Monetary policy announcements and interest rates volatility: evidence from the Mexican TIIE futures market.

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Abstract. This study contributes to the debate about the effectiveness of monetary policy transmission mechanisms by exploring the link between the Mexican Central Bank's monetary policy announcements and interest rates futures volatility. The results show that announcements have a positive and significant impact on futures volatility and that this impact is mostly produced when a restrictive monetary policy stance is announced. Moreover, it shows that the change to an interest rate operational target has increased the non-anticipated component in monetary policy signalling.

Keywords *interest rates futures · monetary policy · TIIE futures*

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1 Introduction

A topic of great interest, both for central banks and for financial markets, is the effectiveness of monetary policy transmission measured by the extent to which market participants can anticipate policy actions. If market reaction to policy announcements is large and significant it would imply that central banks are not succeeding in a smooth management of monetary policy information. Several studies have analysed this relation by measuring the impact of monetary policy announcements on changes in stock prices, in short and long term bond yields, or in interest rates futures (Cook and Hahn 1989, Edelberg and Marshall 1996, Poole and Rasche 2000, Kuttner 2001, Bomfim 2003, Bernanke and Kuttner 2005, Hamilton 2008). The empirical results consistently show that monetary policy announcements by the Federal Reserve do have significant effects in short-term interest rates and stock prices. There is also a general agreement in the importance of distinguishing between the unexpected and the expected component of the announcement. Since interest rate futures reflect market expectations of future interest rates, to isolate the unexpected component of a target rate change the common procedure has been to identify this component with changes in the rate implied by the Fed funds futures contract.

Although the majority of these studies have focused on the United States and the Fed's monetary policy actions, the topic has also raised interest in other financial markets. Results for the European Central Bank (ECB) show that in general market participants were able to predict ECB decisions quite well (Gaspar, Perez-Quiroz and Sicilia 2002), but policy actions are less predictable than Federal Reserve or the Bank of England actions (Ross 2002).

The aim of this study is to contribute to the debate by examining the impact of monetary policy announcements on market expectations in the case of Mexico. Moreover, it exploits the fact that the monetary policy transmission mechanism in Mexico underwent through various changes during the last decade to explore the effects of a transition on the market's ability to anticipate the central bank movements. This study also differs with most of the announcement effect literature in that it is set in a conditional volatility framework. In particular, it focuses on the volatility of interest rate futures, instead of the level of returns, to measure to what extent monetary policy decisions are being anticipated by market participants. The intuition is that larger price volatility in days of policy announcements would indicate that these announcements contain significant new information that market participants did not anticipate, implying a low quality in information management by the central bank (Bernoth and von Hagen 2004).

More specifically, to analyze the impact of monetary policy announcements, the research considers the 28-day interbank-rate futures contracts that are traded in the Mexican Derivatives Exchange. This contract, commonly known as TIIE futures, is one of the most useful instruments in Mexico to derive market expectations about interest rates given its liquidity, the availability of monthly maturities up to ten years ahead, and its common use as hedging instrument by market participants. According to trading volume, it is ranked among the 20 largest futures contracts in the world.

In addition to its relevance among global markets, the Mexican case is of particular interest because of the transition to an interest rate operational target and to a more transparent monetary policy signalling mechanism. Before 2004 the Central Bank did not determined a target for the overnight funds rate. Instead, it transmitted its policy intentions by establishing a target level for banks' current account balances at the central bank and penalizing banks with negative balances in those accounts. Because of the high market volatility in the aftermath of the 1995 financial crisis, the Central Bank deliberately decided not to set the target rate, since short term interest rates were the only reference in the money market. Furthermore, in an environment of decreasing inflation rates, a target level for banks' current account balances allowed interest rates to decline in line with inflation expectations (Banco de Mexico, 2007). Since April 2004, and once the Mexican economy presented more stable conditions, the Central Bank started to announce its target for the overnight interbank rate together with the level of banks' current account balances at the central bank at market rates. In January 2008 the level bank's current account balances was definitively substituted by the overnight interbank interest rate as operating target. Another important change was the decision in 2003 to define pre-established dates to announce the monetary policy stance.

Using a GARCH model to estimate futures price volatility in contracts with monthly maturities up to 12 months ahead, and including policy announcements days as exogenous variable on the conditional variance, we find that the announcements significantly increase futures price volatility. This suggests that interest rates futures market is not correctly anticipating the central bank monetary policy signals. Moreover, the results indicate that the impact is mostly related to a restrictive monetary policy stance. The results also show that the change in the operational target do not correspond to an improvement in the anticipation of monetary policy actions. The paper contributes to the announcement effect literature by assessing the impact on volatility, and by looking at the differences between several policy transmission' mechanisms within the same economy.

The rest of the document is organized as follows. The next section contains a review of previous studies. Section three provides the necessary background to understand the conduction of the Mexican monetary policy over the last 15 years. The data and methodology are explained in sections four and five. Section six presents and discusses the results obtained while some final remarks are exposed in the last section.

2 Previous studies

There is an extensive amount of literature which studies the response of interest rates to changes in the central bank monetary policy stance. Probably the first study in this direction was by Cook and Hahn (1989), who examined how yields on Treasury securities reacted to changes in target Fed fund rates between 1974 and 1979. Using just those days on which there was a change in the target, their procedure was to regress one-day changes in Treasury bills, notes and bonds rates on changes in federal funds target rate. They found that the response to increments in the target rate was positive and significant at all maturities, but smaller at the long end of the yield curve. Their work was followed by a large number of studies, including Roley and Sellon (1998a, 1998b), Kuttner (2001), Poole and Rasche (2000), Poole, Rasche and Thornton (2002) or Hamilton (2008). These studies developed further analysis either focusing on more recent periods or introducing improved specifications or techniques. A consistent result emerges from this literature: interest rates systematically respond to policy actions or policy related information, implying that these actions are not being fully anticipated.

After their introduction in the Chicago Board of Trade (CBOT) in 1989, the 30-day Federal Funds Futures contracts became popular as predictors of the Fed's changes in target rates. The question of the ability of the Fed funds futures rates to forecast the funds target rate and, by extension, short-run movements in monetary policy was initially considered by Carlson, McIntire and Thomson (1995). Krueger and Kuttner (1996) presented more elaborated analysis and concluded that the Fed funds futures market is very good at anticipating changes in the target fund rate. Robertson and Thornton (1997) point out the difficulties arising from the fact that the fed funds futures rate forecasts the funds rate and not the funds rate target, but still agree in the usefulness of the federal funds futures rate as predictor of whether the Fed will change its target. Soderstrom (2001) shows that futures-based proxies for funds rate expectations have weak predictive power for the average funds rate using daily data but are more successful in predicting the average funds rate and the funds rate target around target changes and meetings of the Federal Open Market Committee (FMOC). The predictive power of futures rates has also being assessed by Gurkaynak, Sack and Swanson (2006) and Gurkaynak (2005) for the Fed funds rate, while Sack (2004) demonstrates how to extract the expected policy path of monetary policy from futures rates, under the assumption that risk premia is constant over time and considering both Fed funds and Eurodollar futures contracts.

Roley and Sellon (1998a) and Kuttner (2001) pointed to the need to distinguish between the expected and unexpected elements of monetary policy announcements. Kuttner argued that bond yields set in forward-looking markets should respond very differently to anticipated and unanticipated elements of monetary policy. If the market anticipates much of the target changes occurring on day *d*, then those expectations would have been incorporated into long-term rates on day *d – 1*. Therefore little change should be observed on the day of the target change. On the other hand, a surprise in the target rate will lead to a change in the long-term rates. To isolate the unanticipated component of the target change, Kuttner used the spot-month 30-day Federal Funds Futures contracts as a measure of expected Fed policy. Under this perspective, changes in the futures rate on day *d* are used as a measure of the unexpected change in the target rate on day *d*. Regressing the change in the interest rate on the unexpected and expected components of the target rate change, Kuttner found a small and statistically insignificant response to the anticipated piece, while the response to the unanticipated component was large and highly significant. In fact, for the surprise component, the coefficients obtained were larger than those reported by Cook and Hahn.

