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Monetary policy and financial asset prices in Poland

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Abstract

The aim of this study is to investigate the effects of monetary policy on financial asset prices in Poland. Following Gürkaynak et al. (2005), I test how many factors adequately explain the variability of short--term interest rates around meetings of the Monetary Policy Council, finding that there are two such factors. The first one has a structural interpretation as a "current interest rate change" factor and the second one as a "future interest rate changes" factor, with the latter related to monetary policy communication. Regression analysis shows that not only changes in the current interest rate but also monetary policy communication matters for government bond yields, stock prices and the exchange rate in Poland. It has important implications for the conduct of monetary policy, especially in a low inflation and low interest rate environment.

Keywords: monetary policy, financial asset prices

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1 Introduction

Since the Great Recession (2007–2009), communication has become a more exploited dimension of monetary policy. For example, in December 2008 the Federal Reserve lowered the federal funds rate target to 0–0.25%, hitting the zero lower bound (ZLB). In a statement after the decision, the Federal Open Market Committee (FOMC) indicated that "the Committee anticipates that weak economic conditions are likely to warrant exceptionally low levels of the federal funds rate for some time". Later on "some time" was replaced by other forms of forward guidance, defined as statements about the outlook for monetary policy in the future (Woodford 2012). Forward guidance was advocated by Krugman (1998) and Eggertsson and Woodford (2003) as a method of additional monetary policy accommodation at the ZLB. Specifically, they suggested a commitment of the central bank to maintain a zero interest rate for a longer period than according to the "standard" policy rule, in order to lower long-term interest rates and raise inflation expectations. Or – as Krugman (1998) put it – the central bank should "credibly promise to be irresponsible".

However, one cannot say that forward guidance started with the Great Recession. For instance, the Reserve Bank of New Zealand has published interest rate forecasts since 1997. On the use and effectiveness of forward guidance in other advanced economies see, for example, Woodford (2012).

Forward guidance as a form of communication policy was also used by Narodowy Bank Polski in 2013–2014. After lowering the reference rate to 2.5% in July 2013, in September 2013 the Monetary Policy Council (MPC) indicated in a statement that "in the Council's assessment interest rates should be kept unchanged at least until the end of 2013". In November 2013 "the end of 2013" was replaced by "the first half of 2014", again replaced by "the third quarter of 2014" in March 2014. It should be noted that, in contrast to forward guidance of the FOMC aimed at lowering the expected path of interest rates, the goal of the MPC was to stabilise expectations. According to the Inflation Report from November 2014, during the period of forward guidance expectations about the path of interest rates have indeed stabilised (NBP 2014).

The future policy stance was also signalled both before and after explicit forward guidance, however, in a more subtle way. Nevertheless, the signals could influence financial markets. For example, the largest two-day change in 5-year government bond yields around MPC meetings between 2001 and mid-2016 (-109 bps) occurred in October 2008. At that meeting the MPC did not change the interest rate, but in the statement it replaced "The Council assessed the probability of inflation overshooting the inflation target in the medium term to be higher than the probability of inflation running below the target" with "The Council assessed the probability of inflation running above or below the target in the medium term to be roughly equal". In this way it signalled the end of policy tightening. On the other hand, for instance, in March 2013 there was no significant change in the statement. However, the interest rate was lowered by 50 bps when a 25 bps cut was expected. Following the decision the yields decreased by 11 bps.

In the light of these considerations, the aim of this study is to investigate the effects of monetary policy – represented by both actions and statements (not only explicit forward guidance) – on financial asset prices (stock prices, government bond yields and the exchange rate) in Poland. Compared with existing literature for Poland, I explore this within an unified framework. Following Gürkaynak, Sack and Swanson (2005, GSS from now on) I test how many factors adequately explain the variability of short-term interest rates around MPC meetings, finding that there are two such factors. The first one

has a structural interpretation as a "current interest rate change" factor and the second one as a "future interest rate changes" factor, with the latter related to MPC communication. Regression analysis shows that not only changes in the current interest rate, but also MPC communication matters for financial asset prices in Poland.

The second section reviews the relevant literature. The third section describes data used in the analysis. The fourth contains factor analysis (construction of independent variables for regression analysis, representing MPC actions and communication) and the fifth – regression analysis (including the main results – the effects of MPC actions and communication on financial asset prices). In the sixth section there are extensions, and in the seventh there is sensitivity analysis. The last section concludes, providing policy implications.

2 Literature review

The relevant related literature started with a paper of Cook and Hahn (1988) for the United States. They estimate the reaction of interest rates on instruments with maturities between 3 months and 20 years to changes in the federal funds rate target between 1974 and 1979, within 1-day windows. They find that changes in the target cause large movements in short-term interest rates, moderate movements in medium-term rates and small but significant movements in long-term rates. Kuttner (2000) shows that government bill and bond yields practically do not respond to expected changes in the federal funds rate target, but their reaction to unexpected changes is large and significant. He also uses 1-day windows. However, his sample spans from 1989 to 2000, and the analysed set of instruments additionally includes government bonds with 30 years to maturity. GSS, using factor analysis, distinguish between monetary policy actions (unexpected changes in the federal funds rate) and statements. They use 30-minute and 60-minute windows instead of changes within 1 day. According to their estimates, both actions and statements influence government bond yields (with 2, 5, and 10 years to maturity), and unexpected changes in the federal funds rate influence stock prices. Their analysis is based on a sample between 1990 and 2004. The results were confirmed on a longer sample (ending 2007) by Campbell et al. (2012), however, using wider (1-day) windows. Additionally, they show that corporate bond yields react to statements.

For Poland, the literature can be divided into two groups: the first related to the effects of changes in interest rates and the second related to the effects of communication on financial asset prices. Starting with the first one, Serwa and Smolińska-Skarżyńska (2004) analyse responses of the exchange rate to changes in interest rates between 2000 and 2002, comparing observed exchange rate movements with theoretical ones (from regressions with a constant or with a constant and the USD/HUF exchange rate, with the latter used in order to control for regional effects). Firstly, they find that within windows of between 1 and 3 days around MPC meetings, the exchange rate does not react to actual changes in the reference rate. Secondly, in 1-day windows (however, in a sample not limited to MPC meetings) the exchange rate depreciates (appreciates) after unexpected increases (decreases) in the market interest rate – a reaction inconsistent with uncovered interest rate parity (UIP) and carry trade views. For 3-day windows, only responses to unexpected decreases in the interest rate are statistically significant. Serwa (2006) uses an instrumental variable approach (allowing for feedback from financial asset prices to the reference rate) to estimate the reaction of short- and long-term interest rates, as well as the stock market

and the exchange rate, to actual and unexpected changes in the reference rate. His sample spans from 1999 to 2005, and he uses 1-day, 2-day and 1-week windows. In essence, he finds that although short-term interest rates react to both actual and unexpected interest rate changes, the reactions of long-term rates, the stock market and the exchange rate are not statistically significant. Serwa and Szymańska (2004) arrived at the same conclusions on a shorter sample (ending 2002), additionally using the methods of Cook-Hahn (1988) and Kuttner (2000), mentioned above. Rembeza and Przekota (2008) estimate a VAR model for the reference rate, overnight interbank interest rate and stock prices. They use daily data for 2001–2006. According to their estimates, the response of stock prices to interest rate shocks is relatively weak. Janecki (2012) uses the method of Cook-Hahn (1988) to measure the reaction of short- and long--term interest rates to changes in the reference rate between 2001 and 2011, using windows of between 1 and 3 days. He finds statistically significant responses of both short- and long-term interest rates.

Moving to the second group of the literature, Włodarczyk (2008) investigates the reaction of FRA (forward rate agreement) and IRS (interest rate swap) rates to comments of MPC members between meetings, on a sample from 2004 to 2007. He uses an approach similar to the one employed by Serwa and Smolińska-Skarżyńska (2004), described above (however, he looks at 4-day windows). According to his estimates, FRA 1×4 (3-month interest rate in 1 month) and FRA 2×5 rates do react to MPC members comments, but FRA 1×2, FRA 2×3, IRS 2Y, and IRS 5Y rates do not. Finally, Rozkrut (2008) shows that both short- and long-term interest rates, as well as stock prices do respond to comments of MPC members between meetings and statements after interest rate decisions, but the exchange rate does not. He uses the EGARCH model, controlling for interest rate changes, macroeconomic releases, a foreign interest rate and foreign stock prices. Interestingly, in one of the extensions he decomposes unexpected changes in the interest rate into "timing" (representing the change in the timing of policy actions) and "level" (influencing the general level of policy expectations) components, finding that "there must be other than "level" factors influencing market expectations. These would most likely include policy-makers' statements and central bank press releases following the decision on interest rates". The present study shows this is exactly the case.

3 Data

The investigation is based on three groups of variables. The first one represents the expected path of interest rates over a 1-year period. For that purpose, GSS use current-month and 3-month-ahead federal funds futures contracts and 2-, 3-, and 4- quarter-ahead eurodollar futures contracts. For Poland, futures on WIBOR (Warsaw Interbank Offered Rate) have been available on the Warsaw Stock Exchange (WSE) only since the end of 2013. Therefore, 1-month WIBOR and FRA 1×2, 2×3, 3×6, 6×9, and 9×12 rates are used instead. These are employed in factor analysis to construct variables representing MPC actions and communication.

