Bank of Israel **Research Department**

Measuring the Effect of Forward Guidance in Small Open Economies: The Case of Israel

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Discussion Paper 2020.03
March 2020

First Version: Dec. 2017

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I thank Jeffrey Campbell, Zvi Hercowitz, Daniel Nathan, Sigal Ribon, Yossi Yakhin, the participants of the IDC Herzliya Economic Workshop, the participants of the CEBRA annual conference and the participants of the Bank of Israel Research Department Seminar for helpful suggestions and comments. Any errors that remain are my own. I am also grateful to David Ettun and Dafna Koby for their outstanding research assistance.

אמידת ההשפעה של "הכוונה לעתיד"
עבור משק קטן ופתוח: ישראל כמקרה בוחן

ארי קוטאי

תקציר

המאמר אומד את השפעתה של "הכוונה לעתיד" (Forward Guidance) עבור משק קטן ופתוח ומשתמש בישראל כמקרה בוחן. אני מציע בעבודה זו גישה אלטרנטיבית לשיטה הסטנדרטית של Gürkaynak et al. (2005), שמשחררת את הנחת המבנה הקבוע ואומדת את ההשפעה עבור כל מאורע וטווח לפדיון בנפרד. כלומר, ההנחה שההשפעה היחסית של זעזועי "הכוונה לעתיד" על פני עקום התשואות היא קבועה לאורך זמן, ללא תלות במידע הגלום בכל הצהרת "הכוונה לעתיד" - משוחררת. במסגרת גישה זו, מתבצע גם פיקוח על זעזועים גלובליים על רקע ההערכה שהשפעתם עבור משק קטן ופתוח לא זניחה. תוצאות המחקר מעלות שיש מתאם גבוה בין הזעזועים שנגזרים משתי השיטות, אולם, במקרים שבהם הזעזועים השפיעו בעיקר על טווחים מסוימים לפדיון, השיטה הסטנדרטית מובילה לזיהוי לא מדויק. לאור התוצאות עולה שחשוב שקובעי המדיניות יקחו בחשבון על איזה טווחים לפדיון משפיעה כל הצהרת "הכוונה לעתיד" שהם מפרסמים. בהתאם לתוצאות המחקר נמצא גם שלחלק מהצהרות "הכוונה לעתיד" המרכזיות שפורסמו על ידי בנק ישראל, הייתה השפעה משמעותית על עקום התשואות.

מילות מפתח: מדיניות מוניטרית, הכוונה לעתיד, משקים קטנים ופתוחים.

מספרי סיווג JEL: E43, E33, E52, E58.

Measuring the Effect of Forward Guidance in Small Open Economies: The Case of Israel

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Mar. 2020

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 Gürkaynak *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, in cases where the FG shocks mainly affect specific terms to maturity the standard method leads to imprecise identifications. 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 had a significant effect on yields.

JEL classification codes: E43, E44, E52, E58.
Keywords: Monetary Policy, Forward Guidance, Small Open Economies.

First Version: Dec. 2017

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I thank Jeffrey Campbell, Zvi Hercowitz, Daniel Nathan, Sigal Ribon, Yossi Yakhin, the participants of the IDC Herzliya Economic Workshop, the participants of the CEBRA annual conference and the participants of the Bank of Israel Research Department Seminar for helpful suggestions and comments. Any errors that remain are my own. I am also grateful to David Ettun and Dafna Koby for their outstanding research assistance.

Any views expressed in the paper are those of the author and do not necessarily reflect those of the Bank of Israel.

1 Introduction

The global financial crisis led many central banks (CBs) to reduce their policy rate to zero or to an effective lower bound (ELB). Facing that constraint, CBs resorted to the use of 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 employs Israel as a case study. The paper argues that Gürkaynak, Sack, and Swanson's standard method (2005) (henceforth GSS) may not be suitable for a SOE, and that their measure for FG partially captures the effect of global shocks. The paper also investigates the validity of an implicit underlying 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 a 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.[1] 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,[2] 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).

[1] 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.

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

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.[3] In spite of its prevalence, the mechanism of this policy tool has remained unclear.

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 better understand 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 not suitable 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 not possible 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 it is important for policymakers 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.[4] Furthermore, this paper argues that the standard method may not be suitable for a SOE in particular, as GSS's measure may partially capture the effect of global shocks.

This study compares FG shocks obtained from two different methods. The first are obtained by using Gürkaynak *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

[3]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).

[4]The "Operation Twist" program was first used in 1961 to decrease medium-to-long-term interest rates while maintaining or increasing shorter-term rates, in order 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).

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 therefore, presumably may affect the yield curve differently according to the information it contains.[5]

In order to examine whether different FGs have a differential effect on the yields I use an alternative approach. 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 resulting from these regressions are good candidates for the FG effect estimates for different maturities. In order to interpret these residuals as FG, we must first be convinced that there was no other relevant economic news (foreign or domestic) during the event window. 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, but it must not be too narrow, or it would lead to an underestimation of the shock or even to an entirely incorrect estimation.[6] Furthermore, in relation to the issues raised

[5] 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.

[6] As in a case where the market has not had the chance to fully comprehend the message.

above, the paper uses Israel as a case study, in light of a number of unique characteristics that make it easier to obtain more accurate estimates. First, since in Israel the Central Bureau of Statistics publishes all of its notices long after or before the interest rate decision, a window that is relatively long can be used without concern that relevant information (domestic news shocks) was published during the event window. 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 recent years. Therefore, it is easier to identify FG, since there is no need to disentangle it from LSAP.[7]

In a SOE, the yields may be strongly affected by global shocks. By using foreign yields as explanatory variables, we 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 for the purpose of validating 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.

This alternative approach is similar to one presented in 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 shocks. However, they are calculated using daily, not intra-day, changes. Therefore, they needed to add to the regression proxies for unexpected macroeconomic developments.[8] In addition, they didn't include any controls for global shocks.[9]

I find that on days that included a release of "new information" by the BOI, both

[7] The BOI implemented an asset purchasing program only for a short period between March 2009 and August 2009, prior to the period investigated in the paper which started in 2010.

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

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

approaches—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 shocks. As a result, the use of 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). The latter examination is beyond the scope of this article. I also find that when regressing the GSS measure for FG shocks on US Treasury yields, the coefficients are statistically significant. 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 true, and 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 certain type of FG shock. Simply speaking, the GSS method actually 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 to decomposing to 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.

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 shocks 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.[10]

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 $t+h$.[11] Namely, the new monetary rate R^1_{new} is decided and announced on day t but for the next h days the actual monetary rate is still R^1_{old}. The new rate would last for H days (at least), so the next monetary implementation is planned to be at day $t+h+H$.[12] 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 next new and known rate (R^1_{new}), and expected future overnight rates:

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

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:

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

As Equation 1 and Equation 2 show, the direct effect of a change in the monetary rate comes from its unexpectedness - $R^1_{new} - E_t\left[R^1_{new}\right]$ -, which is proportional to $\frac{H}{d}$ and therefore diminishes in d. However, the effect of a monetary interest rate shock also comes from the reevaluation of the forward rate (R^{d-H-h}_{t+h+H}) and since H is relatively small in proportion to

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

[11] In Israel the implementation of the new monetary rate happens a few days after the CB announcement.

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

d, the effect on the forward rate is the more significant one. 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 takes measures that increase certainty in this area, it reduces the risk premium and thus reduces interest rates. In other words, FG affects long-term interest rates, both by influencing the expected risk-free interest rates and by lowering risk premiums.

3 Empirical Framework

3.1 Data

In order 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 frequently, 12 times a year, close to the end of each month. The estimation period included 83 BOI monetary rate meetings, 82 of which were planned in advance while the additional meeting was not scheduled.[13] 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).[14] 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 shock could not

[13] In February 2013, the BOI Monetary Committee decided to cancel 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 rate 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.

[14] 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, prior to June 2014 the calculation of the 30-minute and 1-hour event windows included using bond prices of the day following the monetary announcement.

be calculated.[15] Two other observations were omitted in the long window regression, since there was no trade on the TASE on the day following the announcement.[16] The data set includes yields on government bonds for maturities of 1, 2, 3, 5, 7 and 10 years.[17] The data set also includes overnight interest swap (OIS) quotes from the official TELBOR interest rate, which is published every business day via Reuters.[18]

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, in order to study the impact of monetary policy on yields, unexpected policy changes must be isolated. This use of unexpected policy changes also allows us to deal with issues of endogeneity and simultaneity. For this purpose, the following regression, which has been frequently estimated in the literature, is used:

$$\Delta y_t = \alpha + \beta_1 surprise1_t + \varepsilon_t \tag{3}$$

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. Due to omitted variable bias and simultaneity, it is problematic to estimate Equation 3 using weekly, monthly or quarterly

[15] For the following announcements the surprise monetary shock 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 surprise monetary shock is calculated are in Appendix C.

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

[17] The data set includes government bond quotes at one-minute frequency using the BOI stock exchange database. In the few cases where data were missing in the database, 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.

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

data. For example, the monetary policy change could be a response to a macroeconomic development that also affects yields. In order 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), Gürkaynak *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 shock using futures contracts, which are not traded in Israel. As such, this paper uses OIS contracts to deduce the monetary interest rate shock. These contracts also embody market expectations about the interest rate path, but are traded over the counter (OTC).[19]

OIS contracts are very similar to interest rate futures contracts in the sense that both of them are instruments that hedge against, or speculate on, changes in short-term interest rates. Similar to 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 that is issued before the announcement and one after. 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. This makes the surprise component calculation more complex.

[19] Alternative methods for estimating unexpected monetary shocks 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.