Poole and Rasche (2000) argued that monetary policy should be conducted in such a way that the market can predict policy actions. In other words, the interest rate futures rates can be used as a tool to measure the efficiency of monetary policy transmission. If the market was able to perfectly anticipate the central bank policy decisions – actions or non-actions – then market interest rates should adjust in response to information innovations, but not to the central bank's announcements of monetary policy decisions.

The research has widened up to include other central banks and markets, and it has also tended to support the view that, as transparency and markets' understanding of policy have increased over the years, the accuracy of market forecasts of central bank policy actions has improved. For example, Haldane and Read (2001) found that the introduction of inflation targeting in the United Kingdom appears to have a dampening effect in the yield curve responses at the short term. For the United States, Poole, Rasche and Thornton (2002) showed that predictability of the Fed's actions increased after the 1994 decision to announce changes in the target rate immediately after the FOMC meetings. The study of Gaspar, Perez-Quiroz and Sicilia. (2002), examines the impact of the European Central Bank (ECB) policy decisions in the level and volatility of the daily overnight interbank rate (EONIA) using a GARCH model. They concluded that market participants were able to predict the ECB's interest rate decisions quite accurately. However, the study of Ross (2002) suggests there was some difficulty of the market in anticipating large changes in ECB target rates.

Bernoth and von Hagen (2004) analyze three aspects of the predictability of interest rates in the European Monetary Union (EMU): the efficiency of the Euribor interest rate futures market, the impact of monetary policy announcements on the volatility of Euribor futures rates, and the effect of ECB policy announcements on the prediction error contained in Euribor futures rates. They find that Euribor futures rates with a forecast horizon of up to four months are unbiased and efficient predictors of future spot rates, and that the patterns in volatility indicated that market participants correctly anticipated the direction of interest rates changes intended by the ECB but there was uncertainty about the timing. During the first five years of EMU the average volatility of Euribor futures rates on Council days was significantly larger than on non-Council days. Finally they found that the information released by the Governing Council meetings did not improved the market's ability to forecast interest rates.

3 The Mexican Central Bank's Monetary Policy Transmission Mechanism.

3.1 The "corto"

During the last decade the monetary transmission mechanism in Mexico have undergone important changes. The decade was marked by the recovery from the 1995 financial crisis that brought a strong depreciation of the currency, high inflation, and a severe deterioration in the real economy. In such a context, the Central Bank considered inadvisable to use target interest rates as operational target. The argument was that, in a period with high volatility and when short-term interest rates were practically the only reference rates in the money market, it was not convenient to determine a specific level of interest rates: too low a rate would have encouraged lending and higher inflation, while a high rate would have aggregated the problems faced by borrowers and the difficulties faced by commercial banks.

In 1995 the Central Bank introduced an operational framework to send qualitative signals to the market without determining interest rate levels. It comprised a reserve requirement with averaging around a level of zero reserves over a 28-calendar-day maintenance period. Under this scheme, the Central Bank did not remunerate positive settlement balances nor did it charged for overdrafts posted at the end of each day in the commercial banks current accounts balances at the Central Bank. Instead, it charged a penalty rate at the end of the maintenance period if the cumulative balance of daily positive and negative balances was negative. The high level of the penalty, twice the overnight interbank rate, was intended as an incentive for the banks to end the maintenance period with a zero cumulative balance, making the net cost of end-of-period negative cumulative balances similar to the cost of holding end-of-period positive cumulative balances. The transmission of monetary policy under this framework involved providing or withdrawing liquidity, at market rates, so that banks' current accounts at the central bank equalled zero at the end of the measurement period. To maintain a restrictive policy, the central bank announced a negative balance target, and for an accommodative monetary policy, a positive balance target.

By 1998, once the major difficulties posed by the crisis were overcame, Banco de Mexico started to signal a bias towards a restrictive monetary policy stance through a negative overdraft target on the cumulative balance of commercial banks' current accounts (the monetary policy instrument known as "el corto"). When the negative balance target is used, the central bank provides all the liquidity needed by the financial system. However, part of this liquidity, the size of the corto, was provided at the penalty rate. This action pressured interest rates upwards as banks tried to obtain the funds through the interbank market to avoid paying the penalty rate. An increase in the corto was thus interpreted as a signal of a tighter monetary policy stance, while its reduction was seen as a more neutral stance, even though the level of the corto was not taken to zero.

3.2 Transition to an interest rate operating target

Since 2001, Banco de Mexico's monetary policy has been conducted exclusively under an inflation targeting framework. In 2002, an annual inflation rate of 3% was defined as the long-term inflation target, with a variability interval of plus/minus one percentage point. The introduction by Banco de Mexico of inflation targeting has been associated with a major break in the transmission mechanism: since then, the level and volatility of inflation have not only declined, but the degree of inflation persistence has fallen (Capistran and Ramos-Francia 2006) and inflation has switched from a non-stationary to a stationary process (Chiquiar, Noriega and Ramos-Francia 2007).

Once stability in financial markets and low inflation were attained, the exclusive use of the corto to signal the monetary policy stance became less appropriate. In an environment of stable inflation, the desired level of interest rates needs to be specified more clearly. For this reason, and to strengthen monetary policy implementation, Banco de Mexico started in 2003 the gradual process of adopting an operating interest rate target. First, the target level for banks' current account balances at the central bank was determined on daily balances instead of accumulated balances. In addition, Banco de Mexico decided to announce its monetary policy stance on pre-established days. In April 2004, in addition to the level of the corto, it also started to communicate specific levels of interest rates (euphemistically called "monetary conditions"). Through its press releases, Banco de Mexico's signalling of an adjustment in monetary conditions led to a precise and stable adjustment of the overnight interbank rate. Since 2004, the market has functioned according to the interest rate signalled by Banco de Mexico. In fact, the last change in the overnight interbank rate associated with the corto took place in February 2005. This smooth transition to an operating interest rate target concluded when, in January 2008, the corto was definitively substituted by an operating target for the interbank overnight rate.

Banco de Mexico has insisted that the change in operating target does not imply any other change in monetary policy objectives or instruments. Open market operations will continue to be carried out to attain a zero balance of banks' current accounts at the end of each day, and to provide or withdraw liquidity. The interest rates at which surpluses are rewarded will continue to be zero and the rate charged on banks' overdrafts will continue to be twice the overnight rate.

4 The TIIE rate and its futures contracts

4.1 The TIIE Spot Rate

Since March 1996, Banco de Mexico determines and publishes the short-term interest rate benchmark known as Tasa de Interés Interbancario de Equilibrio, or TIIE. This rate is the measure of the average cost of funds in the Mexican interbank money market and it is based on quotations submitted daily by full-service banks. The participating institutions submit their quotes by noon (Mexico City time) and Banco de Mexico determines the TIIE as a weighted average between bid and ask quotes. The rates quoted by institutions participating in the survey are not for informational purposes only; they are actual bids and offers by which these institutions are committed to borrow from or lend to Banco de Mexico. In case Banco de Mexico detects any irregularity, it may deviate from the stated procedure for determination of the TIIE rates.