The second group consists of other financial asset prices – dependent variables for regression analysis. The group includes the stock market index (WIG20 – an index for the 20 biggest and most liquid corporations on the WSE), 2-, 5-, and 10-year government bond yields and the exchange rate. In the case of the exchange rate, EUR/PLN is used in the whole sample. However, the use of either EUR/PLN since the accession to the European Union (May 2004) and USD/PLN before or USD/PLN in the whole sample does not qualitatively change the results.

The last group contains control variables for regression analysis – domestic and foreign ones. Domestic controls are used to capture responses to macroeconomic data releases and consist of five economic surprise indices: for GDP, production, sales, prices and the labour market. They were calculated as standardised differences between data releases and median forecasts in Bloomberg surveys. In the first three cases single variables (GDP, sold industrial output and retail sales accordingly) were used. In the last two cases – sums of surprises in CPI, core CPI and PPI for prices, and in the unemployment rate (with a negative sign) and wages for the labour market.

Foreign controls represent interest rates and risk in the United States and in the euro area. Interest rates are measured by 1-year OIS (overnight index swap) for the US dollar and the euro, in order to match the horizon for the expected path of interest rates used for Poland. It should capture monetary policy actions and communication, but also other factors affecting outlook for monetary policy, including macroeconomic data releases. Because the data for 1-year OIS for the US dollar has been available only since January 2004, 1-year LIBOR is used before. As a measure of risk implied volatility for S&P 500 and EURO STOXX 50 (VIX and VSTOXX accordingly) is used.

GSS use intraday data (30- and 60-minute changes around interest rate decisions and statements) for days of FOMC meetings. For Poland, data on the WIBOR rate is based on fixings, which take place at 11 AM. For FRA rates there exists intraday data, but the daily number of observations is rather small. For example, on the second day of the last MPC meeting in the sample (8 June 2016) for FRA 9×12 there were 7 observations at different minutes, for FRA 3×6 – 6 and for FRA 1×2 – none. Moreover, intraday data on FRA rates could be accessed only for a very short period. There is also data based on fixings, taking place at 4.30 PM. Usually, the MPC announces interest rate decisions between 11 and 2 PM, and the statement is released at 4 PM, at the beginning of the press conference. Therefore, WIBOR fixing on days of the announcements would not reflect interest rate decisions, and FRA fixing might not fully reflect information from the statement and the press conference. Consequently, 2-day windows around MPC meetings (between the day before and the day after) are used. Using (relatively) high frequency data allows to better disentangle the effects of monetary policy from other factors. Furthermore, the feedback from financial asset prices to monetary policy is less likely.

In extensions and sensitivity analysis other variables are also used. First, as candidates for variables differentiating responses of financial asset prices to monetary policy the following are checked: dummy variables for tenures of the MPC, an index of financial market depth from Svirydzenka (2016), liquidity indicators for government bonds (calculated as transactions to stock ratios) and an average of levels of VIX and VSTOXX. Second, the reference rate is employed instead of factors as a measure of monetary policy. Third, sub-sector stock market indices are used instead of WIG20. For banking, construction, food industry, IT and telecom sectors the data is available for the whole sample. For developers it starts in June 2007, for energy in January 2010, for media in January 2005 and for oil and gas – in January 2006.

Fourth, in each exercise in sensitivity analysis the following are used: the difference between the actual change in the reference rate and the median forecast in Reuters (before 2004) / Bloomberg (since 2004) surveys, a variable representing a change in MPC bias, dummy variables for dates of an introduction and changes in forward guidance, and revisions in NBP projections for inflation and GDP. As far as the variable representing MPC bias is concerned, it takes 1 for bias towards tightening, 0 for neutral attitude and -1 for bias towards easing. Only in two short periods does it take a value halfway between one of the two states. Otherwise, it does not reflect subtle, but significant changes

in communication. The change from "the Council will consider adjustment of monetary policy" to "the Council will ease monetary policy" in statements in September and October 2012, accordingly, can be used as an example. Before 2006 the bias was explicitly written in statements, since 2006 it was implied. The details of the construction of the variable are described in the Appendix.[1] Fifth, 1-month OIS is employed instead of 1-month WIBOR to estimate factors in an analysis in 1-day windows. In this case the data has been available since August 2004.

Changes in interest rates were calculated in percentage points, while changes in stock prices and the exchange rate – in percent. The baseline sample consists of 179 observations for MPC meetings between January 2001 and June 2016 (with FRA rates, available from the end of 2000, being the bottleneck). Graphs of the series are available in the Appendix.

The choice of 2 days for the width of the window seems to be optimal given the limitations related to data quality and availability. However, it comes at a price of inclusion of more variability related to factors other than monetary policy. On the other hand, if it takes time for financial markets to process new information, relatively wide windows may actually help to find the causal effect. Of course, provided that there are available suitable control variables and a sufficient number of observations. Taking this trade-off into consideration, where possible, sensitivity analysis shall be conducted in tighter windows.

Table 1 shows the results from regressions of changes in financial asset prices in 2-day windows around MPC meetings on their changes in 1-day windows. For the stock market index and the exchange rate, as independent variables changes in 30- and 60-minute windows around releases of MPC decisions and statements are also used. The last two windows are asymmetric, with 10 (15) minutes before and 20 (45) minutes after decisions/statements. Intraday data for the two variables could be accessed for the period since 2008. Changes in the stock market index in 60-minute windows around MPC statements could be calculated only since 2011, as earlier the market was closed already at 4.30 PM.

For each financial asset changes in 1-day windows explain about half of variability in 2-day windows (in 4 cases slightly more, in 1 – slightly less). Changes in 30- and 60- windows account for about 15% of 2-day variability in the exchange rate and for below 5% for the stock market index. According to the F test, in the last case (models 6 and 8) R-squared is not significantly different from 0, meaning that movements of WIG20 very close to releases of MPC decisions/statements are small from the perspective of 2-day variability. However, as explained above, it does not have to be a problem. In some cases coefficient estimates are larger than 1, which may indicate that on average changes in tighter windows are amplified in wider ones. But in none of them does a one-sided t test (with an alternative hypothesis that a coefficient is larger than 1) reject that these coefficients are equal to 1.

4 Factor analysis

Using factor analysis, a vector of (many) variables can be represented as a linear combination of (less) unobserved factors. In the present study this method was employed to estimate the measures of unexpected changes in the current interest rate and of MPC communication.[2] In the former case,

[1] Available, together with series from Sections 3–5, at: https://figshare.com/s/9337ebf517a785f4a454.

[2] For analysed instruments, expected changes should already be internalised by financial markets around individual MPC meetings.

it can possibly give more precise estimates than the conventional use of changes in WIBOR 1M around meetings of the MPC. On the effects in that respect see footnote 4. Following GSS, let X denote the $T \times n$ matrix, with rows corresponding to MPC meetings and columns corresponding to variables representing the expected path of interest rates over a 1-year period. Then X can be written in the form:

$$X = F\Lambda + \eta$$

where:

F – $T \times k$ matrix of unobserved factors,

Λ – $k \times n$ matrix of factor loadings,

η – $T \times n$ matrix of white noise disturbances,

T, n, k – numbers of MPC meetings, variables and factors accordingly.

The number of factors adequately describing X was determined using the minimum average partial method (Velicer 1976), supported by simulation evidence (Zwick, Velicer 1986). The selected number of factors is two. It remains unchanged when the sample is restricted either to its first half or to the second one. Factors (let F_1 and F_2 denote them) were estimated using the principal components method. The use of the maximum likelihood method to extract factors does not change the results.[3] Average partial correlations, factor loadings and graphs of factors are provided in the Appendix.

The interpretation of the results above is the following – the variability of short-term interest rates around MPC meetings cannot be adequately explained using changes in the reference rate only (or using only one variable in general). Since F_1 and F_2 do not have economic interpretation, GSS propose to rotate them so that the first factor corresponds to unexpected changes in the current reference rate, and the second factor corresponds to variations in the expected path of interest rates over a 1-year period not driven by changes in the current reference rate. In other words, the matrix of rotated factors Z is defined by:

$$Z = FU$$

where:

$$U = \begin{bmatrix} \alpha_1 & \beta_1 \\ \alpha_2 & \beta_2 \end{bmatrix}$$

and U is identified by four restrictions:

– columns of U have unit length,

– Z_1 and Z_2 are orthogonal.

$$\alpha_1\beta_1 + \alpha_2\beta_2 = 0$$

Z_2 does not influence WIBOR 1M (reflecting mainly the current policy surprise)

[3] After rotations, factors estimated using principal components explain 98–99% of variability in corresponding factors estimated by maximum likelihood. The latter have qualitatively the same impact on financial asset prices in regressions from Section 5.

$$\gamma_2 \alpha_1 - \gamma_1 \alpha_2 = 0$$

where γ_1 and γ_2 are loadings of WIBOR 1M on F_1 and F_2 accordingly.

After solving for U and calculating Z, rotated factors were rescaled so that Z_1 moves WIBOR 1M one-for-one, and Z_2 has the same effect on FRA 9×12 as Z_1. Therefore, Z_1 can be interpreted as an unexpected current interest rate change and Z_2 as communicated future interest rate changes in units of an unexpected current interest rate change. Or – in short – Z_1 reflects MPC actions and Z_2 reflects MPC communication.

The first factor is depicted on Figure 1. In order to provide a sense of the quality of the generated variable, three illustrative dates (accompanying the largest absolute values in the second, less volatile half of the sample) are denoted by solid bars on the graph:

November 2008 – the MPC lowered the reference rate by 25 bps, when according to the Bloomberg poll no change was expected. Estimated MPC action amounts to -23 bps.