The Israeli swap market has two unique features that are appealing in trying to deduce market expectations for the interest rate path. First, as opposed 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 in a similar manner to the way 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 shock for the current monetary rate. As in GSS, this paper presents results for various sizes of windows around the monetary announcement.[20] The 30-minute window is the difference in the yield after 30 minutes of trade.[21] Table 1 includes three more windows: a 1-hour trade window, a mid-day window which ends at 12:45 on the day following the announcement, and a daily window that ends

[20] Currently 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, trading ends 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.

[21] 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 day of the announcement (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 the announcement and the yield 30 minutes after the announcement, namely between 15:45 and 16:30. The pre-opening phase starts each day at 09:00 and the continuous trading phase starts at 09:30.

at the end of the next day.[22]

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 raise 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-year) is about 15 basis points, similar to the results in GSS. In addition, and as the literature already points out, 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. It seems that in Israel at the short part of the curve (1- and 2-year), the R^2 does not change a lot (around 0.5) when increasing the window's size . However, the R^2 does decline for yields with longer maturities, as in GSS. It seems that most of the decline occurs 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

There are two different approaches 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 BOI monetary 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 monetary announcement, I calculate the change in yield that is not driven by the unexpected change in the monetary rate or other known factors. In order to interpret the remaining change in yield as the FG shock, it must be proven that no other relevant and significant economic news was released during the event window. This

[22] Similarly, the 1-hour window is calculated between the end of 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-mintue window						
	(1)	(2)	(3)	(4)	(5)	(6)
	1 year	2 year	3 year	5 year	7 year	10 year
Surprise1	0.376***	0.292***	0.232***	0.228***	0.180***	0.145***
	(0.082)	(0.061)	(0.043)	(0.038)	(0.033)	(0.026)
Constant	-0.001	-0.002	-0.005	-0.004*	-0.005**	-0.006***
	(0.004)	(0.003)	(0.003)	(0.002)	(0.002)	(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
Surprise1	0.386***	0.278***	0.222***	0.197***	0.153***	0.123***
	(0.084)	(0.058)	(0.046)	(0.043)	(0.036)	(0.030)
Constant	0.000	-0.002	-0.003	-0.005	-0.006*	-0.007**
	(0.005)	(0.003)	(0.003)	(0.003)	(0.003)	(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
Surprise1	0.397***	0.272***	0.218***	0.195***	0.142***	0.113**
	(0.097)	(0.069)	(0.055)	(0.056)	(0.049)	(0.047)
Constant	0.004	0.001	-0.001	-0.003	-0.007	-0.008*
	(0.005)	(0.004)	(0.004)	(0.005)	(0.005)	(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
Surprise1	0.399***	0.290***	0.220***	0.227***	0.184***	0.156***
	(0.108)	(0.072)	(0.047)	(0.053)	(0.049)	(0.042)
Constant	0.002	0.004	0.001	-0.002	-0.004	-0.005
	(0.004)	(0.004)	(0.004)	(0.005)	(0.006)	(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<0.1						

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.

can be achieved by using a narrow time window around the BOI announcement, but not too narrow that it would lead to an underestimation of the FG effect.

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

$$\Delta y_t^m = \beta_0 + \beta_1 surprise1_t + \beta_2 \Delta r_{m,t}^{US} + \varepsilon_t^m \tag{4}$$

The first explanatory variable controls for unexpected change in the monetary rate. The remaining change in yield (if we only controlled for that variable) could be attributed to FG or to 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 FED, the Bank of England or the ECB), the BOI has not made use of an asset purchasing program in recent years. Therefore, it is easier to identify FG, since there is no need to disentangle it from LSAP (for example, as in Swanson (2017)).[23] Using a narrow time window around the monetary announcement helps deal with the second and third points noted above, but this solution is still not perfect, especially when using a slightly larger window (such as in order to avoid an underestimation of FG shocks). In addition, the assumption that global shocks are negligible in a SOE seems unlikely. Therefore, for each bond, the change in the corresponding US Treasury bond is used to control for these shocks. This solution is usually not applicable because this kind of estimation is subjected to simultaneous and endogenous issues. But since Israel is a SOE, it can be assumed 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.[24] So as long as the estimating window ends before 1 pm, it is likely that no relevant information has

[23] The BOI implemented an asset purchasing program only for a short period between March and August 2009, which is not included in period investigated in this paper.

[24] 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 15th of every month.

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, for the purpose of validating 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 hypothesis 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).

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. In both methods, the residuals are deduced after controlling for the short-term monetary shock. However, in Kohn *et al.* (2003) the residual is calculated using daily, rather than intraday, changes. As such, survey information was added to the regression as proxies for unexpected macroeconomic news, but no control was included for global shocks.[25,26]

US Treasury securities are traded OTC. Therefore, in principle they are traded all day. In the paper, I use opening and end-of-day yields taken from Bloomberg.[27] For the benchmark estimation (1-hour window), I use the change between the opening and end-of-day yields for corresponding US Treasury bonds. Clearly, 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

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

[26] 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.

[27] 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 receives the value zero.

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 1 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, after adding US yields to the regressions, the R^2 in the 1-year regression does not increase. However, it does increase by 2, 5, 8 ,11 and 11 percentage points for 2, 3, 5, 7 and 10-year yield regressions respectively.[28] In conclusion, these results support adding US yields as explanatory variables to the regressions, at least for the yields with maturities of longer than 2 years. In contrast, it is not clear if it is worthwhile to add the US yield as a control variable to the short-term regressions.

At this stage the regression residuals are only good candidates for FG shocks.[29] 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".[30] 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 of them are identified as including "new information" according to the classification rule.[31]

Panel A of Table 3 presents the results for the whole sample. The results verify our

[28] Compared to the results reported in Table 1, the adjusted R^2 decreased by 1 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.

[29] In light of the results in Table 2, the estimation was performed without a constant (i.e. $\beta_0 = 0$).

[30] 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.

[31] Of those 45 announcements, 43 were identified in view of the paragraph based identification.

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
Surprise1	0.383***	0.276***	0.224***	0.201***	0.157***	0.123***
	(0.084)	(0.057)	(0.045)	(0.042)	(0.036)	(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	-0.001	-0.001	-0.003	-0.003	-0.004
	(0.005)	(0.003)	(0.003)	(0.003)	(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

hypothesis about the structural interpretation for 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. Panel *B* presents the results for the same test in which the outlier observation—the monetary announcement from June 2015—is omitted from the sample. That interest rate decision included a press conference and a staff forecast, which was perceived as positive and surprising.[32,33] In addition, the press conference included the following dramatic statement made by the Governor: *"It appears that the probability that we will be required to use*

[32] 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).

[33] Jonathan Katz, Chief Economist at Leader Capital Markets, said: *"The decision not to change the interest rate was not really surprising, but we did not rule out the possibility of a rate cut. 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', June 22, 2015).

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	0.009**	0.013***	0.013***	0.011***	0.013***
	(0.008)	(0.004)	(0.004)	(0.004)	(0.004)	(0.003)
Constant	0.024***	0.015***	0.012***	0.011***	0.011***	0.010***
	(0.006)	(0.002)	(0.002)	(0.002)	(0.002)	(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	0.009**	0.012***	0.012***	0.009***	0.012***
	(0.008)	(0.004)	(0.004)	(0.004)	(0.003)	(0.003)
Constant	0.024***	0.015***	0.012***	0.011***	0.011***	0.010***
	(0.006)	(0.002)	(0.002)	(0.002)	(0.002)	(0.001)
Observations	74	74	74	74	74	74
R-squared	0.000	0.048	0.089	0.118	0.086	0.151

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

unconventional tools in the near future has decreased". The results remain similar.

3.3.2 GSS Standard Approach

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

$$X = F\Lambda + \varepsilon \tag{5}$$

where F is a $T \times k$ matrix containing $k < n$ unobserved factors, Λ is a $k \times n$ matrix of factor loadings, and ε is a $T \times n$ matrix of white noise residuals.

The hypothesis is that $k = 0$ means that the data is well described by white noise, in the case $k = 1$ the data is well described by a single factor (e.g., the change in monetary

rate), and in the case $k = 2$ the data is well described by two factors. In a similar way 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.[34,35] 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 1-hour trading window two factors are required.

The principal component method makes it possible to decompose the data to 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 change in the monetary rate). Formally, if F and Λ characterize the matrix X as in Equation 5 and U is an orthogonal matrix, then factors $\widetilde{F} \equiv FU$ and loading $\widetilde{\Lambda} \equiv U'\Lambda$ represent an alternative factor model that has 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 has no effect on the current monetary surprise ($surprise1$).[36] 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 and we can therefore 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

[34] Appendix C shows how to extract the surprise components of the monetary rate, and presents the necessary assumption and approximations that are used.

[35] 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 1 year).

[36] Namely, we define 2×2 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, we impose a restriction that Z_1 and Z_2 are to remain orthogonal. Third, we impose a restriction that the element in the second row of the first column of the matrix $\widetilde{\Lambda}$, $\widetilde{\lambda}_{2,1} = 0$ (i.e. Z_2 has no influence on $surprise1$). For further details see Gürkaynak *et al.* (2005).

(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.[37] 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, as suggested in Gürkaynak *et al.* (2012). Namely, some of the monetary interest rate shocks 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 at this stage as before it is only a good candidate. 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, which was 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 for 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, the dummy variable is only statistically significant at the 10 percent level when using the end-of-day window. The results strengthen the assessment about 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.

[37] The correlations with $surprise1$ when using the 30-minute window, the window that ends at 10:30 AM, the mid-day window, and end-of-day window with $surprise1$ are very similar: 94, 93, 92 and 91 percent, respectively. The correlations with the variable $m3\_surprise1$ are 98, 97, 97 and 97 percent, respectively.