Figures 1 and 2 show the evolution of the TIIE spot rate and of its volatility (measured as the absolute value of daily returns) from January 2001 to the second quarter of 2008. During this period different phases on the TIIE spot rate behaviour can be identified. However, what strikes most is the contrast between a period of high volatility that prevailed throughout the first half of 2004 and where movements of almost 150 bps within very short periods (2 weeks) were present, and the later period, where the TIIE spot rate stabilized. In fact, after June 2006, the volatility of TIIE changes has remained close to zero.

The most likely explanation for the abrupt decrease in volatility may be related to the changes in the monetary policy transmission mechanism explained above. As we have mentioned, since April 2004 Banco de Mexico communicates the overnight funds target rate which resulted in the progressive reduction in short-term interest rates volatility.

4.2 TIIE Futures Contracts

The TIIE futures contracts are traded in the Mexican Derivatives Exchange (MexDer) and have as underlying 28-day deposits that produce yield at the 28-day TIIE. Each (28-day) TIIE futures contract covers a face value of $100,000 Mexican Pesos (approximately 7,600 US Dollars). MexDer lists and makes available for trading series of the TIIE futures contracts on a monthly basis for up to ten years. It is important to observe that, in contrast with analogous instruments like CME's Eurodollar or LIFFE's Short Sterling futures, TIIE futures quotes are in terms of future yields, not in terms of prices. The relation between the quoted future yield on day t and the corresponding futures price F_t is determined by the formula

$$F_t = \frac{100{,}000}{1+Y_t\,(28/36000)} \tag{1}$$

where Y_t is the quoted yield divided by 100. The last trading day and the maturity date for each series of 28-day TIIE futures contracts is the bank business day after the Central Bank holds the primary auction of government securities in the week corresponding to the third Wednesday of the maturity month. Since these primary auctions are usually held every Tuesday then, in general, expiration days for TIIE futures correspond to the third Wednesday of every month. For purposes of discharging obligations, settlement date on maturity is the bank business day after the maturity date.

5 Methodology

5.1 Sample data

The TIIE futures contract was initially listed in 1999 and it took a couple of years to reach reasonable levels of trading volume. For this reason, and considering that it was not until 2001 that the Central Bank conducted its monetary policy exclusively under an inflation targeting framework, the period analysed is from January 2001 to June 2008. During that period Banco de Mexico released 77 policy announcements, 44 of which maintained monetary conditions unchanged, 22 announced the contraction of monetary conditions and 11 the expansion (Table 1). As mentioned above, before 2003 there were not specific release dates, for example, there were only three policy announcements in 2001 and four in 2002. From 2003 the third Friday of each month was set as the predetermined date to communicate the monetary intentions, but the Central Bank kept the right to release further announcements if necessary. In 2003 and 2004 there were 14 announcements, that is, two more than the expected. All four additional releases were to announce monetary contraction, three of them followed a predetermined announcement of unchanged monetary conditions, and the other one at the beginning of 2004, was to increase a previous announced contraction. Despite the fact that Banco de Mexico started to set the target for the overnight interest rates since April 2004, policy press releases during 2004 did not contain explicit information about target interest rates. During 2005 the four releases that mentioned interest rates announced the decrease of the target rate. From January 2006 every press release mentions the interest rate target, in most cases leaving the target rate unchanged.

The futures rates data used in this study are those provided by the MexDer. In particular, the analysis considers the period from January 3rd, 2001 to June 30th, 2008 (a total of 1890 trading days). For each trading day, we consider 12 observations corresponding to the daily settlement rates of each of the 28-day TIIE futures contracts expiring every month, from the next-to-expiration contract to the contract expiring 12 months ahead. For each of these series, plus the series of TIIE spot rates, the analysis considers the logarithmic price changes (or log-returns)

$$r_t = ln\left(\frac{S_t}{S_{t-1}}\right) \tag{2}$$

where S_t is the settlement price on day t, which is calculated according to formula (1)[1].

To avoid the problem of the limited lifespan of individual futures contracts, a panel is created by rolling over contracts: once the most immediate contract reaches maturity, we rollover each of the log-return series to the contract that is

[1] For consistency TIIE spot rates are also transformed to prices.

next according to maturity. The result of this procedure is a panel consisting of 12 rollover series defined according to time to maturity. The first series (Series No. 1) contains log-returns for the most immediate contract, the second one contains log-returns for the contract that will expire between two and one months ahead, the third one log-returns for the contract with expiration between three and two months ahead, and so on.

As we mentioned before, in April 2004 Central Bank introduced the spot rate target as its main instrument for monetary policy. Hence, the analysis will also consider two separate subperiods: a first subperiod from January 3rd 2001 to March 31st 2004 (816 daily observations) and a second subperiod from April 1st. 2004 to June 30th., 2008 (1,074 daily observations)[2].

5.2 The GARCH Specification

To take into account the heteroscedasticity of the series, the study will consider a GARCH(1,1) specification to model the volatility of the futures prices. More specifically, to test the effects of monetary policy announcements, we will consider an AR(1)-GARCH(1,1) model of the form

$$r_t = \mu + \phi r_{t-1} + u_t \tag{3}$$

$$h_t = \alpha_0 + \alpha_1 u_{t-1}^2 + \beta_1 h_{t-1} + \gamma_n D_{nt} \tag{4}$$

where μ is a constant, r_t is the logarithmic change of settlement prices on day t and the residuals u_t are assumed to be normally distributed with mean zero and conditional variance h_t. The variable D_n will be a dummy variable for the different type of monetary policy announcements. Moreover, to control for possible day-of-the-week effects not related with monetary policy announcements, we will also include in the conditional variance equation daily dummies for days of the week as exogenous variables.

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[2] Estimations were also performed with different dates between April 2004 and December 2004 as break points to separate the two subperiods. The results obtained are qualitatively the same.

Equations (3) and (4) will be estimated jointly by maximum likelihood (ML). The ML estimates were obtained with RATS (v.5) software package using the Berndt-Hall-Hall-Hausman algorithm. Since the accuracy of GARCH model estimation and of the associated *t*-statistics may depend on the software employed, the maximum likelihood estimation was also performed under EViews package using the Marquardt optimization algorithm. Although the coefficient estimates and their standard errors differ slightly, the reported results are qualitatively the same.

The methodology is similar to the one used by financial economists to analyse the effects of economic data releases on market volatility (Bomfim, 2003 and Jones, Lamont and Lumsdaine, 1998). These studies use GARCH estimations to model the conditional volatility to assess the surprise element of policy announcements.

6 Results and discussion

The reaction of the TIIE futures price volatility to monetary policy decisions will allow us to draw conclusions of how well money market participants predict Central Bank decisions. It also should indicate how the changes in the operational target affected the way monetary policy stance is transmitted to the market.

The analysis of the TIIE futures volatility is performed in two directions: the first focuses on the changes occurring between the first and second subperiods. The second takes into account the type of announcement. That is, the analysis not only considers the dates in which monetary policy announcements occur, but will also distinguish between restrictive announcements, expansive announcements or days where the announcement meant no change in the monetary policy conditions.

6.1 Preliminary analysis

Panels A, B and C in Table 2 provide summary statistics of each series of rate changes for the whole sample and for the first and second periods, respectively. For the whole sample means are significantly different from zero in the first four contracts (Panel A), and standard deviation is higher for contracts closer to expiration. In the first subperiod (Panel B) some means are significantly different from zero and the standard deviation also tends to increase when contracts are closer to expiration. However, in the second subperiod (Panel C) no mean is statistically different from zero, volatility has smaller values and it decreases as contracts approach to expiration. This inversion of volatility patterns confirms the change in the market conditions: as the monetary policy implemented since April 2004 removes uncertainty in short term interest rates, and inflation progressively stabilizes, long term contracts tend to show higher volatility with respect to short term ones.

