The Greenspan Effect on Equity Markets: An Intraday Examination of US Monetary Policy Announcements

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Abstract

This paper studies the impact of monetary policy announcements as well as expectations of future monetary policy on the stability of equity markets. Specifically, we study the changes in asset prices and volatility associated with changes in Federal Open Market Committee announcements and changes in expectation of future US monetary policy as measured.

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- A 'Greenspan Rally' Proves Short for Stocks[1]
- Investors Stay on Sidelines Ahead of FOMC Meeting[2]
- Nasdaq Jumps 10.5% as Stock Rally Is Sparked by Greenspan Remarks[3]
- FOMC will be in a position to either validate or topple the market's economic beliefs.[4]
- Investors endured extra drama during the day as stocks gyrated during a speech by Federal Reserve Chairman Alan Greenspan. [5]
- Stocks, Bonds Drop on Fed Move[6]
- Getting the Read on Greenspan[7]
- Stocks Decline on Fed Chairman's Remarks About Rates[8]

1. Introduction

Monetary policy has an enormous influence on the behavior of financial market participants, as evidenced by the extensive attention that the Federal Reserve Board receives in the financial press. The reason is simple, monetary policy can significantly affect asset prices. By influencing short-term interest rates, the actions of policymakers such as Alan Greenspan can change expectations about future cash flows as well the cost of capital. The increased frequency of reports in the financial press regarding the Federal Open Market Committee's next interest rate move makes it clear market participants closely watch the Federal Reserve Board for possible changes in the federal funds rate target (see Table 1).

[Table 1 about here]

Not surprisingly, the interest in the impact of monetary policy announcements is not limited to the financial press and a number of academic studies have examined trading behavior

[1]WSJ 02/28/02.
[2]WSJ 05/10/01.
[3]WSJ 12/06/00.
[4]WSJ 10/02/00.
[5]WSJ 01/14/04
[6]WSJ 01/29/04.
[7]WSJ 03/1/04.
[8]WSJ 04/3/04.

surrounding the release of the Federal Open Market Committee (FOMC) announcements. Most of the research on monetary policy and asset prices has followed Cook & Hahn (1989) whose approach was to regress daily returns for FOMC announcement days on changes in the federal funds rate target.

Since 1994, however, Federal Reserve policy has become significantly more transparent and the Federal Reserve now announces at 14:15 EST following regularly scheduled FOMC meetings a description of any change in policy with a statement about future anticipated policy changes. As such, policy actions have become more widely anticipated and expectations regarding the movements in the federal funds rate target may already be incorporated into asset prices.

While expectations of Fed policy are not directly observable, several papers have attempted to disentangle policy announcements into an anticipated and an unanticipated component by inferring expectations. Earlier studies for the most part relied on newspaper accounts about Fed policy or survey data on expectations of the federal funds rate target (for example, Reinhart and Simin (1997)), but more recent studies have relied on market based proxies to infer expectations on the federal funds rate target. In fact, Krueger & Kuttner (1996) show the federal funds future rate is an efficient forecast of the funds rate and therefore an appropriate market based measure of policy expectations. Kuttner (2001) provide evidence that asset prices respond to the unanticipated changes and not to anticipated changes in monetary policy announcements. In much the same spirit, Bomfim (2003) extended this work to volatility and finds the asset prices are more volatile following surprise announcements. However, consistent with the earlier work of Cook & Hahn (1989), these studies relied on daily data and focused on the periods immediately surrounding the policy announcement.

More recently, a number of studies have taken advantage of high frequency data and the regularity of macroeconomic announcements such as the FOMC announcement during market hours to examine the intraday impact of policy announcements. For example, Bollerslev, Cai & Song (2000) find that regularly scheduled macroeconomic announcements are an important source of intraday volatility in asset prices. Specifically, they discover two spikes in the intraday volatility at 0830 and 1000 EST in the US Treasury bond market corresponding to regularly scheduled macroeconomic announcements at these times. Andersen, Bollerslev, Diebold & Vega (2003) also use high frequency data to examine the intraday impact of macroeconomic announcements. They examine the intraday impact on the foreign exchange market of 41 different macroeconomic announcements including the federal funds rate target using the International Money Market

Services real-time data on expectation to decompose the surprise component. They find that unanticipated announcements significantly impact asset prices and volatility.

In this paper, we investigate the impact of monetary policy on equity markets using high frequency data. In examining these impacts, we follow the spirit of Andersen et al. (2003) by modeling intraday returns and their time-varying volatility. Unlike Andersen et al. (2003), we focus on the intraday impact of one news event on the equity markets rather than 41 regularly scheduled news events on the foreign exchange market. This allows a more detailed examination including an analysis of regularly scheduled announcements as well as inter-meeting announcements. Furthermore, our work differentiates itself from earlier papers by examining the response of financial markets to monetary policy announcements along several dimensions. First, the use of intraday data allow us to more accurately characterize the price discovery process in the equity markets. Our primary motivation is to characterize the response of the equity markets to changes in expectations of a fundamental asset price determinant – interest rates. Specifically, we examine the response of the broad equity market by examining Standard and Poor's Depositary Receipts (SPDRs). Consistent with previous research, our findings indicate the federal funds rate does indeed impact the equity markets. The analysis shows the equity market tends to respond inversely to changes in the federal funds target rate within 15 minutes of an announced policy change.