Table 4: Estimated Effects of "New Information" Announcements on the Size of the FG Factors

	Absolute Value Z1					Absolute Value Z2				
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.[38] An increase in Z_1 causes an effect similar to the effect of *surprise*1 reported in Table 1, particularly 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 7 years.

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

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Variables	surprise1	m3_surprise	bond 1y	bond 2y	bond 3y	bond 5y	bond 7y	bond 10y
Z1	1.000	0.734	0.517	0.354	0.269	0.219	0.162	0.131
Z2	0.000	0.087	0.237	0.354	0.524	0.576	0.576	0.507

Figure 8 in Appendix F plots a time series of the two monetary factors, and 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.

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

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 publication of various types of news has the same effect on the yield curve. In 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. In particular, under the GSS structure, it is not possible that news will affect only the medium-short part of the yield curve because the factor loadings measure the average effect on each maturity. This might lead to an imprecise identification, as the effect of bonds that were affected and ones that were not are averaged during the estimation process. In the next section, I show that this assumption is not valid, 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.

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 in June 2015.[39] Table 6 shows the announcement days on which the FG shock on at least one maturity term is found statistically significant at the 5 percent level.

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

Table 6: Forward Guidance Shocks Deduced from the Residuals Method

Date	A description of the main " new information"	Staff forecast	Press conference	Monetary rate	FG shocks (Residuals) 1-year	2-year	3-year	5-year	7-year	10-year
26-Apr-10	Statement indicating that there were additional factors supporting 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 taking into account the increased uncertainties in the global economy.				-0.062	**-0.069****	**-0.052***	-0.032	-0.021	-0.026
28-Mar-11	In this interest rate decision it was decided to increase the monetary rate by 0.5 percentage point 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-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.				0.019	0.009	0.002	-0.038	-0.036	**-0.046****
26-Sep-11	First easing after a yearlong series of 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-Oct-12	The Supervisor of Banks issued a directive limiting the LTV, in view 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 in order 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****

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

Date	A description of the main " new information"	Staff forecast	Press conference	Monetary rate	FG shocks (Residuals) 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 will 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 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 decided to reduce the interest rate from 0.25 percent 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 environment for one year ahead will return to the target range."* ('Calcalist',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

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 of these cases the information was embodied in the press release, while in others it came via the BOI Research Department's forecast or the press conference. However, in one case that was statistically significant, in March 2011, it appears that there was 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, which were derived from days of interest rate decisions, might be too high, as these days usually contain information. In this approach, I compare the residuals in relation 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.[40] For each day, I calculate confidence intervals 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 statistically significant. These results support the hypothesis that the previous confidence intervals are too conservative, at least for maturities longer than 2 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.[41] However, on only about half of the additional occasions for the 1- and 2-year maturities (17 and 9 respectively), "new information" was released.[42]

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

[41] Statistically significant at 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 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.

[42] Except 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).

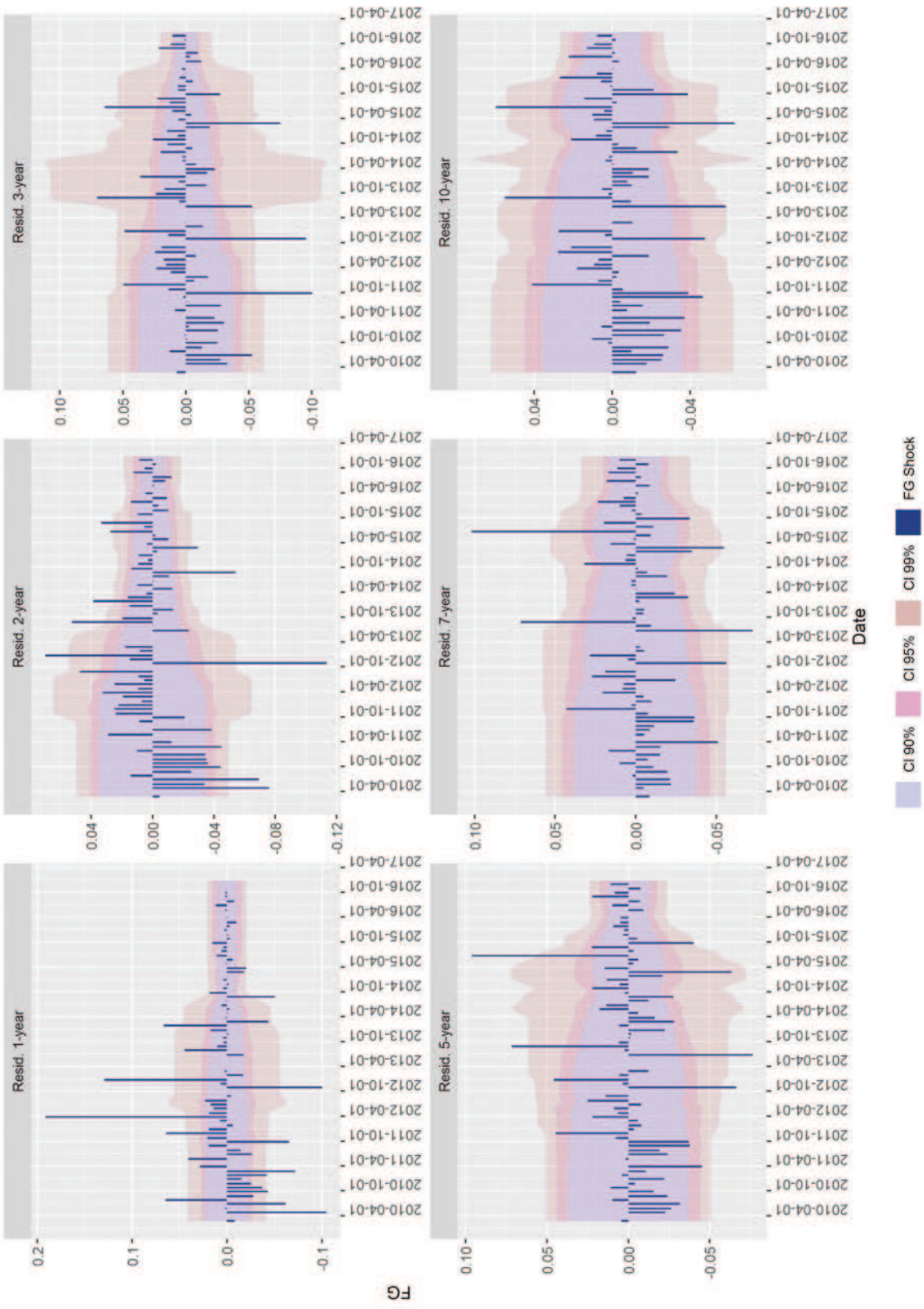


Figure 1: Estimated FG Shocks with Time-Varying Confidence Intervals Derived from "Days without Information"

As noted earlier, some of the significant results obtained in the short-term yields might be due to a bias estimation of the variable *surprise*1. This hypothesis is examined in Section 5.1.[43]

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 4. in Appendix C). As such, dates with significant BOI's statements are now found to be statistically significant. For example, when the BOI had 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 with the relaxation of the assumption that the noise distribution is constant over time.

4.3 Comparison Between the Two Approaches

In this section, I compare 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-year and longer) are close to 0.9. The correlation with the 3-year maturity shocks is still high (75%), but it drops for shorter maturities. According to these results, we can safely determine that on average the shocks that derived from both methods are similar. However, if we 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.[44] Figure 2 shows the estimated effect of the two methods on these dates. For each date, the graph on the left presents the effect of the two factors (Z_1 and Z_2), and the graph on the right presents the effect of FG in accordance with the residuals method and the effect of a monetary interest rate shock (*surprise*1).[45] When

[43] It might be the case that some of the monetary interest rate shock as estimated in the variable was only a "timing" shock, related to the exact meeting in which the change in monetary rate occurred.

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

[45] The plots in the left column show the predicted effect of each factor on the yields: $\beta_i^m Z_{i,t}$, $m \in$

using the GSS method, we 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. When using the residuals method, we identify negative and statistically significant FG shocks along the entire yield curve, with most of that effect in the short-term. Conversely, according to the GSS method we identify the effect only on the long-term yields, and we identify a large interest rate shock, which is much larger than the one estimated by $surprise1$. In the third case (June 2015), there was a press conference that included a dramatic statement from the Governor. According to the GSS method, on that date there were also short-term FG shocks, but according to the residuals method the shocks were solely on the medium- and long-term yields.[46] In summary, it seems that in cases where news only affected specific terms, we estimate the FG effect incorrectly when using the GSS method, especially at the short part of the yield curve when these effects are sometimes perceived by the model as interest rate shocks.

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

In order to further examine whether the GSS method estimates the FG effect incorrectly, I check if Z_2 also partially captures the effect of global shocks. Table 8 presents the results of regression Z_2 on US Treasury yields. If we estimated the FG effect accurately, the US Treasury variables would not be statistically significant. However, the result confirms the assessment that part of the FG shocks captures global influences. The US Treasury bonds for periods of three years and more are statistically significant at the 5 percent level, and the 2-year bond is significant at the 10 percent level.

$\{1, 2, 3, 5, 7, 10\}$ and $i \in \{1, 2\}$ $t \in T$. 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 $surprise1$: $\beta^m surpise_t^1$, $m \in \{1, 2, 3, 5, 7, 10\}$ and $t \in T$.