All series, including the spot rate, tend to have negative skewness, they are leptokurtic and, according to the Bera-Jarque statistic, are far from being normally distributed. However, the non-normal behaviour tends to be stronger for nearby contracts. The Engle (1982) LM-test for an autoregressive conditional heteroscedasticity (ARCH) effect clearly rejects the null of no ARCH effect in both the futures and TIIE log-price changes.

To further explore the behaviour of futures prices changes on announcement days we estimate the mean average abnormal return for each contract using the TIIE spot prices change as the expected return for the futures contract on any particular day. We use the following equation:

$$\overline{AR}_i = \frac{1}{n}\sum_{t=1}^{n}(r_t - Y_t) \qquad (5)$$

where $\overline{AR_i}$ is the average abnormal return for contract i ($i \in \{1 \text{ to } 12\}$), r_t is the daily log return on day t for the futures contract from equation (2), and Y_t is the daily log return for the spot TIIE. The average abnormal returns are estimated for all announcements, and for restrictive and expansive announcements separately. Fig. 3 (a), (b) and (c) plot the average abnormal returns for all announcements, restrictive and expansive announcements respectively. Consistently, the magnitude of the average abnormal returns for every contract, regardless the time to expiration, is higher on the announcement days than days without monetary policy news. As it will be confirmed later, market participants seem to present a strong reaction to the information released by the Central Bank reflected on futures contract prices.

6.2 The impact of monetary policy announcements

Table 3 reports the maximum-likelihood parameter estimates for the GARCH(1,1) specification defined by equations (3) and (4), when all the announcements are included as exogenous variable. Results show that, when the whole period is considered, the announcement days are always significant, especially for nearby contracts. This is also true for the second subperiod (2004-2008), but not for the first subperiod, where the announcement days coefficient is only significant in five contracts. This suggests the introduction of an operational interest rate target increased the non-anticipated component in target rate changes.

It should also be noted that, in general, there is no apparent relation between the magnitude of the impact of the announcement on futures volatility (i.e. the size of the announcement coefficient), and the time to maturity of the contract. However, the magnitude of these impacts tends to be smaller in the second period, a result in line with the previous observation that in the second period futures volatility has diminished as a consequence of the monetary policy implemented since April 2004, and of the stabilization of inflation rates.

We now distinguish between announcements corresponding to an expansive policy, a restrictive policy or those that implied no change in the monetary policy conditions. Table 4 reports the coefficients obtained for the whole period and the subperiods when the dummy variable D_{nt} in the GARCH(1,1) model takes the value *1* whenever the announcement corresponds to a relaxation of the monetary conditions and zero otherwise. It can be seen that, either in the whole period or in any of the subperiods, the effect of expansive announcements has little significance in explaining changes in volatility.

In contrast, restrictive announcements appear to be significant for almost all contracts during the whole period, as can be seen in Table 5. However, when the subperiods are considered separately, we find they behave very differently. While in the first period restrictive announcements do not appear to have a major effect on the volatility of the TIIE futures returns, in the second subperiod those announcements are highly significant.

Although not reported here, we should add that when we consider those announcements in which no change was made, only the nearby contracts appear to be affected, either on the whole period or in the subperiods.

In summary, the results indicate that: 1) The announcements most of the time have a positive and significant impact on volatility. 2) The strength or significance of the impact depends on the nature of the announcement: restrictive announcements are the ones that significantly induce a change in volatility, while expansive announcements have little effect. 3) With respect to the effects of announcements on futures volatility, the two periods present a different behaviour. With respect to the first period, in the second period the announcements have a much greater impact increasing futures volatility.

Although not reported, the normality and correlation tests for standardized residuals and squared standardized residuals confirm the adequacy of the model for all the series considered.

6.3 Controlling for day-of-the-week effects

Although differences in price volatility in futures contracts across days of the week has been mainly attributed to macroeconomic scheduled announcements, it is important to verify that abnormal behaviour during policy announcements is not the result of day-of-the week anomalies. These anomalies have been commonly reported in the literature, for example Dyl and Maberly (1986a,b), Harvey and Huang (1991), Ederington and Lee (1993) and Han, Kling, and Sell (1999).

To control the potential effects of any recurrent pattern in a particular day of the week in the futures price returns and variance, we estimate the following regressions,

$$r_t = \mu + \phi r_{t-1} + \delta_M D_{Mt} + \delta_T D_{Tt} + \delta_H D_{Ht} + \delta_F D_{Ft} + u_t \qquad (6)$$

$$h_t = \alpha_o + \alpha_1 u_{t-1}^2 + \beta_1 h_{t-1} + \gamma_n D_{nt} + \sum_k \gamma_k D_{kt} \qquad (7)$$

The variables D_{Mt}, D_{Tt}, D_{Ht} and D_{Ft}, are binary dummies for Monday, Tuesday, Thursday, and Friday respectively. Given that a constant term is allowed in the regression equation, the dummy trap is avoided by not including a dummy for Wednesdays (the choice was dictated by the fact that Wednesday is the usual expiration day for all contracts). As before, D_{nt} are the dummies for monetary policy announcements and D_{kt} in the conditional variance are day of the week dummies ($k \in \{M, T, H\ F\}$).

Results (not reported here, but available from the authors) show a significant Tuesday effect in volatility which can be strongly related with the fact that Banco de Mexico conducts Treasury Certificates (CETES) auctions on Tuesdays. These auctions release information about interest rates for the 28 and 91-days treasury bills. Regardless of this Tuesday effect, the impact of monetary policy announcements on futures price volatility remains positive and significant. We therefore conclude that the results obtained are still robust after controlling for day-of-the-week effects.

7 Conclusions

This paper investigates the existence of monetary policy effects in the volatility of the interest rate futures in the specific case of the Mexican market. Using a GARCH model to estimate futures price volatility in contracts with monthly maturities up to 12 months ahead and including policy announcements days as exogenous variable on the conditional variance, we find that the announcements have a significant and positive impact on futures volatility. This suggests that the market is not correctly anticipating the Central Bank monetary policy signals. Moreover, the results indicate that this impact mostly occurs when the announcement corresponds to a restrictive monetary policy stance. In other words, there is an asymmetry in the way market participants perceive or anticipate the Central bank monetary policy actions.

The results also show the change in the operational target used by the Central Bank to transmit its monetary policy brought changes in the effects of the announcements on futures price volatility. More specifically, it appears that with the introduction of a interest rate operational target market participants have been less capable of anticipating monetary policy actions. Results are still robust after controlling for day-of-the-week effects.

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Fig. 1 TIIE spot rate (January 1, 2001 – June 30, 2008). The graph presents the daily TIIE spot rate in percentage.

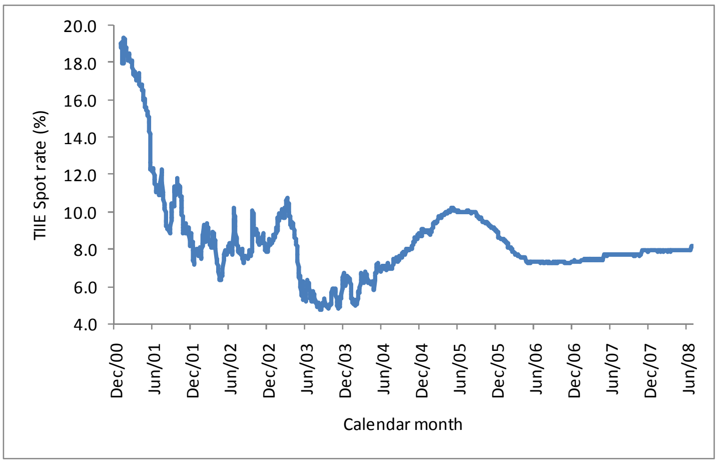

Fig. 2 TIIE spot volatility (January 1, 2001 – June 30, 2008). The graph presents the volatility of the TIIE spot rate measured as the absolute value of daily log rate changes.