March 2013 – the MPC lowered the reference rate by 50 bps – a 25 bps cut was expected – estimated MPC action: -31 bps.

November 2014 – the MPC did not change the reference rate – a 25 bps cut was expected – estimated MPC action: 26 bps.

The same exercise was performed for the second factor, depicted on Figure 2:

October 2008 – the MPC replaced "The Council assessed the probability of inflation overshooting the inflation target in the medium term to be higher than the probability of inflation running below the target" in the statement with "The Council assessed the probability of inflation running above or below the target in the medium term to be roughly equal" – a signal of ending the monetary tightening cycle – the estimated measure of MPC communication: -44 bps.

January 2013 – the MPC replaced "Should the incoming information confirm a protracted economic slowdown, and should the risk of increase in inflationary pressure remain limited, the Council will further ease monetary policy" in the statement with "The Council does not rule out further monetary policy easing should the incoming data confirm a protracted economic slowdown and should the risk of increase in inflationary pressure remain limited". At the press conference the Chairman of the MPC Marek Belka said, "this round of interest rate cuts is coming to an end" – a signal of ending the monetary easing cycle – the estimated measure of MPC communication: 33 bps.

June 2013 – the MPC removed "The Council's decisions in the coming months will depend on the assessment of the incoming data with regard to probability of inflation remaining markedly below the NBP target in the medium term" from the statement. At the press conference the Chairman of the MPC Marek Belka said, "we are approaching the level of interest rates that for current economic conditions can be judged adequate" – a signal of ending the monetary easing cycle – the estimated measure of MPC communication: 47 bps.

In essence, Z_1 indeed appears to reflect unexpected interest rate changes, and Z_2 – to reflect changes in communication, referring to future interest rates. Neither is Z_1 equal to WIBOR 1M nor Z_2 to

FRA 9×12. However, the correlation between those variables is high – between Z_1 and WIBOR 1M 0.67,[4] between Z_2 and FRA 9×12 – 0.84. The correlation between Z_1 and FRA 9×12 is 0.65, and between Z_2 and WIBOR 1M, by construction, 0. The similarity between those pairs of variables can also be noticed on the graphs in the online Appendix.

Furthermore, the dates of explicit forward guidance announcements are denoted by dotted bars on Figure 2. Interestingly, the absolute values of Z_2 for that time are relatively low (5–11 bps), probably indicating that forward guidance provided little new information on the future path of interest rates to the money market.[5]

The left-hand panel of Table 2 shows the results from regressions of Z_1 and Z_2 computed using 2-day windows on their 1-day counterparts. For Z_1, the latter explain a reasonable 66% of the former. However, with a coefficient significantly larger than 1, according to a one-sided t test. The explained share of variability is much smaller for Z_2 (11%). Furthermore, the coefficient is estimated to be as large as 6.1 (significantly larger than 1 only at a 10% significance level, due to a high variance). This means that if the expected path of interest rates around MPC meetings moves mainly because the MPC does or communicates something, the measure of actions is somewhat underestimated, and the measure of communication considerably underestimated, when calculated in 1-day windows.

Whether these movements are driven by other factors is tested in the right-hand panel of Table 2. In models 12 and 14, Z_1 and Z_2 (computed in 2-day windows) are regressed on the most likely candidates for these factors – control variables from regression analysis in the next section. There were also checked prices of Brent oil and 5-year CDS, but it did not change the results. In both models the F test does not reject that R-squared is equal to 0, indicating that Z_1 and Z_2 are not significantly affected by macroeconomic data releases or foreign interest rates and risk.

Models 13 and 15 extend the previous two, adding proxies for MPC actions and communication from sensitivity analysis (Section 7) as independent variables. Z_1 is significantly related to the surprise in the reference rate versus surveys, while Z_2 – to proxies of communication (with F statistic 65.55 in the F test for joint significance). In the second case, revisions in NBP projections are individually not significant. However, point estimates have signs in line with intuition – an upward revision in inflation and/or GDP implies a higher path for interest rates. R-squared is not impressive in any of the models (38% and 10%, accordingly), which should not come as a surprise. Compared to the surprise in the reference rate versus surveys, Z_1 additionally captures, for example, the arrival of information between surveys and MPC meetings. Z_2 should reflect subtle changes in wording in statements and information from Q&A at press conferences, not captured by any of the proxies. It should be noted that the results from models 13 and 15 indicate that the proxies for MPC actions and communication could make suitable instruments for Z_1 and Z_2. This finding shall be used in the seventh section.

[4] In some cases, WIBOR 1M probably overestimates monetary policy surprises. For instance, in December 2008 the MPC lowered the interest rate by 75 bps, when according to the Bloomberg poll a 50 bps cut was expected. Nevertheless, WIBOR 1M points to a 61 bps policy surprise, whereas Z_1 – to a 17 bps surprise. This example shows the advantage from using factor analysis to estimate monetary policy surprises instead of simply employing WIBOR 1M.

[5] Regressing dummy variable for forward guidance on absolute values of Z_2 (not reported, available on request) supports that finding – dummy variable is statistically insignificant.

5 Regression analysis

For each dependent variable (the stock market index, 2-, 5-, and 10-year government bond yields and the exchange rate) two linear regression models were estimated. Both include estimated measures of MPC actions (Z_1) and communication (Z_2) from the previous section as independent variables. However, one group of models additionally controls for domestic macroeconomic data releases and international developments – foreign interest rates (OIS 1Y for the US dollar and the euro) and risk (VIX and VSTOXX). In a formal notation:

$$Y_t = \alpha + Z_t'\beta + X_t'\gamma + \varepsilon_t$$

where:

Y – change in a price/yield of a financial asset,
Z – vector of measures of monetary policy,
X – vector of control variables,
α, β, γ – vectors of coefficients,
ε – error term.
In models without controls γ is restricted to be a vector of zeros. The results are shown in Table 3.

Additionally, the Appendix shows residual diagnostics. Normality was rejected in all models. However, having a large sample, this does not affect inference. Lack of serial correlation was rejected only in 2 out of 10 models (or in none of them for a 0.01 significance level). Homoskedasticity was rejected in 6 models. Therefore, White heteroskedasticity-consistent standard errors are used.

Firstly, both MPC actions and communication matter for government bond yields. The reaction is of a "correct" sign (in line with expectations/liquidity premium/preferred habitat theories of the term structure of interest rates, see, for example, Mishkin 2013) – yields increase following current, and signals of future, monetary policy tightening (or decrease after easing – models are linear). Furthermore, 2-year government bond yields increase after (positive) surprises in GDP and 10-year bond yields – following surprises in production. This is because they may imply higher interest rates in the future. On the other hand, the response of 2-year bond yields to surprises in sales is negative. In this case the risk premium channel probably prevails – better economic conditions are associated with a lower probability of default. International factors do not influence yields around MPC meetings in a statistically significant manner. The inclusion of control variables improves the adjusted R-squared for 2- and 5-year bonds.

Secondly, communication appears to be more important for the stock market – prices decrease when the MPC signals higher future interest rates (as higher interest rates lower economic growth, profits, dividends and – therefore – stock prices). The response to increases in the current interest rate is of a magnitude indistinguishable from zero. The point estimate is positive, but this result is driven by outliers. After their removal, however, the effect remains insignificant. Furthermore, the stock market index goes down after surprises in prices. Also, an increase in risk in the euro area decreases stock prices.

Thirdly, communication influences the exchange rate, but the estimated sign is controversial (or not in line with UIP and carry trade views) – the exchange rate depreciates after MPC statements signalling tighter future monetary policy. Perhaps the influence over one income-earning asset –

shares (via economic growth) – exceeds the significance of the impact on the other one – interbank deposits. In other words, the pressure for appreciation arising from higher expected returns on money market instruments is more than compensated by the pressure for depreciation stemming from lower expected returns on shares. That a carry trade strategy can be executed using both was argued by Cenedese et al. (2015). For a discussion on interest parity see, for example, Lavoie (2014). Following increases in the current interest rate, the exchange rate does not appear to change in a statistically significant manner. Moreover, rolling regression analysis (in Section 6) shows that the signs are time-varying. Among controls, surprises in production strengthen the exchange rate, while increases in risk in the United States weaken it.

For the effects of changes in the current interest rate, the findings are in line with those of Janecki (2012) on government bond yields and in some sense similar to those of Serwa and co-authors on stock prices and the exchange rate (namely, the impact on those two variables is ambiguous). For the effects of communication, except on the exchange rate, the results are in line with those of Rozkrut (2008).

The results remain unchanged when prices of Brent oil or CDS are added as control variables, even as they were found to significantly affect the stock market index. However, as shall turn out in Section 7, the impact (or lack thereof) of MPC actions on stock prices and the exchange rate that one finds depends on the width of the window.

6 Extensions

The analysis from the previous two sections was extended in three directions. First, it was determined whether the effects of MPC actions and communication have varied over time. Time-variation might stem, for example, from the changing composition of the MPC (there were four tenures of the MPC between 2001 and 2016 – ending 2004, 2004–2010, 2010–2016 and starting 2016), the deepening of financial markets or financial market disturbances. To that end, in the first exercise, for each dependent variable a rolling regression was estimated. A 38-period window was used in order to preserve more than 30 degrees of freedom (in econometric practice one of the rules of thumb for a "sufficiently large" sample). Foreign interest rates, VIX, and VSTOXX were used as control variables. In all exercises in this section outliers and influential observations were removed, using the DFFITS (difference in fits, see Belsley, Kuh, Welsh 1980) measure. Qualitatively, it did not affect the full sample results. Estimated rolling coefficients and *p*-values (for the *t* test) for monetary policy variables are shown in Figures 3–4. The DFFITS are shown in the Appendix.