[46] 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 7: Correlation Matrix Between the FG shocks Derived From the "Residuals Method" and Factors Z_1 and Z_2

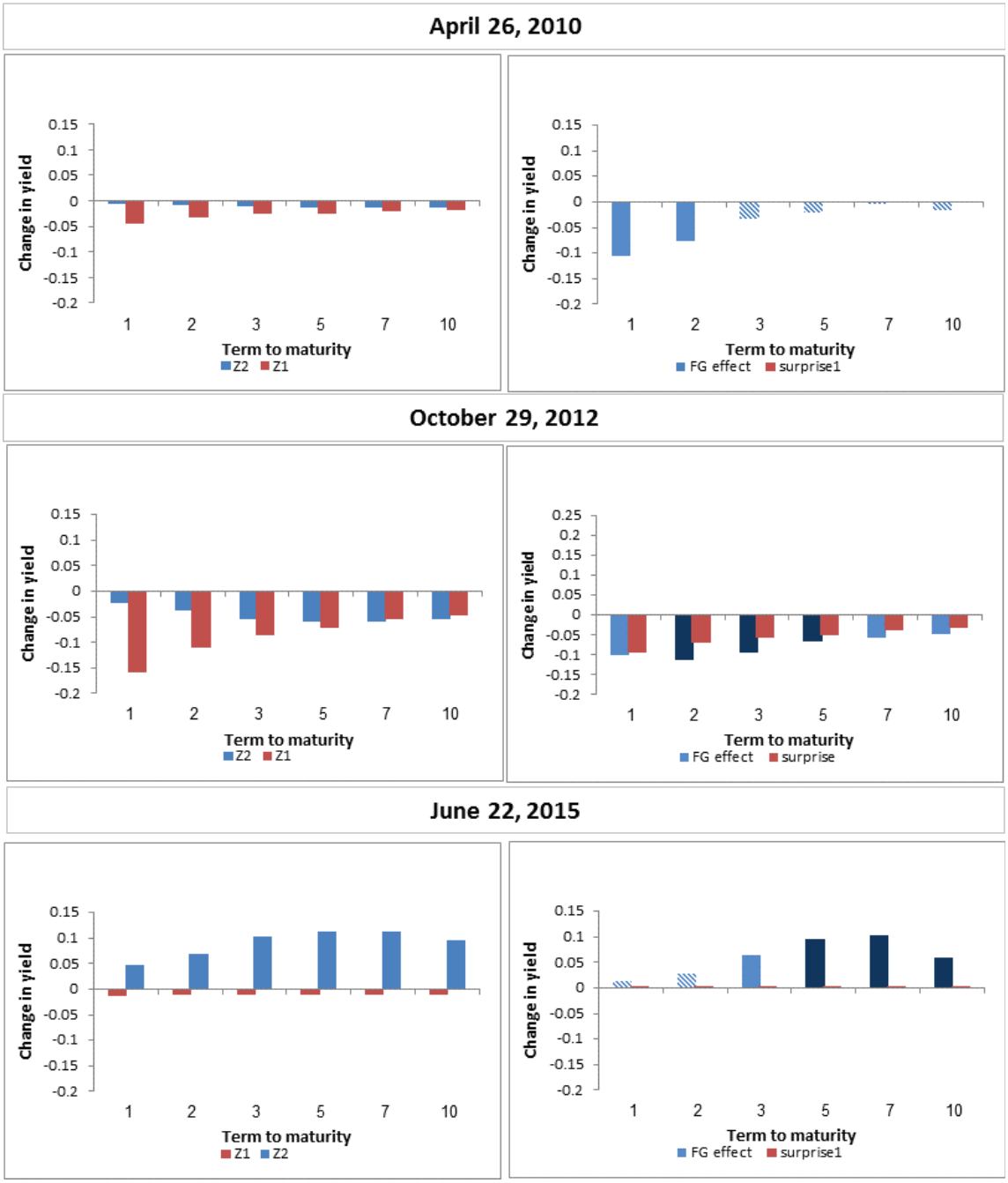
	Z2	Z1	Resid. 10-year	Resid. 7-year	Resid. 5-year	Resid. 3-year	Resid. 2-year	Resid. 1-year
Z2	1.00							
Z1	0.00	1.00						
Resid. 10-year	0.88	0.02	1.00					
Resid. 7-year	0.89	0.02	0.93	1.00				
Resid. 5-year	0.88	0.07	0.91	0.95	1.00			
Resid. 3-year	0.75	0.16	0.76	0.79	0.85	1.00		
Resid. 2-year	0.52	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

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

	Z2					
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	0.001	0.004	0.004	0.005	0.004
	(0.006)	(0.005)	(0.006)	(0.006)	(0.006)	(0.006)
Observations	75	75	75	75	75	75
R-squared	0.000	0.080	0.113	0.123	0.144	0.140

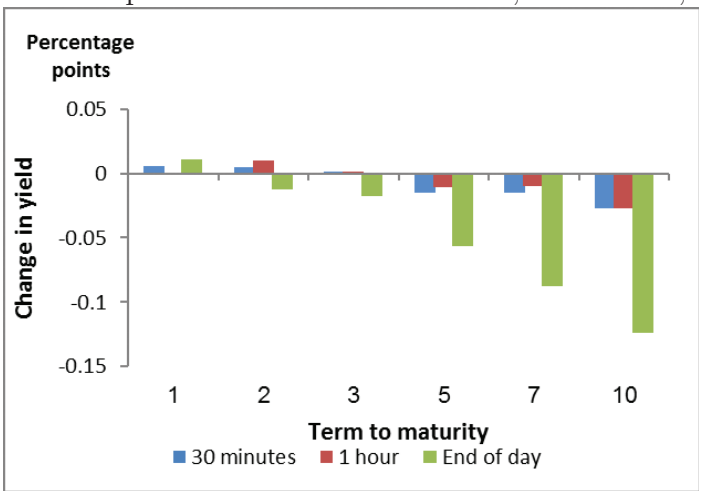
Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

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



The graphs on the left present the predicted effect of the factors Z_1 and Z_2 on the yields: $\beta_i^m Z_{i,t}$, $m \in \{1, 2, 3, 5, 7, 10\}$ and $i \in \{1, 2\}$ $t \in T$. The graphs on the right presents 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 shock, as estimated by the variable $surprise1$: $\beta^m surpise_t^1$, $m \in \{1, 2, 3, 5, 7, 10\}$ and $t \in T$.

Figure 3: Responses of Government Bonds, October 26, 2015



4.5 Identifying FG Shocks Through Wider Windows

This section explores the hypothesis that using a narrow time window around the monetary announcement is consistent with an underestimation of the FG shocks. This may be the case if it takes some time for financial markets to fully understand the implication of the news, especially when the news is ambiguous or complex. As opposed to a change in the monetary rate, which is fully absorbed by the markets shortly after it is announced (as also reported in Section 3.2.2), the information published by the CB that is subject to interpretation and an assimilation process is also dependent on other market participants.

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 effect of that message was only moderate: 1 basis point on the 5-year yield and 3 basis points on the 10-year yield (see Figure 3). However, the 1-day effect was very significant: 6 and 12 basis points, respectively. Furthermore, our FG estimates from both methods (and maturities) on that announcement 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, it is likely that no relevant local news had been published.[47] In addition, we minimize the impact of global shocks by using the control variables of the US yields. The results while using the mid-day window again identify all the dates that were found to be statistically significant with the 1-hour window. In addition, we identify four more dates: November 28, 2011, August 25, 2014, August 24, 2015 and October 26, 2015.

With the exception of the August 2014 announcement, all others included a release of information that can affect the public's expectation of the future path of the monetary rate. More importantly, I find that the press release in October 2015 had a statistically significant effect on the 10-year yield (8 basis points), as would be expected from such significant statement. When the window size is increased further until the end of business day, it seems that the impact of the statement was even stronger: 12 and 8 basis points on the 10- and 7-year yields, which are both statistically significant.[48] These results support the assessment that in some cases, use of an intra-daily window would be consistent with a large underestimation of the FG shock.

5 Robustness Checks

5.1 An Alternative Measure for a Surprise Monetary Shock

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 shocks (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 we may have used imprecise estimates for the unexpected monetary rate change (i.e., $surprise_1$). As already mentioned in Section 3.3.2, Z_1 is more highly correlated with the 3-month monetary shocks (i.e., $m_3\_surprise$), than

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

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

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

VARIABLES	1 year	2 year	3 year	5 year	7 year	10 year
m3_surprise1	0.629***	0.442***	0.350***	0.309***	0.237***	0.190***
	(0.055)	(0.065)	(0.061)	(0.057)	(0.055)	(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)
Observations	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

with our measure for current monetary surprise. 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. Simply put, the alternative explanations suggest that the GSS method actually 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 $m_3\_surprise$. I conclude that even if there was some bias in our measure for unexpected monetary rate change, it does not affect our conclusion regarding the validity of the assumption in question.

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, which are taken from Bloomberg.[49] 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.[50] Clearly, since the changes in the corresponding US yields do not match our 1-hour window, some of these changes are not relevant in explaining the yield change 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 a different time convention. Their 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), respectively.[51]

Table 10 shows the results of estimating Equation 4 without a constant (i.e., $\beta_0 = 0$),

[49] US data are the on-the-run Treasuries obtained from Bloomberg (mid price).

[50] The hours according to Tel Aviv time are correct excluding differences due to the exact date of the beginning and end of daylight savings time.

[51] Yahoo Finance data are the on-the-run Bid price.

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)
Observations	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

for five- and ten-year yields.[52] Columns 1 and 2 show the results while 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.

Results for the FG shocks from the two data sources are similar with a few exceptions, which are shown in 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 that were found to be statistically significant using the Yahoo Finance data seem more reasonable (as would be expected ex-ante).

[52] Because Yahoo data are available only for these maturities.