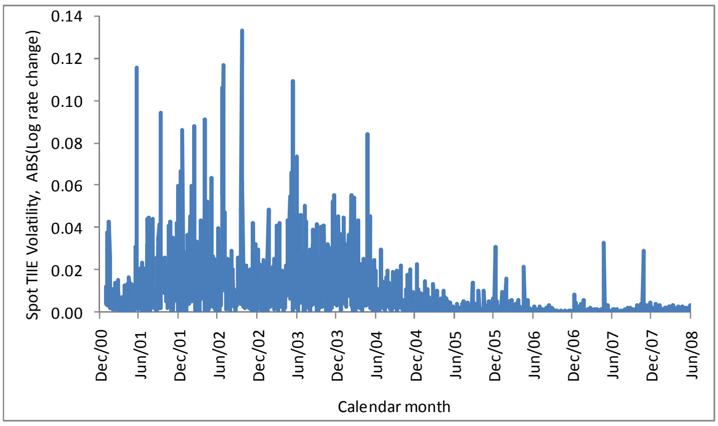

Fig. 3 (a) Average daily abnormal returns by contract (January 1, 2001 – June 30, 2008). The graph presents the average daily abnormal return for each of the twelve contracts for the announcements days and for the rest of the days. One stands for the contract next to maturity and 12 for the contract expiring 12 months ahead.

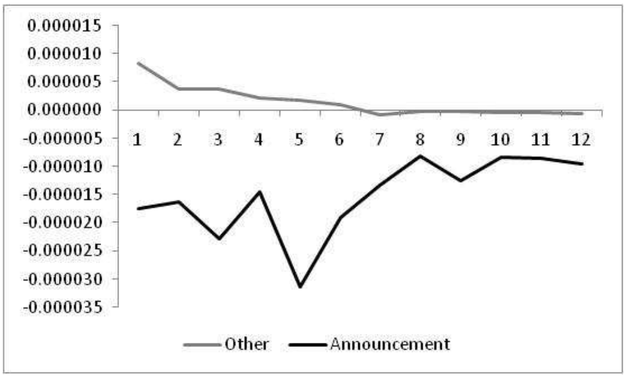

Fig. 3 (b) The graph presents the average daily abnormal return for each of the twelve contracts for the restrictive announcements days and for the rest of the days.

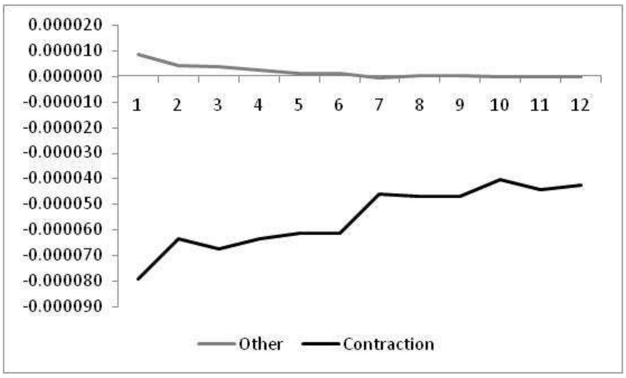

Fig. 3 (c) The graph presents the average daily abnormal return for each of the twelve contracts for the expansive announcements days and for the rest of the days.

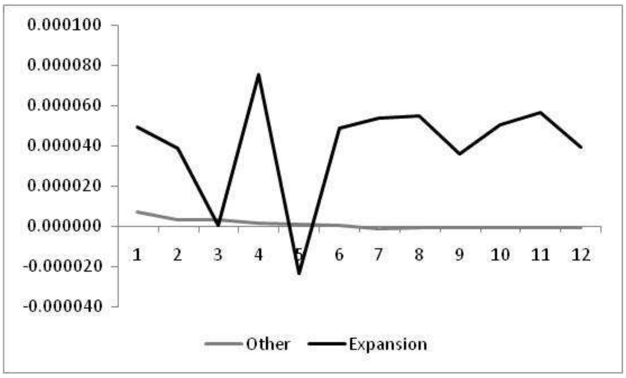

Table 1 Banco de Mexico, Monetary Policy Announcements January 2001 – June 2008

	Monetary Policy				Target rate			
Year	Contraction	Expansion	Unchanged	Total	Increase	Decrease	Unchanged	Total
2001	1	2	0	3	N.A	N.A	N.A	
2002	3	1	0	4	N.A	N.A	N.A	
2003	3	0	11	14	N.A	N.A	N.A	
2004	9	0	5	14	N.A	N.A	N.A	
2005	3	4	5	12		4		4
2006	0	4	8	12		4	8	12
2007	2	0	10	12	2		10	12
2008	1	0	5	6	1		5	6
Total	22	11	44	77	3	8	23	34

Note. The table reports the number of monetary policy announcements by year from January 2001 to June 2008. The first set classified the announcements in contraction, expansion or unchanged; the second set indicates if target interbank rate increased, decreased or remained unchanged. Between 2001 and 2004 there was no indication of target rates.

Table 2 Statistics for the TIIE futures log returns by subperiods

Series	*Mean*		*Standard Deviation*	*Skewness*	*Excess Kurtosis*	*Bera-Jarque*		*ARCH-LM*	
Panel A: Whole period 2001-2008 (1890 obs.)									
1	0.0116	**	0.1365	0.981	94.28	700265.9	**	641.26	**
2	0.0073	**	0.1206	0.831	38.71	118198.8	**	338.90	**
3	0.0071	**	0.1115	-0.484	19.6	30336.8	**	283.53	**
4	0.0059	*	0.1183	-0.544	16.45	21391.3	**	171.03	**
5	0.0047		0.1211	-0.858	24.11	45993.8	**	156.80	**
6	0.0044		0.1200	-0.391	25.76	52286.4	**	195.87	**
7	0.0030		0.1109	-0.152	18.99	28392.0	**	152.50	**
8	0.0038		0.1108	-0.464	16.86	22449.2	**	217.12	**
9	0.0037		0.0995	-0.263	12.33	12001.7	**	155.78	**
10	0.0035		0.0986	-0.441	12.44	12242.0	**	200.83	**
11	0.0035		0.0990	-0.359	12.54	12415.2	**	195.29	**
12	0.0033		0.0949	0.096	11.46	10340.3	**	220.33	**
TIIE	0.0043		0.1001	-0.585	24.98	49258.4	**	67.20	**
Panel B: Subperiod January 2001- March 2004 (816 obs.)									
1	0.0259	**	0.2034	0.488	42.67	61951.37	**	275.89	**
2	0.0175	**	0.1776	0.453	17.42	10347.44	**	142.00	**
3	0.0168	**	0.1623	-0.520	8.74	2635.55	**	103.19	**
4	0.0141	*	0.1723	-0.533	7.10	1753.45	**	46.67	**
5	0.0120		0.1758	-0.753	11.25	4377.98	**	48.89	**
6	0.0114		0.1737	-0.394	12.22	5095.76	**	68.42	**
7	0.0079		0.1588	-0.183	9.07	2800.50	**	48.75	**
8	0.0101		0.1583	-0.460	8.05	2230.76	**	71.74	**
9	0.0097	*	0.1399	-0.298	5.99	1233.59	**	45.64	**
10	0.0093		0.1382	-0.450	6.23	1345.06	**	65.10	**
11	0.0093		0.1381	-0.384	6.42	1422.85	**	63.47	**
12	0.0087		0.1306	0.019	6.14	1283.75	**	76.26	**
TIIE	0.0118	*	0.1475	-0.533	10.80	4007.55	**	15.41	**
Panel C: Subperiod April 2004- June 2008 (1074 obs.)									
1	0.0007		0.0330	-1.232	18.04	14831.78	**	180.91	**
2	-0.0004		0.0386	-0.985	12.47	7133.89	**	176.14	**
3	-0.0004		0.0417	-0.592	7.37	2495.95	**	183.42	**
4	-0.0003		0.0450	-0.357	5.45	1354.07	**	141.17	**
5	-0.0008		0.0476	-0.495	5.49	1393.10	**	158.67	**
6	-0.0009		0.0486	-0.575	5.12	1233.56	**	100.39	**
7	-0.0007		0.0495	-0.525	4.34	891.33	**	83.65	**
8	-0.0010		0.0502	-0.378	3.51	577.78	**	89.41	**
9	-0.0009		0.0501	-0.562	4.48	955.01	**	76.91	**
10	-0.0009		0.0508	-0.482	3.48	583.01	**	63.04	**
11	-0.0008		0.0522	-0.413	3.37	538.15	**	69.76	**
12	-0.0007		0.0537	-0.386	3.3	513.92	**	62.34	**
TIIE	-0.0014		0.0324	-2.720	29.89	41295.37	**	23.89	**