For stock market returns and government bond yields, the coefficients are similar at the beginning and at the end of the sample. However, it appears that the transmission of monetary policy was impaired during the global financial crisis and the euro area crisis, either because of some factors partially compensating for it, or due to structural changes. For stock prices the significance of MPC communication has varied over time according to a very specific pattern – the higher the coefficient estimate, the higher the *p*-value (correlation – 0.78). Except for crisis periods, the coefficients for MPC actions and communication were similar. For 10-year government bond yields it seems that the transmission was weaker also at the beginning of the sample.

In equations for government bond yields many observations at the beginning of the sample were removed as outliers or influential observations. The large number of those observations might explain

the early finding of Serwa and co-authors (their samples cover periods ending 2002 or 2005) that interest rate changes do not affect government bond yields, not supported by other papers (including this one). The comparison of *p*-values removing and not removing outliers and influential observations in rolling regressions (not reported, available on request) supports this view.

The behaviour of coefficients and *p*-values for the exchange rate is more complex. Since the middle of 2006 the positive relationship between the exchange rate and the estimated measure of MPC communication has been disappearing. After the global financial crisis it has not been statistically significant. For most of the sample (since the crisis) the exchange rate would appreciate or would not change in a statistically significant manner after an increase in the current interest rate.

Table 4 shows results from multiple breakpoints tests, which were conducted in order to check whether changes in coefficients for Z_1 and Z_2 were significant, and, if they were, at which points. Specifically, a test proposed by Bai and Perron (1998) was used, in which a null hypothesis of no breaks is tested against an alternative of *n* breaks.

Inferring from scaled *F*-statistics, there were three structural breaks in the equations for the stock market index and government bond yields, and no breaks in the equation for the exchange rate. Most breaks coincide with different stages of crises (March, May and June 2008, February 2009, December 2010, May and June 2011, September 2013). However, in equations for government bond yields the test points also to breaks before it (March 2004, February and March 2005 and March 2006).

These apparent changes in estimates of parameters may have basically two causes. The first one is omitted variables bias. It may be the case that there were factors that significantly affected financial asset prices, but were not controlled for. In effect, the coefficient estimates are biased. The use of economic surprise indices or prices of Brent oil and CDS as additional controls does not change the results. But it cannot be fully ruled out that there were some other, including one-off, factors.

The second potential explanation is structural changes. They may be systematically related to the factors mentioned at the beginning of this section. Tables 5a–5c show the results from regressions with the core as in Table 3, but additionally with interaction terms between measures of monetary policy and some other variables. In the results in Table 5a, as variables differentiating responses of financial asset prices to monetary policy actions and communication there were checked dummy variables for the second, the third and the fourth tenure of the MPC. This exercise is probably not too meaningful for the last tenure, as there are only a few observations for it, from a period of no actual changes in the reference rate. On average, compared to reactions during the first tenure, 2-year government bond yields reacted more strongly to MPC actions during the second tenure. 10-year government bond yields reacted more to Z_2 during the third one.

In Table 5b there are results from regressions with interaction terms between Z_1 and Z_2, and measures of financial market depth/liquidity. In models 31–35 the index calculated at the IMF (Svirydzenka 2016) was used, in models 36–38 – liquidity indicators for government bonds, computed using data published by the Ministry of Finance. Using both measures, responses of 10-year government bond yields to MPC communication appear to be stronger when markets are deeper/more liquid.

A candidate variable to differentiate the marginal effects of monetary policy in Table 5c is an average of levels of VIX and VSTOXX, supposed to measure financial stress. However, here the interaction terms are not significant in any of the models.

In a second extension, Table 6 shows the results from regression analysis with the reference rate as a measure of monetary policy. It means that actual, not only unexpected, monetary policy actions

are taken into account, and monetary policy communication is being ignored. Measured in this way, monetary policy is not found to significantly affect the stock market index or the exchange rate. It does affect 2-year government bond yields, but the point estimate of the marginal effect is relatively small (12 bps). There is no significant influence on longer-term government bond yields. However, it does not mean that the results from the previous section are not robust. Instead, it suggests that what matters around MPC meetings are unexpected, not actual actions, and these should be used to identify the effects of monetary policy.

This intuition is confirmed by the results from models 49–53, where a change in the reference rate was decomposed into its unexpected (Z_1) and expected (a change in reference rate – Z_1) component. The latter is not significant in any of the models. Moreover, as shown in the previous section, mere actions do not give the full picture – communication matters as well.

As a last extension, it was checked whether the effects on the stock market are broad or rather limited to corporations from some sectors. Table 7 shows results from models with sub-sector stock market indices as dependent variables. Similarly as in the analysis based on the aggregate stock market index, monetary policy communication appears to be more important than actions around MPC meetings. But it should be interpreted as a sign of high informational efficiency of the stock market, rather than of insignificance of what the MPC does. Only for the media sector are the effects of monetary policy not found to be statistically significant. However, this result seems to be driven mostly by the high variance of the estimate. In general, the effects are broad. More detailed comparisons between sectors are rather unwarranted, as models are estimated on different samples. Having more observations (and a more detailed database), it would be interesting to analyse whether the strength of responses is related to the interest rate exposure, similarly as in Ippolito, Ozdagli and Perez-Orive (2013). In this way they identify the floating-rate channel of the monetary transmission mechanism.

7 Sensitivity analysis

Although in Section 4, Z_1 and Z_2 were shown to be unrelated to macroeconomic data releases and foreign interest rates and risk, it cannot be fully ruled out that they contain a measurement error. If there are errors (ζ_1, ζ_2) correlated with unobserved, "true" measures of MPC actions and communication (Z_1, Z_2), ordinary least squares (OLS) estimation produces a consistent estimator, but it may have an elevated variance. However, if there is a correlation between errors and Z_1 and Z_2, the OLS regression gives a biased and inconsistent estimator due to endogeneity.

Table 8 shows the results from tests for endogeneity, in which residuals from reduced forms for Z_1 and Z_2 were added as additional independent variables to baseline regressions for financial asset prices (from Table 3) and tested for joint significance (see, for example, Wooldridge 2009). As instruments, the following were used: the surprise in the reference rate versus surveys (for Z_1), the variable representing a change in MPC bias, dummy variables for dates of an introduction and changes in forward guidance, and revisions in NBP projections for inflation and GDP (for Z_2). In Section 4 they were shown to be valid instruments. Moreover, test statistics in tests for overidentifying restrictions are well below critical values. At a 5% significance level, a null hypothesis of no endogeneity cannot be rejected in any of the models. It can be rejected in a model for 5-year government bond yields at a 10% level. However, in instrumental variables (IV) estimation the results are qualitatively unchanged.

Furthermore, ignoring the results from endogeneity tests and estimating other equations by the IV method, one also obtains similar results. In some cases measures of monetary policy significant in the OLS are insignificant in the IV, but the IV is less efficient. These results mean than endogeneity due to a measurement error is not an issue here.

In a second robustness check, Table 9 shows the results from the analysis in 1-day windows (between the days of MPC meetings and the days before them). As shown in Section 4, they should be treated with caution. Factors estimated using changes in OIS and FRA rates from fixings at 4.30 PM most likely somewhat underestimate monetary policy actions and considerably underestimate monetary policy communication. Indeed, if they were able to fully capture them, the analysis in 1-day windows would be the baseline one. Standard deviations in the overlapping part of the sample of factors estimated in 2-day windows are higher – 0.12 versus 0.09 and 0.15 versus 0.11 for Z_1 and Z_2, accordingly. As before, monetary policy actions are found to significantly affect government bond yields, but now also the stock market index, with higher interest rates decreasing stock prices. The effects of monetary policy communication are statistically significant only for 5-year government bond yields, at a 10% significance level. This is even as point estimates in models for government bond yields and the exchange rate are higher than in 2-day windows (having the same signs), but their variances are higher as well. An estimate in a regression for the stock market index is lower, but still has the same sign.

In models 68–72, Z_1 and Z_2 were replaced by instruments for MPC actions and communication. A surprise increase in the reference rate versus surveys is associated with increases in 5- and 10-year government bond yields. At a 10% significance level – also with an increase in 2-year bond yields. The point estimate in the model for the stock market index is again negative, but this time the coefficient is insignificant. When bias is changed for more restrictive, 5- and 10-year government bond yields go up and the exchange rate depreciates. At a 10% significance level, there is also a decrease in stock prices and an increase in 2-year bond yields. The introduction of forward guidance, after which the expected path of interest rates went up, was associated with a decrease in the stock market index, increases in government bond yields and a depreciation of the exchange rate. With changes in forward guidance, followed by decreases in short-term money market rates, all government bond yields decreased. After the first change in forward guidance there was also an increase in stock prices (at a 10% significance level – after the second change in forward guidance as well). Results from the analysis in 1-day windows are rather supportive for the baseline outcomes, with the exception that 2-day windows appear be too wide to identify the impact of monetary policy actions on stock prices.