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

Date	A description of the main "new information"	Staff forecast	Press conference	Monetary rate	FG shocks (Residuals) Bloomberg 5-year	Bloomberg 10-year	Yahoo Finance 5-year	Yahoo Finance 10-year
May 24, 2010	The Supervisor of Banks issued draft guidelines to exercise strict checks on housing credit and limiting the LTV, in view 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****
August 29, 2011	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***
November 28, 2011	The Monetary Committee stated that the reduction in the interest rate, together with the weakening of the exchange rate, is expected to help Israel's economy deal with the difficulties confronting it.				**0.045***	**0.041***	**0.060****	**0.058*****
June 24, 2013	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 will continue to examine the impact of the steps and will act as necessary in the future.	+			**-0.076*****	**-0.058*****	-0.037	-0.27
September 24, 2015	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.	+	+		**-0.040***	**-0.038***	**-0.046***	**-0.046****

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

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 can be implemented in a SOE and 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 they are both informative measures. Furthermore, I find that the FG shocks from both methods are highly correlated. Correlations between the standard measure and the new measure for long maturities (5-year 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, the standard method in some cases derives imprecise shocks when that news only affected specific terms, especially at the short part of the yield curve when these effects are sometimes perceived by the model as interest rate shocks. 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 types of FG shocks. Simply speaking, the GSS method actually 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. It is important for policymakers to better understand the mechanism—particularly the effect of each specific FG shock—since different information is conveyed with each decision. Furthermore, it is important for policymakers to understand how different maturities are affected.

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Appendices

A Alternative Methods to Estimate Monetary Interest Rate Shocks

There are alternative methods to estimate monetary interest rate shocks that do not use futures contracts: Professional forecasters' expectations (e.g., Hussain (2011)),[53] deduce the expected change from short forward rates, or infer from a model (e.g., DSGE).

There are serval disadvantages in these other methods. The literature has shown that forward rates are poor measures of policy expectation (Gürkaynak *et al.* (2012)).[54] 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 estimator. Therefore, the surprise estimator might include an anticipated component.[55] Another problem is that each forecaster estimates the mode, as their forecasts are in increments of 0.25%. As a result, the surprise measure would be imprecise. For example, if all forecasters predict that there is a 51% likelihood that the monetary rate will not change and a 49% likelihood

[53] Hussain (2011) uses professional forecasters' expectations from the Bloomberg World Economic Calendar and calculates the surprise component as the standardized difference between the expected change and the actual change: $\Delta r_t^u = \frac{\Delta r_t - mean(foracater's)}{\sigma(foracater's)}$

[54] 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 in order to forecast the upcoming monetary rate, bonds with short maturities must be used, and the estimator would be noisy and imprecise.

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

that it will rise, then according to the estimator, there is no expectation for a 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 is realized, the yields would change significantly, but it would mistakenly not be attributed to a monetary shock. 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 that were not available at the time of the decision. In the paper I choose to identify the surprise component using OIS contracts. Further details are explained in Appendices B and C.

B The Israeli Swap Market (TELBOR)

In order to support the development of the TELBOR market, the BOI established an interorganizational 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 fixing TELBOR interest rates.[56]

The Tel Aviv Inter-Bank Offered Rate (TELBOR) is based on interest rate quotes by a number of commercial banks in the interbank market.[57] 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 1 business day, 1 month, 3 months, 6 months, 9 months, and 1 year. The contributors report the TELBOR interest rates on a continuous basis, 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, which are the references for the interest rate derivatives (e.g., the 1M TELBOR is the fixing leg for the 1 month OIS), are calculated

[56] 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

[57] Currently 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, quotations were also received from a number of foreign banks, including Barclays Capital, Citibank, HSBC and Deutsche Bank.

each day as the average quotes at a random time between 11:45 and 11:55.

As opposed to other benchmark interest rate markets such as the LIBOR market, the TELBOR market includes a commitment mechanism to carry out transactions according to their quotes between 11:00 and 12:00. The commitment in relation to over-night rate quotes is for a loan at the TELBOR interest rate quote, or for a deposit at the TELBOR interest rate quote, minus 4 basis points for an amount of at least NIS 50 million. For the longer rates, each rate is linked to some interest rate derivative, and there are obligations for making transactions relative to the contributor's quote. For example, the commitment for a 1-month or 3-month OIS transaction is at an obligatory spread of ± 2 basis points from the quoted TELBOR interest rate for 1 or 3 months respectively, for an amount of NIS 100 million.

As a result, according to Stein (2017), 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 interest rate, determined on the basis of citations, includes a relatively low risk and liquidity premium. These two characteristics are appealing when trying to deduce the market expectation of the future monetary rate. Until 2007, there was no commitment to make transactions according to quotes, and the commitment for the over-night rate only began in 2007. The relevant commitment for the 3-month OIS started in June 2010, and the relevant commitment for the 1-month OIS started in May 2013.[58]

C Deducing Monetary Shocks via OIS Contracts

Optimally, to avoid endogeneity and simultaneity issues, it is important to take a small window around the monetary announcement (such as half an hour), during which we deduce the monetary interest rate shock. Unfortunately, in practice the commercial bank 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

[58] Further details regarding to the TELBOR market, especially regarding the commitment and transactions may be found at http://www.boi.org.il/en/Markets/TelborMarket/Documents/telbordef_eng.pdf.

interest rate shock 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 1-month TELBOR rate (1-month OIS), namely, the rate on the announcement day, which is calculated around 12:00, 4 hours before the announcement ($5\frac{1}{2}$hours prior to 2014), and the rate at 12:00 on the day following the announcement.[59] In practice, there are no quote updates after 12:00. However, it is possible to use earlier quotes, as some banks start reporting at 08:00, thus shrinking the window's size. However, only a small number of banks do so, and using these early rates could therefore lead to some 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 4 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.

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:

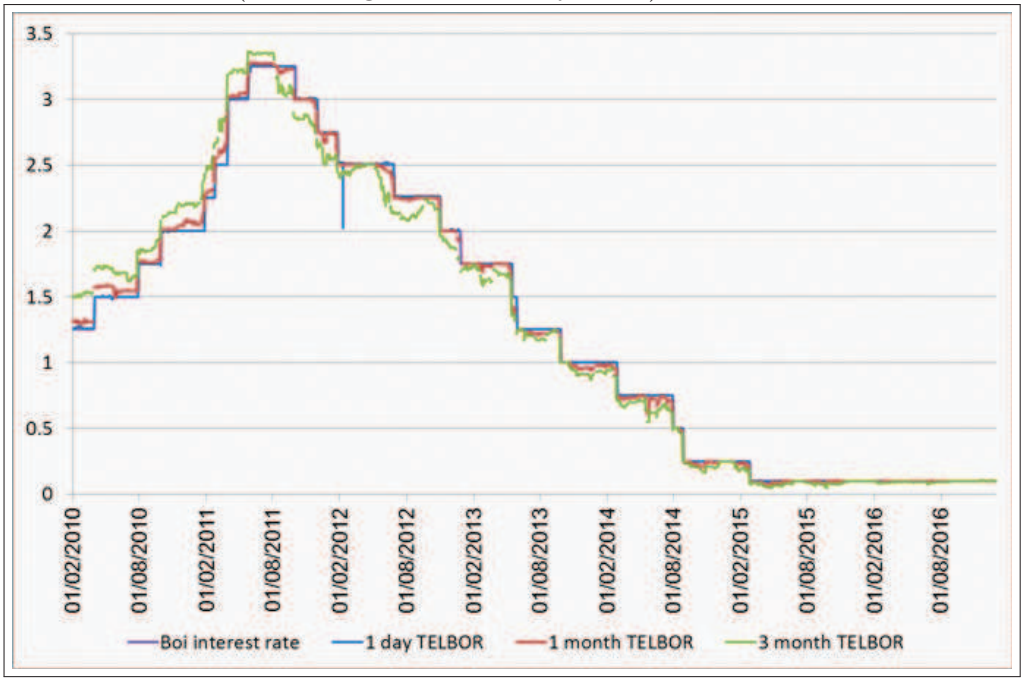
$$\left[\prod_{i=t^*}^{d_0(t)}\left(1+\frac{r_i^{0/N}}{365}\cdot n_i\right)-1\right]\cdot\frac{365}{m_t^*} \tag{C.1}$$

where $r_i^{0/N}$ 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 day), 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 $r_i^{O/N}$,[60]

[59] For five monetary announcements, I calculated the monetary interest rate shock 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 day of the announcement to three days after. March 24, 2013 - from two days before the announcement to one day after. However, in practice, in our sample I used the longer window only **once**, December 24, 2012. The other dates are not being used since there was also no trading on the stock market (TASE) on those days.

[60] For example, on a regular business day, n_i is equal to 1, and on Fridays it is equal to 3 since there is

Figure 4: BOI Interest Rate, and 1-Day, 1-Month and 3-Month TELBOR Rates, February 2010 to December 2016 (Percentage Points, Daily Data)



and m_t^* 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, when calculating the floating leg, the average for all the calendar days within the period is calculated, but the interest rate is compounded only for business days. From a no-arbitrage argument:

$$1+\frac{m_t^*\cdot f_t^s}{365}=E_t\left[\prod_{i=t^*}^{d_0(t)}\left(1+\frac{r_i^{0/N}}{365}\cdot n_i\right)\right]\cdot\left(1+\frac{m_t^*\mu_t}{365}\right).$$

The term μ_t^s may represent a risk premium, liquidity premium or any other premium. 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:

no trading in the TELBOR market until Monday.