Note. Series n consists of rates changes for the contract with expiration between n and $n-1$ months ahead. LM(5) is the LM-statistic for ARCH effects with 5 lags. * and ** indicate significance at 5% and 1% levels respectively.

Table 3 GARCH estimates for all monetary policy announcements

Series	$\mu \times 10^5$	*tstats*	ϕ	*tstats*	$\alpha_0 \times 10^7$	*tstats*	α_1	*tstats*	β_1	*tstats*	$\gamma \times 10^7$	*tstats*
	Whole sample											
1	0.1283	3.31 *	0.15	7.15 *	0.00003	2.64 *	0.31	16.97 *	0.77	81.7 *	0.0046	22.38 *
2	0.1351	2.10 *	0.14	5.75 *	0.00003	1.69	0.20	19.34 *	0.83	127.5 *	0.0029	7.73 *
3	0.1623	2.04 *	0.17	6.92 *	0.00008	2.45 *	0.18	19.62 *	0.85	121.3 *	0.0027	5.02 *
4	0.1533	1.54	0.13	5.90 *	-0.00006	-2.25 *	0.06	13.62 *	0.94	278.4 *	0.0029	4.74 *
5	0.2319	2.43 *	0.13	4.97 *	0.00014	2.15 *	0.17	28.57 *	0.86	173.6 *	0.0046	4.28 *
6	0.1112	0.99	0.12	5.77 *	-0.00010	-1.98 *	0.05	14.42 *	0.96	429.2 *	0.0031	3.47 *
7	0.1996	1.91	0.11	5.26 *	0.00010	1.30	0.14	17.22 *	0.88	137.7 *	0.0037	2.72 *
8	0.1589	1.39	0.11	5.26 *	-0.00001	-0.17	0.09	20.74 *	0.92	273.7 *	0.0040	3.19 *
9	0.0865	0.72	0.10	4.78 *	-0.00010	-1.55	0.04	14.46 *	0.96	425.8 *	0.0033	2.63 *
10	0.1001	0.81	0.11	5.69 *	-0.00014	-2.07 *	0.04	13.29 *	0.96	389.2 *	0.0042	3.37 *
11	0.1194	0.94	0.11	5.40 *	-0.00008	-1.20	0.06	16.30 *	0.94	325.7 *	0.0043	3.33 *
12	0.1777	1.40	0.10	4.88 *	0.00012	1.11	0.12	18.90 *	0.88	162.2 *	0.0076	4.61 *
TIIE	0.0264	1.51	0.05	2.17 *	0.00000	0.13	0.43	22.53 *	0.70	107.2 *	0.0105	33.10 *
	Subperiod 2001-2004											
1	1.8911	3.52 *	0.15	3.58 *	0.01218	8.92 *	0.21	9.38 *	0.78	46.17 *	0.0004	0.02
2	1.4576	3.42 *	0.16	4.64 *	0.00352	2.76 *	0.17	11.14 *	0.84	93.97 *	0.0298	2.14 *
3	2.0006	4.83 *	0.10	2.35 *	0.02841	7.04 *	0.39	14.03 *	0.56	21.16 *	0.1089	2.70 *
4	1.7110	3.43 *	0.09	2.07 *	0.01181	5.47 *	0.18	9.21 *	0.80	46.20 *	0.0162	1.16
5	1.5170	4.11 *	0.09	1.87	0.00906	4.95 *	0.23	15.07 *	0.78	76.85 *	0.0079	0.62
6	0.8915	1.88	0.01	0.21	0.00494	5.61 *	0.04	8.67 *	0.94	141.19 *	-0.0473	-6.31 *
7	1.1301	3.25 *	0.02	0.57	0.00407	3.50 *	0.20	11.27 *	0.83	62.95 *	0.0022	0.20
8	1.3318	3.59 *	-0.01	-0.21	0.00521	5.34 *	0.19	12.00 *	0.82	63.84 *	0.0182	1.60
9	0.7557	1.90	-0.04	-1.00	0.01153	6.75 *	0.18	10.81 *	0.78	52.38 *	0.0235	1.54
10	1.1099	3.21 *	-0.01	-0.33	0.00932	7.23 *	0.20	12.14 *	0.78	58.52 *	0.0184	1.52
11	1.1139	3.24 *	0.00	0.05	0.00688	5.13 *	0.26	13.98 *	0.74	60.62 *	0.0535	4.48 *
12	1.1539	3.38 *	0.00	0.05	0.00600	5.30 *	0.21	12.53 *	0.78	66.18 *	0.0312	2.85 *
TIIE	0.7322	1.60	0.36	8.46 *	0.01830	5.08 *	0.21	7.81 *	0.69	30.31 *	0.2305	7.26 *
	Subperiod 2005-2008											
1	0.1443	3.57 *	0.07	2.26 *	0.00017	7.66 *	0.45	13.24 *	0.61	45.81 *	0.0087	16.65 *
2	0.1722	2.66 *	0.10	2.61 *	0.00027	5.79 *	0.32	9.69 *	0.69	35.82 *	0.0065	7.57 *
3	0.1250	1.51	0.18	4.86 *	0.00025	4.10 *	0.17	7.96 *	0.80	47.11 *	0.0042	5.69 *
4	0.1466	1.43	0.16	4.48 *	0.00027	3.45 *	0.13	7.34 *	0.85	52.12 *	0.0053	5.43 *
5	0.1103	1.00	0.16	4.66 *	0.00039	3.26 *	0.11	7.29 *	0.86	50.99 *	0.0051	4.39 *
6	0.1199	1.05	0.19	5.72 *	0.00030	2.44 *	0.11	7.85 *	0.87	54.81 *	0.0060	4.63 *
7	0.1372	1.19	0.17	5.14 *	0.00049	3.05 *	0.13	7.95 *	0.84	44.28 *	0.0059	3.56 *
8	0.0537	0.44	0.18	5.74 *	0.00008	0.72	0.06	6.30 *	0.92	72.69 *	0.0044	3.41 *
9	0.0701	0.58	0.19	5.89 *	0.00027	1.89	0.09	7.56 *	0.89	58.93 *	0.0038	2.69 *
10	0.0644	0.53	0.18	5.59 *	0.00040	2.59 *	0.10	7.00 *	0.87	51.83 *	0.0056	3.44 *
11	0.0539	0.42	0.19	5.85 *	0.00029	1.95	0.09	6.35 *	0.89	55.47 *	0.0046	2.93 *
12	0.0401	0.30	0.17	5.04 *	0.00038	2.23 *	0.10	6.36 *	0.88	51.08 *	0.0074	4.05 *
TIIE	0.0255	1.25	-0.22	-6.02 *	0.00008	7.22 *	0.55	14.07 *	0.54	48.60 *	0.0187	23.82 *