As a last robustness check, a similar exercise was conducted using intraday data on the stock market index and the exchange rate since 2008. Table 10 shows the results from regressions of changes in these variables in tight (30-minute) and wide (60-minute) windows, around releases of MPC decisions and statements, on instruments for Z_1 and Z_2. In contrast to the full sample results in 2- and 1-day windows, here the exchange appreciates after surprise increases in the reference rate. The impact on the stock market index is not significant, but point estimates have signs in line with intuition. The exchange rate depreciated after changes in forward guidance (interpreted as signalling lower future interest rates). Other coefficients are insignificant and/or qualitatively differ depending on the size of the window.

Summing up, models based on 2-day windows do not suffer from endogeneity due to a measurement error. However, these windows appear to be too wide to identify the effects of monetary policy actions on the stock market index and the exchange rate. In 1-day and intraday windows, accordingly, they are

found to be consistent with economic theory. But, in this respect, the results from analysis in 2-day windows are not entirely at odds with those in tighter windows. Without outliers, the point estimate for the impact of Z_1 on stock prices is negative. For the exchange rate, this is also the case in rolling regressions in the second half of the sample. As far as the effects of monetary policy communication are concerned, given data limitations, estimates based on 2-day windows seem to be the best available ones. Robustness checks in tighter windows give them at least some support, though with some contradictory results for the exchange rate.

8 Conclusions

The study shows that not only changes in the current interest rate but also MPC communication (signalling future interest rate changes) matters for financial asset prices in Poland. Both MPC actions and communication affect government bond yields, and communication is important for stock prices. Furthermore, the exchange rate used to depreciate after MPC statements signalling tighter future monetary policy. However, the effect disappeared at the end of the sample. Analysis in 2-day windows and using intraday data did not reveal significant decreases in the stock market index following tightening of current monetary policy, but in 1-day windows it did. In 2-day windows, for most of the sample the exchange rate would appreciate or would not change in a statistically significant manner after an increase in the current interest rate. In 30- and 60-minute windows around releases of MPC decisions since 2008 it tended to appreciate.

The findings have important implications for the conduct of monetary policy, especially in a low inflation and low interest rate environment. Although the probability of falling into a liquidity trap for Poland remains low, it has been elevated in recent years (Brzoza-Brzezina, Kolasa, Szetela 2016). This paper implies that the MPC can use forward guidance to influence monetary conditions, also facing the ZLB.

However, as GSS indicate, the findings, "do not imply that (…) statements represent an independent policy tool. In particular, (…) statements likely exert their effects on financial markets through their influence on financial market expectations of future policy actions. Viewed in this light, (…) results do not indicate that policy actions are secondary so much as that their influence comes earlier – when investors build in expectations of those actions in response to (…) statements".

Furthermore, it should be noted that during the last crisis the ability of the MPC to influence financial asset prices was impaired. Also, regarding stock prices, Tobin's q and wealth channels of the monetary transmission mechanism in Poland remain to a large extent unexplored. The same goes for the role of long-term interest rates (Zachłod-Jelec 2010 and Wesołowski 2016 being exceptions). Finally, the results for the exchange rate are unstable.

For future research, it would be useful to determine whether the results hold when MPC communication is measured using text mining (for example, in a similar way as in Hansen, McMahon 2016). Moreover, measures of MPC actions from this article can be applied as externally identified monetary policy shocks in SVAR analysis of the monetary transmission mechanism, as, for instance, in Bagliano and Favero (1999), Barakchian and Crowe (2013) or Gertler and Karadi (2015).