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

Assuming the expected average gap $\left(\overline{1+\frac{\eta}{365}}\right)$ is independent before and after the announcement and of expected r_1^f:

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

Applying the logarithm function and using first order Taylor approximations, we derive[61]:

$$m_t^*\cdot f_t^{1m}=x_t^*r_0^f+(m_t^*-x_t^*)E_t\left[r_1^f\right]+x_t^*E_t\left[\bar{\eta}_{t^*\le t<t^*+x_t^*}\right]+(m_t^*-x_t^*)E_t\left[\bar{\eta}_{t^*+x_t^*\le t\le t^*+m_t^*}\right]+m_t^*\mu_t\Rightarrow$$
$$f_t^{1m}=\frac{x_t^*}{m_t^*}r_0^f+\frac{(m_t^*-x_t^*)}{m_t^*}E_t\left[r_1^f\right]+\frac{x_t^*}{m_t^*}E_t\left[\bar{\eta}_{t^*\le t<t^*+x_t^*}\right]+\frac{(m_t^*-x_t^*)}{m_t^*}E_t\left[\bar{\eta}_{t^*+x_t^*\le t\le t^*+m_t^*}\right]+\mu_t \tag{C.2}$$

As Equation C.2 shows, the contract rate 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 and the last term is a risk premium. Similarly , f_j^s, the contract rate issued on day j, after the monetary announcement, equals the following[62]:

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

[61] Using second order Taylor approximation of $\log(x)$ around $E(x)$: $log(x)\approx log(E[x])+\frac{1}{(E[x])}(x-E[x])-\frac{1}{2E^2[x]}(x-E[x])^2\Rightarrow^{E(\cdot)}$
$Elog(x)\approx log(E[x])-\frac{Var(x)}{2E[x^2]}$.
If we use the first order approximation we get, $Elog(x)\approx log(E[x])$.

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

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

$$surprise := (r_1^f - E_t\left[r_1^f\right]) = \frac{\left(m_j^* \cdot f_j^{1m} - m_t^* \cdot f_t^{1m}\right)}{(m_t^* - x_t^*)} + \frac{(x_t^* - x_j^*)}{(m_t^* - x_t^*)} r_0^f - \frac{\left\{(m_j^* - m_t^*) + (x_t^* - x_j^*)\right\}}{(m_t^* - x_t^*)} r_1^f +$$
$$- \frac{x_j^*}{(m_t^* - x_t^*)}\left(E_j\left[\bar{\eta}_{j^* \le t < j^* + x_j^*}\right] - E_t\left[\bar{\eta}_{t^* \le t < t^* + x_t^*}\right]\right) - \left(E_j\left[\bar{\eta}_{j^* + x_j^* \le t \le j^* + m_j^*}\right] - E_t\left[\bar{\eta}_{t^* + x_t^* \le t \le t^* + m_t^*}\right]\right) +$$
$$- \frac{(x_t^* - x_j^*)}{(m_t^* - x_t^*)}\left(E_j\left[\bar{\eta}_{j^* + x_j^* \le t \le j^* + m_j^*}\right] - E_t\left[\bar{\eta}_{t^* \le t < t^* + x_t^*}\right]\right) - \frac{(m_j^* - m_t^*)}{(m_t^* - x_t^*)} E_j\left[\bar{\eta}_{j^* + x_j^* \le t \le j^* + m_j^*}\right] - \frac{m_j^* \mu_j - m_t^* \mu_t}{(m_t^* - x_t^*)} \tag{C.3}$$

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

$$\begin{aligned}
E_j\left[\bar{\eta}_{j^* \le t < j^* + x_j^*}\right] &= E_t\left[\bar{\eta}_{t^* \le t < t^* + x_t^*}\right] \\
E_j\left[\bar{\eta}_{j^* + x_j^* \le t \le j^* + m_j^*}\right] &= Et\left[\bar{\eta}_{t^* + x_t^* \le t \le t^* + m_t^*}\right] \\
E_j\left[\bar{\eta}_{j^* + x_j^* \le t \le j^* + m_j^*}\right] &= E_t\left[\bar{\eta}_{t^* \le t < t^* + x_t^*}\right] \\
\frac{(m_j^* - m_t^*)}{(m_t^* - x_t^*)} E_j\left[\bar{\eta}_{j^* + x_j^* \le t \le j^* + m_j^*}\right] &= 0 \\
and\ \frac{m_j^* \mu_j - m_t^* \mu_t}{(m_t^* - x_t^*)} &= 0
\end{aligned}$$

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 calculation of the floating leg is the same (the amount 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. A sufficient assumptions instead of the first four assumption is that the expected sum of the four factors would be zero.

I have checked the realization of the sum of the four factors for a period even longer than the sample, and 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 the gap differences are therefore also close to zero. Additionally, we can usually take $j^* = t^* + 1$, and we would usually find 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 $j^* = t^* + 1$, $m_j^* = m_t^*$ and under the assumptions above, we derive a similar expression to the surprise component that is derived from futures contracts plus a small adjustment:

$$surprise := (r_1^f - E_t\left[r_1^f\right]) = \frac{m_t^*\left(f_j^{1m} - f_t^{1m}\right)}{(m_t^* - x_t^*)} + \frac{1}{(m_t^* - x_t^*)} r_0^f - \frac{1}{(m_t^* - x_t^*)} r_1^f \qquad \text{(C.4)}$$

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

$$m_t^* \cdot f_t^s = x_t^* r_0^f + (x_{2,t}^* - x_t^*) E_t\left[r_1^f\right] + (m_t^* - x_{2,t}^*) E_t\left[r_2^f\right] + x_t^* E_t\left[\bar{\eta}_{t^* \le t < t^* + x_t^*}\right] + (x_{2,t}^* - x_t^*) E_t\left[\bar{\eta}_{t^* + x_t^* \le t \le t^* + x_{2,t}^*}\right] + (m_t^* - x_{2,t}^*) E_t\left[\bar{\eta}_{t^* + x_t^* \le t \le t^* + m_t^*}\right] + m_t^* \mu_t \Rightarrow$$

$$m_j^* \cdot f_j^s = x_j^* r_0^f + (x_{2,j}^* - x_j^*) r_1^f + (m_j^* - x_{2,j}^*) E_j\left[r_2^f\right] + x_j^* E_j\left[\bar{\eta}_{j^* \le t < j^* + x_j^*}\right] + (x_{2,j}^* - x_t^*) E_j\left[\bar{\eta}_{j^* + x_j^* \le t \le j^* + x_{2,j}^*}\right] + (m_j^* - x_{2,j}^*) E_j\left[\bar{\eta}_{j^* + x_{2,j}^* \le t \le j^* + m_j^*}\right] + m_j^* \mu_j$$

where $x^*_{2,t}$ is the number of days until the second monetary interest rate is implemented. Our measure of surprise is equal to:

$$\frac{\left(m^*_j \cdot f^{1m}_j - m^*_t \cdot f^{1m}_t\right)}{(m^*_t - x^*_t)} + \frac{(x^*_t - x^*_j)}{(m^*_t - x^*_t)} r^f_0 - \frac{\left\{(m^*_j - m^*_t) + (x^*_t - x^*_j)\right\}}{(m^*_t - x^*_t)} r^f_1 =$$
$$\frac{(x^*_{2,t} - x^*_t)(r^f_1 - E_t\left[r^f_1\right]) + (m^*_t - x^*_{2,t^*})(E_j\left[r^f_2\right] - E_t\left[r^f_2\right])}{(m^*_t - x^*_t)} + \frac{\left\{(m^*_j - m^*_t) + (x^*_{2,t} - x^*_{2,j})\right\}}{(m^*_t - x^*_t)}(E_j\left[r^f_2\right] - r^f_1)$$

Namely, in a 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 next 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 $(\left\{(m^*_j - m^*_t) + (x^*_{2,t} - x^*_{2,j})\right\})$ is close to zero and in many cases $E_j\left[r^f_2\right] = r^f_1$.

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:

$$surprise\_3M := \frac{m^{3m*}_j \cdot f^s_j - m^{3m*}_t \cdot f^{3m}_t}{m^{3m*}_t - x^{3m*}_{1,t}} + \frac{x^{3m*}_{1,t} - x^{3m*}_{1,j}}{m^{3m*}_t - x^{3m*}_{1,t}} r^f_0 - \frac{\left\{(m^{3m*}_j - m^{3m*}_t) + (x^{3m*}_{1,t} - x^{3m*}_{1,j})\right\}}{m^{3m*}_t - x^{3m*}_{1,t}} r^f_1 \tag{C.5}$$

where m^{3m*}_t is the number of calendar days in the relevant calculation period for a contract issued at day t. $x^{3m*}_{i,t}$ is the number of days on which the next i monetary rate is relevant for the contract (e.g., $x^{3m*}_{1,t}$ is the number of days for next monetary rate). Under similar assumptions as before:

$$surprise\_3M = \frac{1}{(m^{3m*}_t - x^{3m*}_{1,t})} \sum_i \left\{(x^{3m*}_{i+1,t} - x^{3m*}_{i,t})(E_j\left[r^f_i\right] - E_t\left[r^f_i\right])\right\} +$$
$$\frac{\left\{(m^{3m*}_j - m^{3m*}_t) + (x^*_{2,t} - x^*_{2,j})\right\}}{(m^{3m*}_t - x^{3m*}_t)} \cdot (E_j\left[r^f_{last}\right] - r^f_1)$$

Our measure for the 3-month is surprise equal to a weighted average of the changes in expectation of the interest rate path and an error term due to our assumption that