Note. The table reports results from the GARCH estimation:

$$r_t = \mu + \phi r_{t-1} + u_t \text{ ; } h_t = \alpha_0 + \alpha_1 u_{t-1}^2 + \beta_1 h_{t-1} + \gamma_n D_{nt}$$

where μ is a constant, r_t is the logarithmic change of settlement prices on day t, the residuals u_t are assumed to be normally distributed with mean zero and conditional variance h_t. D_{nt} is the dummy variable that takes the value of 1 when there is a monetary policy annoucement.* indicates significance at the 5% level.

Table 4 GARCH estimates for expansive monetary policy announcements

Series	$\mu \times 10^5$	*tstats*	ϕ	*tstats*	$\alpha_0 \times 10^7$	*tstats*	α_1	*tstats*	β_1	*tstats*	$\gamma \times 10^7$	*tstats*
	Whole sample											
1	-0.0196	-0.49	0.12	5.59 *	0.00015	9.67 *	0.26	18.29 *	0.80	104.8 *	0.0083	4.31 *
2	0.1074	1.93	0.13	5.64 *	0.00011	6.80 *	0.20	23.71 *	0.84	149.5 *	0.0056	1.89
3	0.1208	1.74	0.16	7.05 *	0.00011	4.23 *	0.15	18.07 *	0.87	129.2 *	0.0023	1.14
4	0.1325	1.36	0.13	5.81 *	0.00006	3.21 *	0.07	13.82 *	0.93	260.3 *	0.0019	1.30
5	0.1944	2.12 *	0.13	5.13 *	0.00024	4.08 *	0.16	27.43 *	0.87	176.9 *	0.0035	0.99
6	0.0879	0.79	0.12	5.80 *	0.00005	2.82 *	0.05	14.73 *	0.96	462.0 *	0.0017	1.49
7	0.1740	1.65	0.11	5.24 *	0.00021	3.42 *	0.14	17.57 *	0.88	141.8 *	0.0033	1.01
8	0.1241	1.10	0.11	5.22 *	0.00013	2.91 *	0.09	20.06 *	0.92	268.7 *	0.0025	1.13
9	0.0637	0.54	0.10	4.83 *	0.00005	1.82	0.05	14.11 *	0.95	400.1 *	0.0021	1.29
10	0.0807	0.66	0.11	5.72 *	0.00006	2.20 *	0.04	13.34 *	0.96	394.7 *	0.0019	1.19
11	0.1012	0.80	0.11	5.48 *	0.00009	2.45 *	0.06	15.22 *	0.94	300.7 *	0.0029	1.19
12	0.1695	1.33	0.11	4.97 *	0.00036	3.80 *	0.12	17.86 *	0.89	160.9 *	0.0092	2.12 *
TIIE	-0.0136	-0.23	0.15	6.56 *	0.00042	34.82 *	0.30	25.95 *	0.77	126.8 *	0.0186	7.65 *
	Subperiod 2001-2004											
1	1.8761	3.58 *	0.16	3.62 *	0.01264	9.51 *	0.20	9.36 *	0.78	46.46 *	0.3868	1.24
2	1.4416	3.30 *	0.16	4.62 *	0.00584	5.77 *	0.15	10.52 *	0.84	89.26 *	0.1823	0.90
3	1.9317	4.59 *	0.10	2.40 *	0.02966	7.16 *	0.37	13.71 *	0.57	20.77 *	0.4862	0.84
4	1.6326	3.35 *	0.09	2.10 *	0.00806	5.48 *	0.16	9.74 *	0.83	67.56 *	0.3691	2.15 *
5	1.4996	3.99 *	0.09	1.85	0.00917	6.32 *	0.22	15.10 *	0.78	80.24 *	0.1761	1.02
6	1.1903	3.01 *	0.01	0.30	0.00521	8.13 *	0.10	10.65 *	0.89	115.32 *	0.0536	0.73
7	1.1075	3.18 *	0.02	0.48	0.00509	4.32 *	0.21	11.40 *	0.81	59.17 *	0.1805	1.08
8	1.2383	3.41 *	-0.01	-0.27	0.00656	6.16 *	0.18	11.57 *	0.81	59.86 *	0.2812	1.87
9	0.8429	2.21 *	-0.05	-1.47	0.00252	3.48 *	0.10	10.00 *	0.89	94.65 *	0.7115	5.29 *
10	1.1235	3.19 *	-0.01	-0.18	0.00473	5.83 *	0.16	11.94 *	0.83	75.78 *	0.8678	4.03 *
11	1.0274	2.93 *	0.00	0.06	0.00780	6.91 *	0.24	13.26 *	0.75	59.79 *	0.5141	1.59
12	1.0884	3.25 *	0.00	0.04	0.00772	7.15 *	0.21	12.48 *	0.76	63.11 *	0.4182	2.05 *
TIIE	0.6863	1.56	0.34	8.64 *	0.01754	5.48 *	0.21	10.42 *	0.71	38.91 *	1.1094	5.71 *
	Subperiod 2005-2008											
1	0.0056	0.14	0.00	0.00	0.00032	10.61 *	0.50	15.02 *	0.63	43.11 *	0.0163	3.81 *
2	0.1426	2.24 *	0.09	2.68 *	0.00031	7.92 *	0.33	14.26 *	0.71	43.31 *	0.0106	1.90
3	0.0721	0.94	0.18	5.50 *	0.00009	3.07 *	0.08	8.26 *	0.91	91.40 *	0.0022	1.59
4	0.0942	0.93	0.16	4.73 *	0.00025	3.95 *	0.10	7.73 *	0.89	65.97 *	0.0035	1.61
5	0.0587	0.54	0.16	5.00 *	0.00035	3.91 *	0.09	7.93 *	0.89	65.90 *	0.0043	1.53
6	0.0664	0.57	0.20	6.16 *	0.00030	3.64 *	0.08	8.19 *	0.90	72.32 *	0.0039	1.80
7	0.0862	0.73	0.18	5.69 *	0.00032	3.04 *	0.09	7.92 *	0.90	62.77 *	0.0039	1.41
8	0.0253	0.21	0.18	5.87 *	0.00020	2.56 *	0.06	6.43 *	0.93	80.38 *	0.0028	1.44
9	0.0462	0.39	0.19	6.08 *	0.00032	2.90 *	0.09	7.85 *	0.90	65.42 *	0.0024	0.93
10	0.0388	0.31	0.19	5.82 *	0.00040	3.28 *	0.09	7.17 *	0.90	61.65 *	0.0026	0.86
11	0.0366	0.28	0.20	6.11 *	0.00033	2.82 *	0.08	6.49 *	0.91	65.10 *	0.0023	0.75
12	0.0306	0.23	0.18	5.37 *	0.00041	3.17 *	0.08	6.29 *	0.91	62.14 *	0.0042	1.02
TIIE	0.0036	0.06	-0.11	-2.72 *	0.00071	23.49 *	0.36	13.15 *	0.66	49.17 *	0.0249	6.90 *

Note. The table reports results from the GARCH estimation:

$$r_t = \mu + \phi r_{t-1} + u_t \text{ ; } h_t = \alpha_0 + \alpha_1 u_{t-1}^2 + \beta_1 h_{t-1} + \gamma_n D_{nt}$$

where μ is a constant, r_t is the logarithmic change of settlement prices on day *t*, the residuals u_t are assumed to be normally distributed with mean zero and conditional variance h_t. D_{nt} is the dummy variable that takes the value of 1 when the monetary policy announcement is expansive.* indicates significance at the 5% level.