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Appendix

Figure 1
Z_1 – "current interest rate change" factor / MPC actions

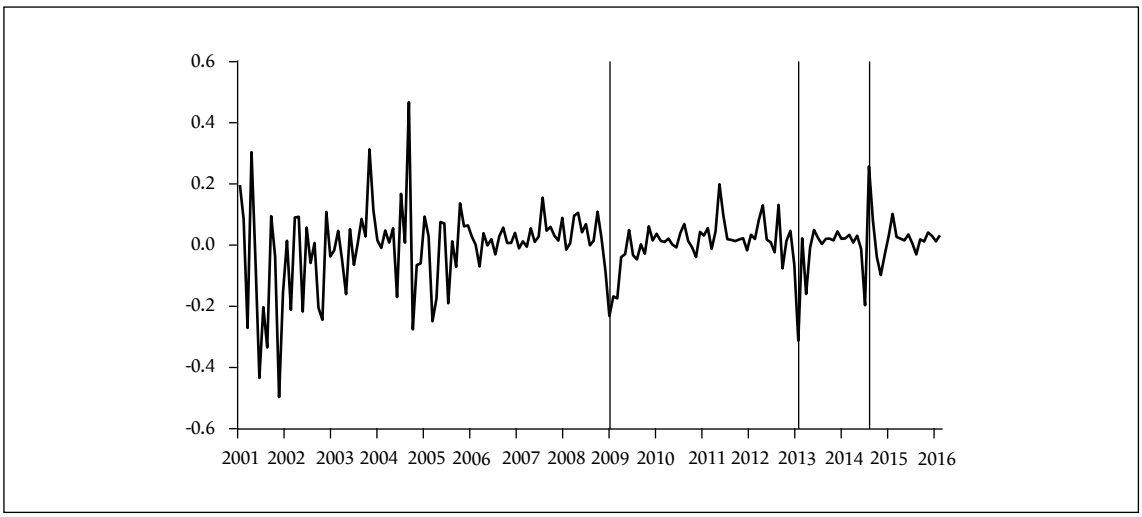


Figure 2
Z_2 – "future interest rate changes" factor / MPC communication

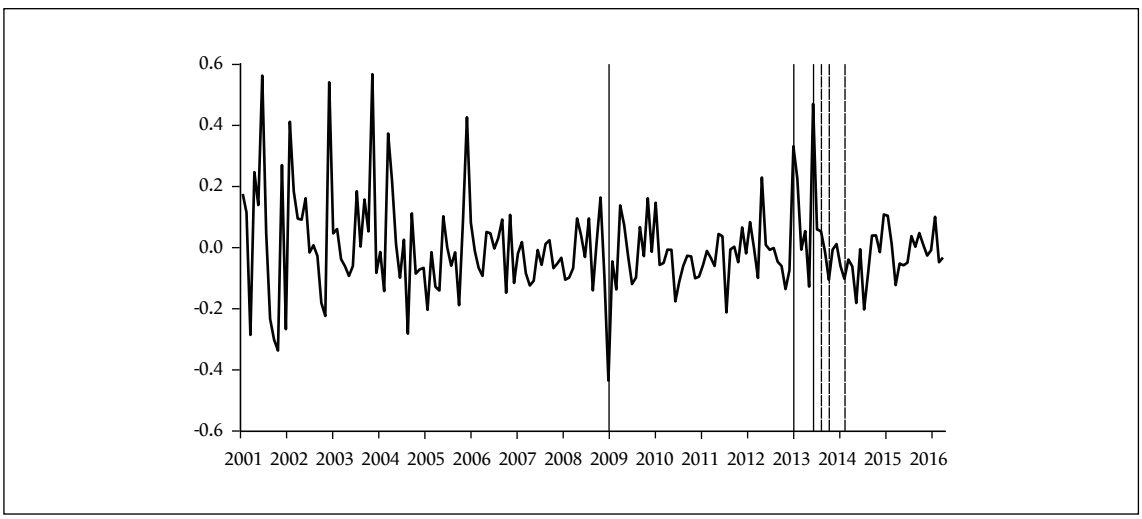
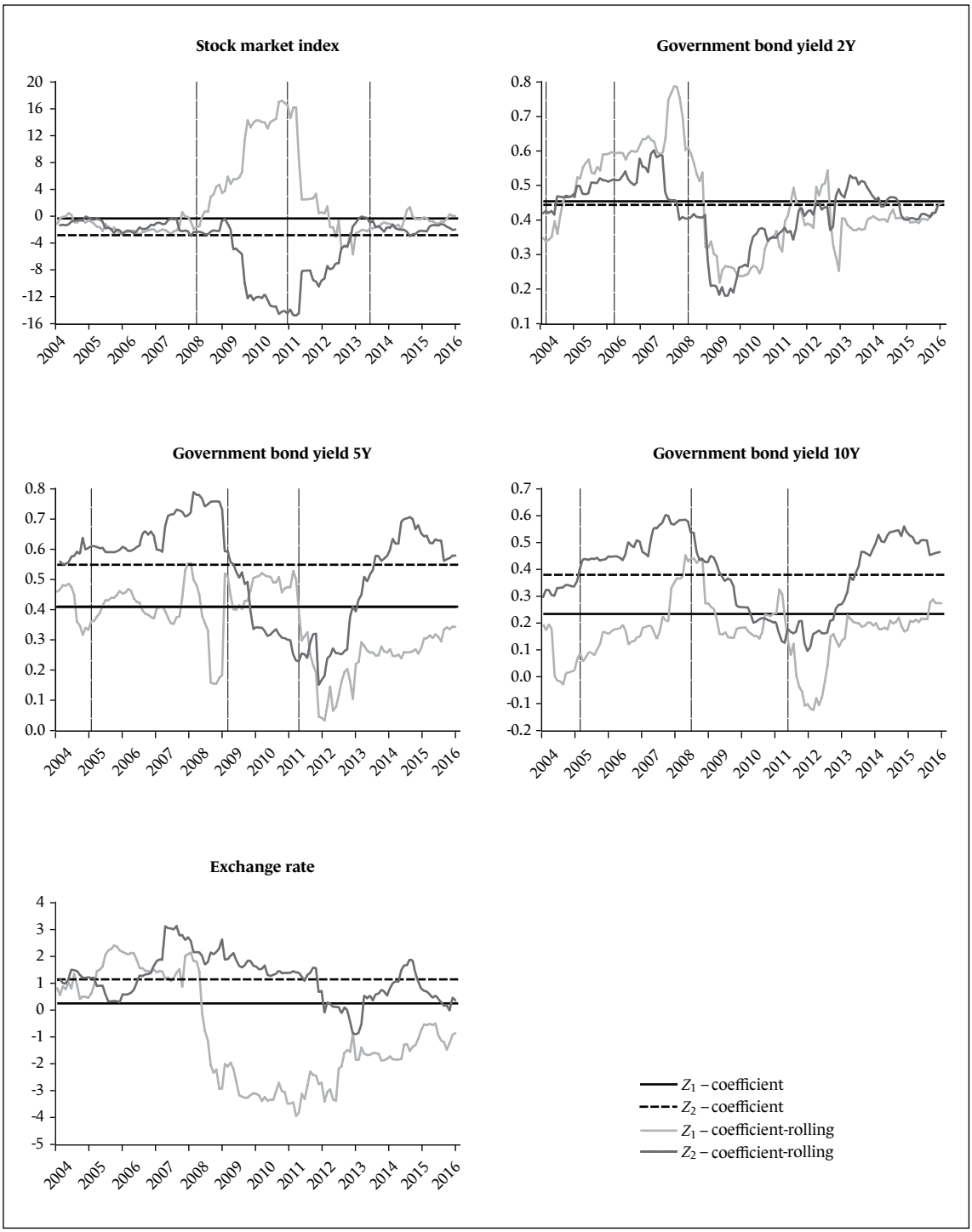
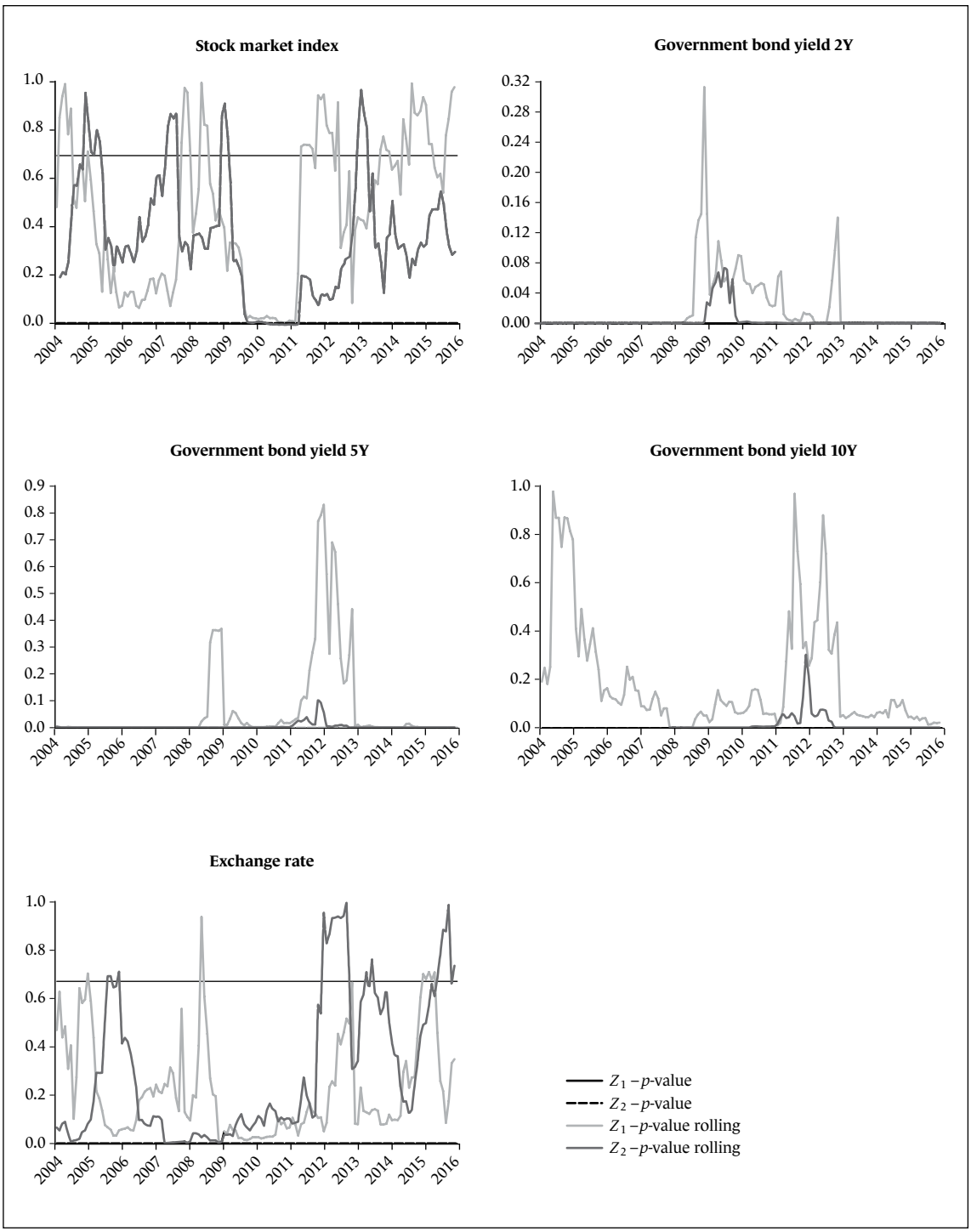


Figure 3
Rolling regression coefficients



Note: panels correspond to equations. Bars denote breakpoints.

Figure 4
Rolling p-values



Note: panels correspond to equations.

Table 1
Regressions of changes in financial asset prices in 2-day windows on changes in 1-day, 30- and 60-minute windows

Dependent variable	**Model**								
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**
	Stock ind. 2D	Government bond yield			Exchange rate 2D	Stock ind. 2D	Exchange rate 2D	Stock ind. 2D	Exchange rate 2D
		2Y 2D	5Y 2D	10Y 2D					
C	0.22 (0.11)*	-0.01 (0.01)	-0.01 (0.01)	-0.01 (0.01)	0.02 (0.05)	0.45 (0.26)	0.07 (0.09)	0.09 (0.27)	0.03 (0.09)
1 day	1.05 (0.08)**	1.00 (0.10)**	1.20 (0.17)**	0.88 (0.13)**	1.03 (0.12)**				
30 min. around decicion						0.25 (1.65)	1.05 (0.37)**		
30 min. around statement						0.10 (0.59)	1.27 (0.37)**		
60 min. around decicion								1.07 (0.98)	0.75 (0.39)
60 min. around statement								0.83 (0.92)	1.53 (0.36)**
Observations	179	179	179	179	179	95	95	60	95
R-squared	0.57	0.53	0.57	0.48	0.51	0.00	0.13	0.04	0.16
F-stat	230.93	200.82	232.10	166.45	187.02	0.04	6.80	1.04	8.44
Probability (F-stat)	0.00	0.00	0.00	0.00	0.00	0.96	0.00	0.36	0.00

Notes:
White heteroskedasticity-consistent standard errors in parentheses.
* and ** denote statistical significance at 0.05 and 0.01 levels accordingly.

Table 2
Regressions of Z_1 and Z_2 in 2-day windows on Z_1 and Z_2 in 1-day windows, economic surprise indices, foreign interest rates and risk, and instruments for Z_1 and Z_2

Dependent variable	**Model**					
	(10)	**(11)**	**(12)**	**(13)**	**(14)**	**(15)**
	Z_1/MPC act. 2D	Z_2/MPC com. 2D	Z_1/MPC act.	Z_1/MPC act.	Z_2/MPC com.	Z_2/MPC com.
C	0.01 (0.00)*	-0.01 (0.01)	0.00 (0.01)	0.01 (0.01)	0.01 (0.01)	0.01 (0.01)
1 day	1.88 (0.23)**	6.10 (2.44)*				
GDP			0.03 (0.02)*	0.03 (0.01)**	-0.04 (0.03)	-0.04 (0.03)
Prices			-0.00 (0.01)	-0.00 (0.01)	-0.01 (0.01)	-0.01 (0.01)
Production			-0.03 (0.02)	-0.02 (0.02)	0.03 (0.02)	0.05 (0.02)*
Sales			0.03 (0.02)	0.02 (0.02)	0.04 (0.02)*	0.04 (0.02)
Labour market			0.03 (0.03)	0.01 (0.03)	0.00 (0.03)	-0.00 (0.03)
OIS 1Y USD			-0.15 (0.27)	0.04 (0.18)	0.42 (0.33)	0.52 (0.33)
OIS 1Y EUR			0.64 (0.25)*	0.44 (0.22)	0.15 (0.34)	-0.03 (0.32)
VIX			-0.00 (0.01)	0.00 (0.00)	0.00 (0.01)	0.01 (0.01)
VSTOXX			0.00 (0.00)	0.00 (0.00)	0.00 (0.01)	-0.00 (0.01)
Reference rate survey vs survey				0.39 (0.12)**		0.02 (0.11)
Bias				0.04 (0.03)		0.08 (0.03)**
Forward guidance 1				0.01 (0.01)		0.04 (0.02)*
Forward guidance 2				0.01 (0.02)		-0.15 (0.04)**
Forward guidance 3				-0.00 (0.01)		-0.14 (0.03)**
Inflation projection revision				0.01 (0.01)		0.01 (0.02)

GDP projection revision				-0.00 (0.01)		0.02 (0.02)
Observations	135	135	179	179	179	179
R-squared	0.66	0.11	0.07	0.38	0.05	0.10
F-stat	259.56	17.22	1.42	6.10	0.91	1.09
Probability (F-stat)	0.00	0.00	0.18	0.00	0.52	0.37

Notes:
White heteroskedasticity-consistent standard errors in parentheses.
* and ** denote statistical significance at 0.05 and 0.01 levels accordingly.