Figure 5: Monetary Interest Rate Shocks, February 2010–December 2016

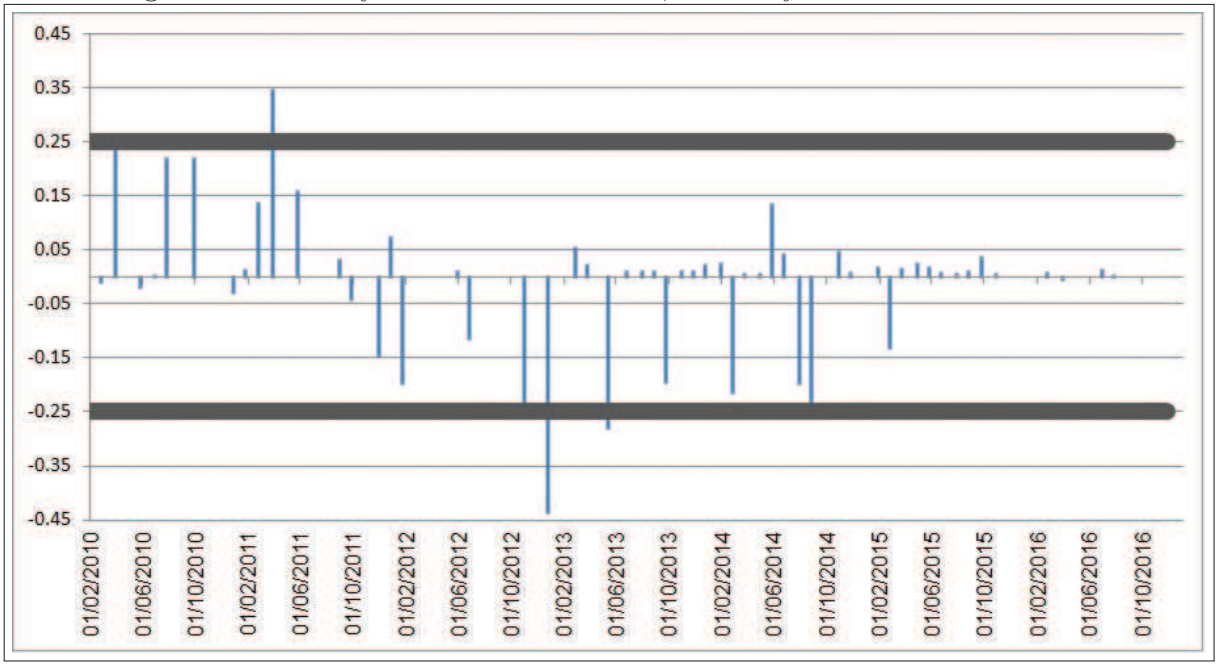


Table 12: Descriptive Statistics, Monetary Interest Rate Shock for Current and 3-Month Rate, February 2010-December 2016

variable	*Obs*	*Mean*	*Std.Dev*	*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

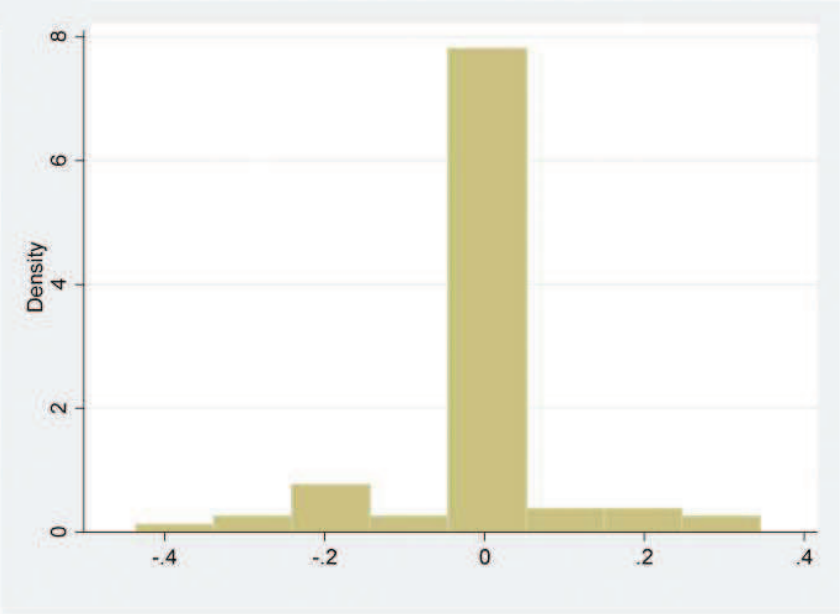
$E_j\left[r^f_{last}\right] = r^f_1$. However, as was explained before, this error term is quite negligible since $\frac{\left\{(m_j^{3m*} - m_t^{3m*}) + (x^*_{2,t} - x^*_{2,j})\right\}}{(m_t^{3m*} - x_t^{3m*})} \approx \frac{1}{90}$.

Figure 5 shows the monetary interest rate shocks in Israel for the current rate, according to the methodology presented in this appendix. Table 12 presents descriptive statistics, and Figure 6 a histogram of the monetary shocks. Table 13 presents the actual, expected, and unexpected changes in the Bank of Israel rate and my measure for the 3-month surprise for our sample period (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
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
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	-	-	-

Figure 6: Histogram of Monetary Interest Rate Shocks, February 2010–December 2016



D Classification Rule for Monetary Decisions that Included New Information

During our sample period, the interest rate press release followed a relatively standard structure, divided 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.). At the time of the press release, the information in this section was already published and known to the public. The second part of the press release includes the considerations behind the decision, and is comprised of three sub-sections: an opening paragraph, the main considerations underlying the decision, and a concluding paragraph. The second sub-section, in spite of its title, does not include any new information 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, and most of the 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 interest rate path, reasons for determining the interest rate, and assessments regarding the extent of risks to achieving the inflation target and growth.

I decided to classify 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. Obviously, this type of classification involves some level of subjectivity, but since I only check for changes in the text, and I do not pretend to determine whether the change is meaningful or the direction of impact, I believe this form of 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.[63] Seven press conferences were held during our estimation period, and six are included in our estimation.[64] I 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.[65]

[63] The briefings take place 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 factors in the decisions, and answers questions from the press on these matters.

[64] 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 shock could therefore not be calculated.

[65] 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.[66] 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).[67] This assessment is supported by a scree test analysis, as shown in Figure 7.[68] 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 suggests 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 7. The results for the longer 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.[69] A

[66] 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.

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

[68] 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).

[69] 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

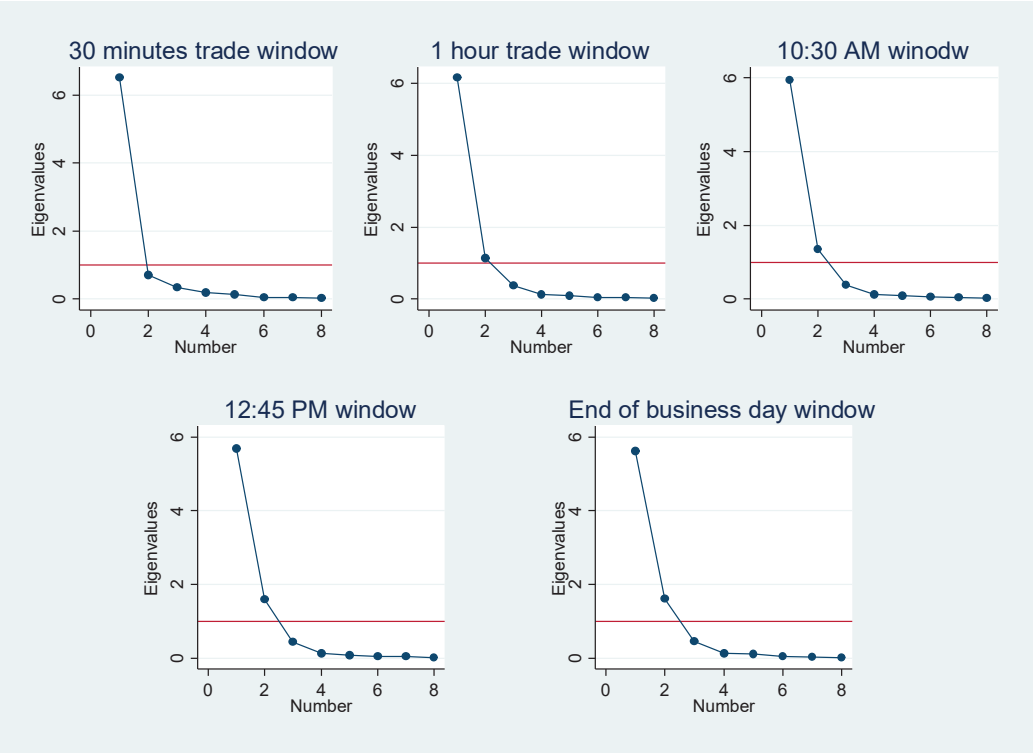
Table 15: First through Fourth Eigenvalues Derived from the Principal Components Analysis, and the Amount of Variation each Factor Explains

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%

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).

of the information is incorporated within 30 minutes and a narrow window helps reduce the noise, thereby increasing the precision of the estimators.

Figure 7: Scree Plots Tests



Scree plot for various sizes of windows, the graphs presents 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, and I specify whether it included a press conference or a quarterly macroeconomic forecast by the BOI Research Department (Table 16).