Table 5 GARCH estimates for restrictive monetary policy announcements

Series	μ *x 10*^{5}	*tstats*	ϕ	*tstats*	α_0 *x 10*^{7}	*tstats*	α_1	*tstats*	β_1	*tstats*	γ *x10*^{7}	*tstats*
	Whole sample											
1	0.1814	4.24 *	0.13	5.38 *	0.00004	6.12 *	0.17	18.10 *	0.86	147.0 *	0.0183	10.26 *
2	0.1733	2.62 *	0.14	5.87 *	0.00010	6.66 *	0.17	19.12 *	0.85	136.1 *	0.0236	7.75 *
3	0.1938	2.43 *	0.17	7.06 *	0.00016	5.19 *	0.17	19.66 *	0.85	119.1 *	0.0231	6.19 *
4	0.1914	1.85	0.13	5.82 *	0.00009	3.44 *	0.10	14.59 *	0.91	179.6 *	0.0073	4.94 *
5	0.2601	2.63 *	0.14	4.99 *	0.00029	4.43 *	0.17	27.43 *	0.85	164.9 *	0.0164	4.38 *
6	0.0964	0.83	0.12	5.75 *	0.00005	2.55 *	0.05	14.69 *	0.95	433.5 *	0.0016	1.54
7	0.2041	1.90	0.11	5.31 *	0.00023	3.72 *	0.14	17.20 *	0.88	138.6 *	0.0093	2.63 *
8	0.1506	1.32	0.11	5.22 *	0.00015	3.17 *	0.09	20.45 *	0.91	263.3 *	0.0060	2.47 *
9	0.0708	0.60	0.10	4.80 *	0.00005	1.76	0.05	13.90 *	0.95	364.8 *	0.0025	1.61
10	0.0961	0.78	0.12	5.69 *	0.00006	2.05 *	0.05	13.51 *	0.95	361.4 *	0.0034	2.08 *
11	0.1212	0.95	0.11	5.48 *	0.00009	2.26 *	0.06	16.83 *	0.94	343.7 *	0.0051	2.47 *
12	0.1876	1.45	0.11	4.92 *	0.00031	3.50 *	0.11	17.83 *	0.89	173.4 *	0.0115	3.14 *
TIIE	-0.0171	-0.81	-0.01	-0.59	0.00007	21.27 *	0.41	27.60 *	0.72	106.5 *	0.0645	6.23 *
	Subperiod 2001-2004											
1	1.9838	3.75 *	0.15	3.49 *	0.01171	9.03 *	0.22	9.45 *	0.78	46.49 *	0.0486	0.89
2	1.4678	3.38 *	0.16	4.49 *	0.00564	5.53 *	0.16	10.61 *	0.84	87.71 *	0.0312	0.68
3	1.9016	4.65 *	0.09	2.19 *	0.02890	6.99 *	0.36	13.29 *	0.58	20.81 *	0.1738	1.69
4	1.5887	3.13 *	0.09	2.10 *	0.01159	6.22 *	0.16	8.97 *	0.82	51.13 *	-0.0194	-0.50
5	1.5231	4.13 *	0.09	1.86	0.00944	6.22 *	0.24	15.43 *	0.77	78.48 *	0.0192	0.53
6	1.0928	2.52 *	-0.01	-0.64	0.00012	1.05	0.01	8.06 *	0.99	899.60 *	-0.0229	-4.89 *
7	1.1301	3.20 *	0.02	0.57	0.00413	3.87 *	0.20	11.09 *	0.83	62.85 *	0.0074	0.31
8	1.3287	3.57 *	-0.01	-0.24	0.00562	5.67 *	0.18	11.89 *	0.82	65.28 *	0.0184	0.99
9	0.8145	2.07 *	-0.03	-0.92	0.01328	7.60 *	0.19	10.82 *	0.76	49.09 *	0.0832	2.66 *
10	1.1141	3.16 *	-0.01	-0.33	0.01034	7.91 *	0.20	11.76 *	0.77	55.45 *	0.0125	0.56
11	1.0850	2.88 *	0.00	0.00	0.01252	9.30 *	0.26	12.67 *	0.72	48.25 *	0.0124	0.44
12	1.0716	2.95 *	0.01	0.20	0.00775	7.12 *	0.19	11.79 *	0.78	63.68 *	-0.0182	-0.94
TIIE	0.7544	1.62	0.35	7.85 *	0.02565	5.80 *	0.23	13.44 *	0.65	27.80 *	0.4289	4.35 *
	Subperiod 2005-2008											
1	0.1779	3.96 *	0.07	2.23 *	0.00007	6.46 *	0.15	11.73 *	0.84	83.03 *	0.0206	9.56 *
2	0.1933	2.89 *	0.11	3.26 *	0.00031	7.75 *	0.22	9.70 *	0.75	42.55 *	0.0426	6.79 *
3	0.1598	1.97 *	0.18	5.41 *	0.00038	5.71 *	0.14	7.88 *	0.82	46.46 *	0.0324	6.31 *
4	0.1915	1.87	0.16	4.61 *	0.00060	5.42 *	0.14	7.60 *	0.82	42.34 *	0.0272	5.23 *
5	0.1563	1.44	0.16	4.80 *	0.00073	4.90 *	0.12	7.21 *	0.83	41.73 *	0.0256	5.10 *
6	0.1397	1.17	0.19	5.82 *	0.00057	4.66 *	0.10	7.85 *	0.86	53.64 *	0.0177	4.55 *
7	0.1521	1.29	0.17	5.32 *	0.00066	4.34 *	0.12	8.26 *	0.85	46.43 *	0.0171	3.42 *
8	0.0691	0.56	0.18	5.63 *	0.00037	3.31 *	0.08	6.57 *	0.91	62.20 *	0.0094	3.12 *
9	0.0941	0.78	0.19	5.93 *	0.00052	3.79 *	0.10	8.05 *	0.88	55.28 *	0.0139	3.32 *
10	0.0975	0.79	0.19	5.70 *	0.00069	4.22 *	0.11	7.22 *	0.86	47.61 *	0.0186	3.51 *
11	0.0867	0.67	0.19	5.89 *	0.00054	3.50 *	0.09	6.45 *	0.88	50.93 *	0.0157	3.47 *
12	0.0759	0.57	0.17	5.11 *	0.00063	3.78 *	0.09	6.34 *	0.88	49.64 *	0.0190	3.75 *
TIIE	0.0176	0.84	-0.31	-9.24 *	0.00009	11.33 *	0.59	16.55 *	0.60	39.41 *	0.0895	4.95 *

Note. The table reports results from the GARCH estimation:

$$r_t = \mu + \phi r_{t-1} + u_t \text{ ; } h_t = \alpha_0 + \alpha_1 u_{t-1}^2 + \beta_1 h_{t-1} + \gamma_n D_{nt}$$

where μ is a constant, r_t is the logarithmic change of settlement prices on day *t*, the residuals u_t are assumed to be normally distributed with mean zero and conditional variance h_t. D_{nt} is the dummy variable that takes the value of 1 when the monetary policy announcement is restrictive.* indicates significance at the 5% level.