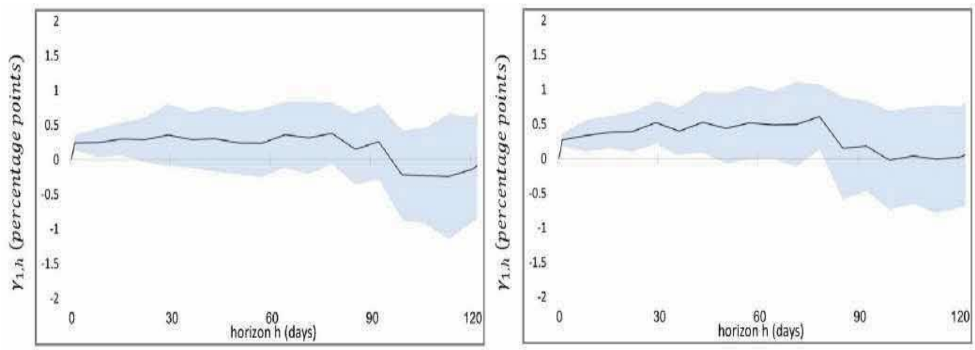
* Estimated effect of Monetary rate shock on 2-year Government bond yield for different horizons h from 1 to 120 days. Estimated coefficients ($\gamma_{1,h}$) (solid black line) and 95 confidence intervals (shaded blue area), based on Robust standard errors. Panel A shows the dynamic effect of the unexpected change in interest rate surprise *(surprise1)*. Panel B shows the dynamic effect of factor Z_1.

[78] The analysis in this section focuses on the persistence and not the effect size since the estimate using the GSS method are normalized.

Figure 13
Effect of Monetary Interest Rate on 5-year Government Bond Yield

Panel A: Effect of interest rate surprise

Panel B: Effect of $Z_{\pm}$ Factor (GSS Method)



* Estimated effect of Monetary rate shock on 5-year Government bond yield for different horizons h from 1 to 120 days. Estimated coefficients ($\gamma_{1,h}$) (solid black line) and 95 confidence intervals (shaded blue area), based on Robust standard errors. Panel A shows the dynamic effect of the unexpected change in interest rate surprise *(surprise1).* Panel B shows the dynamic effect of factor Z_1.