Table 3
Results from regression analysis – baseline

Dependent variable	Model									
	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)
	Stock ind.		Government bond yield 2Y		Government bond yield 5Y		Government bond yield 10Y		Exchange rate	
C	0.20 (0.16)	-0.05 (0.14)	-0.01 (0.01)	-0.00 (0.01)	-0.02 (0.01)*	-0.01 (0.01)	-0.00 (0.01)	-0.00 (0.01)	-0.08 (0.06)	-0.03 (0.07)
Z_1 / MPC act.	0.55 (0.95)	0.85 (1.01)	0.44 (0.05)**	0.44 (0.05)**	0.39 (0.06)**	0.36 (0.07)**	0.26 (0.07)**	0.24 (0.07)**	0.96 (0.68)	0.87 (0.65)
Z_2/MPC com.	-4.00 (1.32)**	-3.36 (0.99)**	0.41 (0.07)**	0.41 (0.06)**	0.60 (0.10)**	0.58 (0.09)**	0.38 (0.06)**	0.38 (0.06)**	1.14 (0.48)*	1.03 (0.43)*
GDP		-0.60 (0.56)		0.06 (0.03)*		0.02 (0.03)		0.00 (0.02)		-0.21 (0.13)
Prices		-0.58 (0.26)*		0.01 (0.01)		0.00 (0.01)		0.00 (0.00)		-0.06 (0.07)
Production		0.30 (0.50)		-0.00 (0.04)		0.04 (0.04)		0.08 (0.02)**		-0.92 (0.31)**
Sales		0.05 (0.27)		-0.05 (0.01)**		-0.02 (0.02)		-0.02 (0.02)		-0.23 (0.12)
Labour market		0.49 (0.27)		-0.03 (0.02)		0.01 (0.02)		-0.01 (0.01)		0.05 (0.11)
OIS 1Y USD		-0.89 (2.42)		0.11 (0.13)		0.09 (0.16)		-0.08 (0.12)		-0.66 (1.48)
OIS 1Y EUR		-2.57 (3.91)		0.05 (0.12)		0.34 (0.25)		0.22 (0.14)		1.26 (1.58)
VIX		-0.13 (0.11)		0.01 (0.01)		0.00 (0.01)		0.00 (0.00)		0.12 (0.05)*
VSTOXX		-0.39 (0.09)**		0.00 (0.00)		0.01 (0.01)		-0.00 (0.00)		0.03 (0.05)
Observations	179	179	179	179	179	179	179	179	179	179
R-squared	0.07	0.34	0.51	0.55	0.53	0.58	0.46	0.48	0.06	0.17
Adjusted R-squared	0.06	0.30	0.51	0.53	0.53	0.55	0.45	0.44	0.05	0.11
F-stat	6.87	7.86	92.17	18.91	99.97	20.84	73.69	13.74	5.83	3.06
Probability (F-stat)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Notes:
White heteroskedasticity-consistent standard errors in parentheses.
* and ** denote statistical significance at 0.05 and 0.01 levels accordingly.

Table 4
Multiple breakpoint tests

Dependent variable	**Stock ind.**	**Government bond yield**			**Exchange rate**
		2Y	**5Y**	**10Y**	
Scaled F-stat					
1 break	3.93	8.68	4.77	5.82	6.85
2 breaks	13.31	11.27	20.02	5.42	6.14
3 breaks	14.00	18.40	20.58	14.50	6.17
4 breaks	10.79	14.79	16.57	10.98	7.47
5 breaks	10.50	11.79	11.75	9.30	5.82
Critical value	11.70	11.70	11.70	11.70	11.70
Estimated	March 2008	March 2004	February 2005	March 2005	
Break	December 2010	March 2006	February 2009	June 2008	
Dates	September 2013	May 2008	May 2011	June 2011	

Table 5a
Results from regression analysis – extension: responses to monetary policy versus tenures of MPC

Dependent variable	Model				
	(26)	(27)	(28)	(29)	(30)
	Stock ind.	Government bond yield			Exchange rate
		2Y	5Y	10Y	
C	-0.06 (0.15)	-0.01 (0.00)	-0.01 (0.01)	-0.00 (0.01)	-0.01 (0.07)
Z_1	0.66 (1.14)	0.39 (0.05)**	0.43 (0.12)**	0.28 (0.11)**	0.61 (0.93)
Z_2	-2.27 (1.09)*	0.40 (0.05)**	0.53 (0.09)**	0.24 (0.08)**	0.87 (0.53)
$Z_1 \cdot$ Ten. 2	-0.67 (2.12)	0.24 (0.09)**	0.03 (0.14)	-0.01 (0.13)	-0.03 (1.44)
$Z_1 \cdot$ Ten. 3	-3.10 (2.20)	-0.00 (0.08)	-0.10 (0.13)	-0.02 (0.14)	-1.65 (1.27)
$Z_1 \cdot$ Ten. 4	-1.58 (16.47)	0.36 (0.49)	-0.23 (0.72)	-0.57 (0.70)	-6.71 (9.66)
$Z_2 \cdot$ Ten. 2	-2.03 (2.36)	0.09 (0.08)	0.00 (0.12)	0.16 (0.10)	0.98 (0.84)
$Z_2 \cdot$ Ten. 3	0.28 (1.89)	0.06 (0.07)	0.03 (0.11)	0.22 (0.10)*	-0.22 (0.97)
$Z_2 \cdot$ Ten. 4	-13.97 (7.61)	0.00 (0.10)	0.33 (0.23)	0.91 (0.23)**	2.05 (5.72)
Observations	171	162	162	165	167
R-squared	0.34	0.76	0.65	0.49	0.26
F-stat	4.64	27.11	15.52	8.44	3.03
Probability (F-stat)	0.00	0.00	0.00	0.00	0.00

Notes:
White heteroskedasticity-consistent standard errors in parentheses.
* and ** denote statistical significance at 0.05 and 0.01 levels accordingly.
Control variables used in estimation, but not reported.

Table 5b

Results from regression analysis – extension: responses to monetary policy versus financial market depth/ liquidity

Dependent variable	Model							
	(31)	(32)	(33)	(34)	(35)	(36)	(37)	(38)
	Stock ind.	Government bond yield			Exchange rate	Government bond yield		
		2Y	5Y	10Y		2Y	5Y	10Y
C	-0.07 (0.14)	-0.01 (0.00)	-0.01 (0.01)	-0.00 (0.01)	-0.01 (0.06)	-0.01 (0.00)	-0.01 (0.01)	-0.00 (0.01)
Z_1	1.35 (2.16)	0.36 (0.10)**	0.47 (0.18)**	0.27 (0.18)	1.51 (1.60)	0.37 (0.07)**	0.36 (0.09)**	0.17 (0.15)
Z_2	-1.95 (2.17)	0.40 (0.08)**	0.45 (0.15)**	0.12 (0.13)	0.95 (0.99)	0.38 (0.06)**	0.35 (0.13)**	0.11 (0.12)
Z_1 · FMD	-11.43 (14.36)	0.71 (0.62)	-0.31 (0.91)	0.02 (0.99)	-8.11 (9.20)			
Z_2 · FMD	-5.48 (14.35)	0.35 (0.48)	0.54 (0.74)	1.47 (0.69)*	1.24 (5.95)			
Z_1 · liquidity ind. 2Y						0.00 (0.00)		
Z_2 · liquidity ind. 2Y						0.00 (0.00)		
Z_1 · liquidity ind. 5Y							0.00 (0.00)	
Z_2 · liquidity ind. 5Y							0.00 (0.00)	
Z_1 · liquidity ind. 10Y								0.00 (0.00)
Z_2 · liquidity ind. 10Y								0.00 (0.00)*
Observations	171	162	162	165	167	162	162	165
R-squared	0.33	0.74	0.65	0.49	0.24	0.75	0.65	0.50
F-stat	5.96	32.93	20.70	10.97	3.79	33.49	21.16	11.78
Probability (F-stat)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Notes:
White heteroskedasticity-consistent standard errors in parentheses.
* and ** denote statistical significance at 0.05 and 0.01 levels accordingly.
Control variables used in estimation, but not reported.