In addition, Figure 8 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 8: Monetary Rate Factor (Z_1) and FG Factor (Z_2), February 2010–December 2016

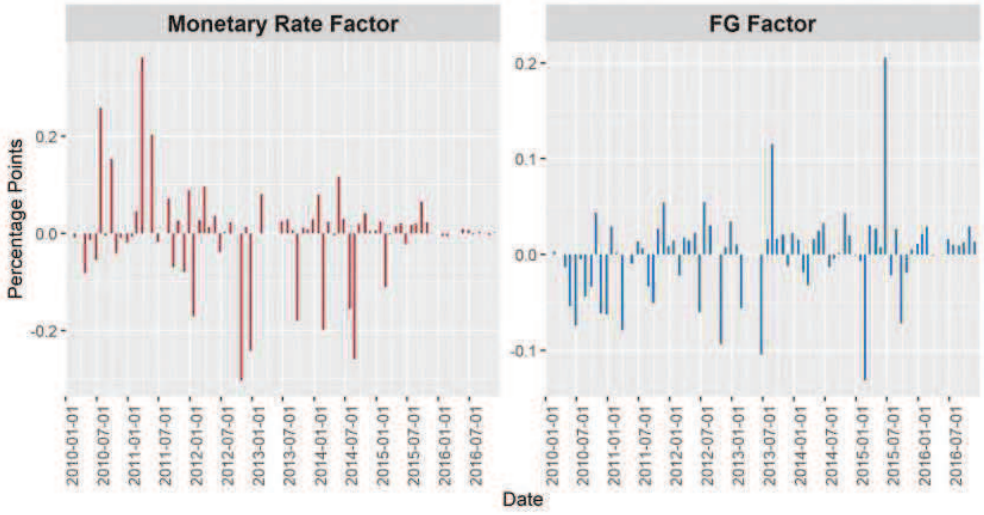


Table 16: Ten Largest Observations of the FG Factor

Date	A description of the main " new information"	Z2	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 made by the Governor *"... it appears that the probability that we will be required to use unconventional tools in the near future has declined."*	0.21	+	+	
23-Feb-15	The Monetary Committee decided to reduce the interest rate from 0.25 percent 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 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 will 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, in view 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 in order to support economic activity, and because of the absence of inflationary pressures.	0.09			-0.25
28-Mar-11	In this interest rate decision it was decided to increase the monetary rate by 0.5 percentage point 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 taking into account the increased uncertainties in the global economy.	0.07			
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.	0.07			
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 the process 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 in relation to the noise distribution on days without interest rate decisions or publication of other important information.[70] 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).[71] In order to avoid bias caused by outliers, the confidence intervals are calculated directly: the $90^{th}, 95^{th}$ and 99^{th} percentiles of the absolute values of the bond yields differences. 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).[72] This approach also allows us to relax the assumption that the noise distribution is constant over the 7 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 combination of confidence level and time to maturity, using a Gaussian kernel.[73] As shown in plots 9, the procedure affects only sharp transitory changes.

It should be noted that in practice I only use specifics points of these series, the days of interest rate decisions.

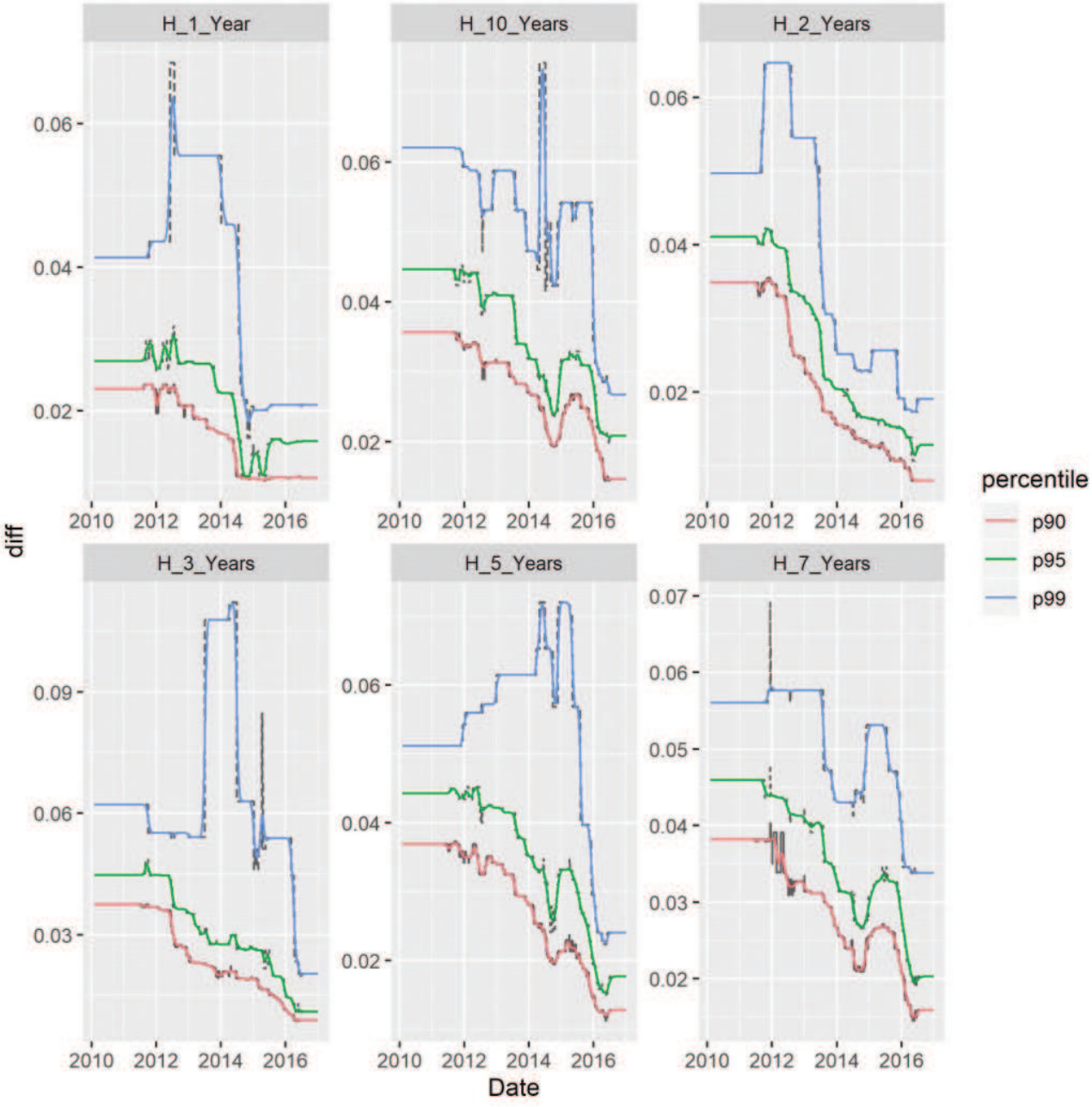
[70] I also omit days of CPI publications in cases it happens during our event window and days on which the BOI had made FX intervention. Some addtional days were omitted in light of problems in the BOI government bond quote database.

[71] For reasons of simplicity and since I only estimate the coefficients and do not know their actual values, I use the difference in bond yields instead of the regressions's residuals. Furthermore, under the additional standard assumption, that the population error is normally distributed, we obtain a more conservative threshold levels.

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

[73] To eliminate the sharp jumps, 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 9: Quantiles With and Without Smoothing - 1-Hour Window



The confidence intervals are calculated directly from the percentiles of the absolute values of the bond yields differences. The "raw" confidence 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

Figure 10:

	Absolute Value Z1					Absolute Value Z2				
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	-0.011	-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)
Observations	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

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

I Results Using the Residuals Method with a Wider Window

The following table shows days on which the FG shock is found statistically significant at the 5 percent level on at least one maturity term. Where 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.

Date	A description of the main " new information"	Staff forecast	Press conference	Monetary rate	FG shocks (Residuals) 1-year	2-year	3-year	5-year	7-year	10-year
26-Apr-10	Statement indicating that there were additional factors supporting 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 taking into account the increased uncertainties in the global economy.				-0.067	**-0.095*****	**-0.067****	-0.053	-0.037	-0.039
28-Mar-11	In this interest rate decision it was decided to increase the monetary rate by 0.5 percentage point 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-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.				0.007	0.032	0.029	**-0.092*****	**-0.093*****	**-0.084*****
26-Sep-11	First easing after a yearlong series of 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-11	The Monetary Committee stated that the reduction in the interest rate, together with the weakening of the exchange rate, is 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

Date	A description of the main " new information"	Staff forecast	Press conference	Monetary rate	FG shocks (Residuals) 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, in view 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 in order 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 will 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 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.				0.02	**0.056***	**0.084****	**0.079****	**0.077****	**0.061***

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

Date	A description of the main " new information"	Staff forecast	Press conference	Monetary rate	FG shocks (Residuals) 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 decided to reduce the interest rate from 0.25 percent 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 environment for one year ahead will return to the target range."* ('Calcalist', June 22, 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 to growth, have increased.				0.01	0.052	**0.072****	**0.074****	**0.078****	**0.074****
26-Oct-15	The Monetary Committee's published its 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 $m3\_surprise$

The following table shows days on which the FG shock is found statistically significant at the 5 percent level on at least one maturity term. Where 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.

Date	A description of the main " new information"	Staff forecast	Press conference	Monetary rate	FG shocks (Residuals)					
					1-year	2-year	3-year	5-year	7-year	10-year
26-Apr-10	Statement indicating that there were additional factors supporting 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 taking into account the increased uncertainties in the global economy.				-0.036	**-0.053** **	**-0.043** *	-0.026	-0.02	-0.023
28-Mar-11	In this interest rate decision it was decided to increase the monetary rate by 0.5 percentage point 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-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.				0.005	**0.000**	**-0.004**	-0.04*	-0.035	-0.047**
26-Sep-11	First easing after a yearlong series of 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

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

Date	A description of the main " new information"	Staff forecast	Press conference	Monetary rate	FG shocks (Residuals) 1-year	2-year	3-year	5-year	7-year	10-year
25-Jun-12	The BOI emphasized that the interest rate reduction will contribute to strengthening 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
29-Oct-12	The Supervisor of Banks issued a directive limiting the LTV, in view 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 in order 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 will 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***

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

Date	A description of the main " new information"	Staff forecast	Press conference	Monetary rate	FG shocks (Residuals) 1-year	2-year	3-year	5-year	7-year	10-year
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.				0.014	**0.055****	**0.071*****	0.07***	0.069***	0.054**
23-Feb-15	The Monetary Committee decided to reduce the interest rate from 0.25 percent 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	0.001	**-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 environment for one year ahead will return to the target range."* ('Calcalist', June 22, 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