Table 5c
Results from regression analysis – extension: responses to monetary policy versus financial stress

Dependent variable	Model				
	(39)	(40)	(41)	(42)	(43)
	Stock ind.	Government bond yield			Exchange rate
		2Y	5Y	10Y	
C	-0.07 (0.14)	-0.01 (0.00)	-0.01 (0.01)	-0.00 (0.01)	-0.02 (0.06)
Z_1	-0.01 (0.88)	0.49 (0.04)**	0.42 (0.05)**	0.26 (0.06)**	0.49 (0.64)
Z_2	-2.96 (0.82)**	0.46 (0.03)**	0.56 (0.04)**	0.38 (0.04)**	1.09 (0.40)**
$Z_1 \cdot$ (VIX + VSTOXX)/2	0.58 (0.64)	0.03 (0.02)	0.03 (0.03)	0.01 (0.02)	0.34 (0.24)
$Z_2 \cdot$ (VIX + VSTOXX)/2	-0.37 (0.65)	0.01 (0.02)	0.04 (0.03)	0.00 (0.03)	-0.14 (0.16)
Observations	171	162	162	165	167
R-squared	0.33	0.74	0.65	0.47	0.25
F-stat	5.97	33.06	21.00	10.40	3.86
Probability (F-stat)	0.00	0.00	0.00	0.00	0.00

Notes:
White heteroskedasticity-consistent standard errors in parentheses.
* and ** denote statistical significance at 0.05 and 0.01 levels accordingly.
Control variables used in estimation, but not reported.

Table 6

Results from regression analysis – extension: reference rate as a measure of monetary policy

Dependent variable	**Model**									
	(44)	**(45)**	**(46)**	**(47)**	**(48)**	**(49)**	**(50)**	**(51)**	**(52)**	**(53)**
	Stock ind.	Government bond yield 2Y	5Y	10Y	Exchange rate	Stock ind.	Government bond yield 2Y	5Y	10Y	Exchange rate
C	-0.07 (0.15)	0.01 (0.01)	0.00 (0.01)	0.01 (0.01)	0.01 (0.07)	-0.07 (0.16)	0.00 (0.01)	-0.01 (0.01)	0.00 (0.01)	-0.01 (0.07)
Reference rate	0.13 (0.52)	0.12 (0.05)**	0.08 (0.06)	0.07 (0.04)	0.23 (0.27)					
Z_1						0.12 (1.13)	0.52 (0.08)**	0.48 (0.12)**	0.32 (0.10)**	1.06 (0.67)
Reference rate – Z_1						0.14 (0.69)	0.02 (0.07)	-0.03 (0.07)	0.00 (0.06)	0.02 (0.31)
Observations	179	179	179	179	179	179	179	179	179	179
R-squared	0.29	0.17	0.15	0.10	0.13	0.29	0.32	0.25	0.18	0.14
F-stat	6.95	3.53	2.87	1.87	2.43	6.28	7.23	5.15	3.41	2.44
Probability (F-stat)	0.00	0.00	0.00	0.05	0.01	0.00	0.00	0.00	0.00	0.01

Notes:
White heteroskedasticity-consistent standard errors in parentheses.
* and ** denote statistical significance at 0.05 and 0.01 levels accordingly.
Control variables used in estimation, but not reported.

Table 7
Results from regression analysis – extension: sub-sector stock market indices

Dependent variable	Model								
	(54)	(55)	(56)	(57)	(58)	(59)	(60)	(61)	(62)
	WIG banking	WIG construction	WIG developers	WIG energy	WIG food industry	WIG IT	WIG media	WIG oil & gas	WIG telecom
C	0.19 (0.17)	0.07 (0.16)	0.15 (0.22)	-0.27 (0.20)	-0.04 (0.13)	-0.24 (0.17)	-0.05 (0.18)	-0.05 (0.24)	-0.11 (0.19)
Z_1 / MPC act.	1.21 (1.38)	0.15 (0.79)	-2.88 (3.91)	0.01 (1.85)	-0.22 (1.07)	1.81 (1.38)	0.64 (2.09)	1.74 (2.76)	0.07 (1.87)
Z_1 / MPC com.	-3.49 (1.09)**	-1.89 (0.93)*	-3.14 (1.63)	-2.55 (1.36)	-1.93 (0.82)*	-2.80 (1.28)*	-2.44 (1.98)	-4.59 (2.17)*	-5.74 (1.42)**
Observations	179	179	102	71	179	179	131	119	179
R-squared	0.31	0.09	0.45	0.18	0.23	0.19	0.15	0.16	0.21
F-stat	6.90	1.49	6.73	1.29	4.47	3.64	1.87	1.79	3.99
Probability (F-stat)	0.00	0.14	0.00	0.26	0.00	0.00	0.05	0.06	0.00

Notes:
White heteroskedasticity-consistent standard errors in parentheses.
* and ** denote statistical significance at 0.05 and 0.01 levels accordingly.
Sample – WIG banking, construction, food industry, IT and telecom: full, WIG developers: since June 2007, WIG energy: since January 2010, WIG media: since January 2005, WIG oil and gas: since January 2006.
Control variables used in estimation, but not reported.

Table 8
Endogenity tests

Dependent variable	Stock ind.	Government bond yield 2Y	Government bond yield 5Y	Government bond yield 10Y	Exchange rate
F-stat	1.26	0.97	2.97	0.12	1.21
Probability (F-stat)	0.29	0.38	0.05	0.89	0.30

Table 9
Results from regression analysis – sensitivity analysis: 1-day windows

Dependent variable	Model									
	(63)	(64)	(65)	(66)	(67)	(68)	(69)	(70)	(71)	(72)
	Stock ind.	Government bond yield			Ex-change rate	Stock ind.	Government bond yield			Exchange rate
		2Y	5Y	10Y			2Y	5Y	10Y	
C	-0.08 (0.12)	0.00 (0.01)	-0.00 (0.00)	-0.00 (0.00)	-0.01 (0.05)	-0.10 (0.10)	0.00 (0.01)	-0.00 (0.01)	0.01 (0.01)	-0.05 (0.04)
Z_1 / MPC act.	-9.61 (3.50)**	1.44 (0.19)**	1.41 (0.12)**	1.12 (0.12)**	3.15 (1.99)					
Z_1 / MPC com.	-0.94 (19.93)	0.68 (0.87)	1.04 (0.64)	0.74 (0.65)	12.42 (9.83)					
Reference rate survey vs survey						-0.60 (0.66)	0.09 (0.05)	0.10 (0.05)*	0.12 (0.04)**	0.36 (0.31)
Bias						-0.65 (0.34)	0.03 (0.02)	0.04 (0.02)*	0.04 (0.01)*	0.31 (0.14)*
Forward guidance 1						-2.89 (0.14)**	0.03 (0.01)**	0.19 (0.01)**	0.15 (0.01)**	0.23 (0.05)**
Forward guidance 2						1.12 (0.45)*	-0.12 (0.02)**	-0.06 (0.02)**	-0.07 (0.02)**	-0.37 (0.28)
Forward guidance 3						0.69 (0.39)	-0.09 (0.03)**	-0.15 (0.02)**	-0.10 (0.01)**	-0.10 (0.22)
Inflation projection revision						0.35 (0.21)	-0.01 (0.01)	-0.00 (0.01)	0.00 (0.01)	-0.05 (0.12)
GDP projection revision						-0.22 (0.34)	0.03 (0.02)	0.00 (0.01)	0.01 (0.01)	0.15 (0.21)
Observations	135	135	135	135	135	179	179	179	179	179
R-squared	0.32	0.54	0.62	0.50	0.27	0.35	0.12	0.19	0.20	0.18
F-stat	5.22	13.07	17.94	11.24	4.15	5.41	1.32	2.37	2.59	2.27
Probability (F-stat)	0.00	0.00	0.00	0.00	0.00	0.00	0.19	0.00	0.00	0.01

Notes:
White heteroskedasticity-consistent standard errors in parentheses.
* and ** denote statistical significance at 0.05 and 0.01 levels accordingly.
Sample – since August 2004.
Control variables used in estimation, but not reported.

Table 10
Results from regression analysis – sensitivity analysis: 30- and 60-minute windows

Dependent variable	Model							
	(73)	(74)	(75)	(76)	(77)	(78)	(79)	(80)
	Stock ind.		Exchange rate		Stock ind.		Exchange rate	
	30 min. dec.	30 min. sta.	30 min. dec.	30 min. sta.	60 min. dec.	60 min. sta.	60 min. dec.	60 min. sta.
C	0.01 (0.02)	-0.01 (0.04)	-0.06 (0.02)**	-0.02 (0.02)	0.02 (0.04)	0.03 (0.06)	-0.03 (0.02)	-0.01 (0.02)
Reference rate survey vs survey	-0.36 (0.26)		-0.91 (0.37)*		-0.43 (0.38)		-1.18 (0.42)**	
Bias		-0.11 (0.07)		0.01 (0.06)		-0.04 (0.07)		0.08 (0.08)
Forward guidance 1		0.50 (0.04)**		0.07 (0.02)**		-0.50 (0.06)**		0.03 (0.02)
Forward guidance 2		-0.39 (0.16)*		0.19 (0.08)*		-0.22 (0.19)		0.17 (0.08)*
Forward guidance 3		-0.00 (0.09)		0.16 (0.07)*		-0.24 (0.13)		0.23 (0.07)**
Inflation projection revision		0.17 (0.10)		0.03 (0.07)		-0.03 (0.05)		0.05 (0.07)
GDP projection revision		0.14 (0.08)		-0.04 (0.05)		0.17 (0.12)		-0.06 (0.05)
Observations	95	95	95	95	95	60	95	95
R-squared	0.02	0.12	0.16	0.04	0.01	0.06	0.21	0.06
F-stat	1.59	2.06	17.36	0.55	1.10	0.60	24.95	0.94
Probability (F-stat)	0.21	0.07	0.00	0.77	0.30	0.73	0.00	0.47

Notes:
White heteroskedasticity-consistent standard errors in parentheses.
* and ** denote statistical significance at 0.05 and 0.01 levels accordingly.
Sample – since August 2004.
Control variables used in estimation, but not reported.