Second, we do not limit the analysis to the announcement date. By using all trading days we are able to effectively integrate changes in expectations of monetary policy into the analysis. The federal funds futures rate is an unbiased estimator of the federal funds targeted rate, therefore, incorporating the first difference of this series into the model allows us to include real time changes in expectations in the price discovery process. This results in a somewhat surprising conclusion that the equity market does not respond to changes in expectations about monetary policy but rather it responds to the announced policy changes.

Finally, we also examine the volatility process surrounding FOMC announcements and changes in expectations regarding monetary policy. As previous researchers have documented volatility does get a boost from FOMC announcements. Once again though by using intra-day data we are able to more fully characterize this boost. In particular, market volatility increases for approximately one hour following a change in the federal funds target rate and this increase is irrespective of whether the change is anticipated or unanticipated by the financial markets.

The remainder of the paper is organized as follows. The next section describes the data used in the study. Section 3 provides an initial descriptive analysis of the data series. Section 4 describes our methodology for modeling the price discovery process and volatility and discusses the results while section V concludes.

2. Data Description

There are three primary data sources used in the analysis: FOMC announcement data, equity data and futures data. The analysis cover the period from January 3, 1995 through December 31, 2002 and the data are constructed into 5 minute intervals for a total sample size of 156,238 observation. A description of each data source and the manipulation of the data into 5 minute intervals is provided below.

2.1. Announcement Data

Table 2 lists FOMC announcements made over the sample period. The table includes regularly scheduled announcements following FOMC meeting as well as inter-meeting announcements. In total the sample includes 71 announcements – 64 following regularly scheduled FOMC meeting and seven inter-meeting announcements. The timing of these announcements is critical. Announcements following regularly scheduled meeting occur during market hours at approximately 2:15 PM. Inter-meeting announcements can occur at any time and these times were provided by the Federal Reserve Board.

[Table 2 about here]

2.2. Equity Data

The broad equity market is proxied using Standard and Poor's Depositary Receipts (SPY), an exchange traded funds (ETF) designed to mimic the S&P 500 Index. ETFs are index funds listed on the AMEX and traded intraday. Previous research by Elton, Gruber, Comer & Li (2002) showed that ETFs trade close to the net asset value of the underlying assets confirming its value as an intraday proxy for the broad based equity markets. Returns at 5 minute intervals were constructed for SPY using NYSE's Trades and Quotes (TAQ) database. Specifically, we

used quote data to observe the average bid and ask price, or mid-quote, at the beginning of each interval. Using these prices, returns are constructed as the log ratio.

2.3. Federal Funds Futures Data

The federal funds futures market is used as a proxy to measure federal funds rate expectations. The federal funds futures contract was established in 1989 and trades on the Chicago Board of Trade (CBOT). The contract is cash settled against the average daily federal funds overnight rate for the delivery month. A contract ceases to trade on the last business day of the delivery month. Typically, the next month's contract is the most liquid contract and it is from this contract we extract expectations of US monetary policy. For example, the implied federal funds rate for November is derived from the December futures contract.

Price quotes on federal funds futures contract were obtained from the CBOT. The implied federal funds rate is derived as 100 minus the contract price. Therefore, a contract priced at 92.75 has an implied federal funds rate, or an expected yield of 7.25 percent. After screening the data for accuracy, the data were partitioned into 5 minute intervals to match the ETF data. The return series created from these five minute intervals provides a real-time measure of changes in expectations of US monetary policy.

3. Initial Descriptive Analysis

Figure 1 presents graphically the three main series used in the empirical analysis from January 1995 to December 2002. The data are presented by year and broken into two panels. The top panel is the mid-quote of the Standard and Poor's Depositary Receipts (SPY) recorded at 5-minute interval while the lower panel compares the implied federal funds rate from the futures market with the announced target rate. In addition, vertical lines are entered into the lower panel to correspond to FOMC announcement dates. Of particular interest in figure 1 is the ability of the futures market to lead announced FOMC policy decisions. For example, in 1999 and 2000 the market anticipated all six of the increases in the Fed funds rate and in 2001 and 2002 the market anticipated nine of the regularly scheduled rate reductions.

[Figure 1 about here]

4. Equity Markets and the Federal Funds Target Rate

Our model is inspired by Andersen et al. (2003). They model 5-minute spot exchange rate returns as a linear function of lagged values of itself and lags of news on fundamentals, and approximate the return volatility in a similar fashion. In what follows, we will separate our exposition of the dynamics relating to the price discovery process and the volatility process.

4.1. Price Discovery Process

In developing a price discovery model, we first estimated an announcement impact model consistent with the existing literature where only the unanticipated shock to the federal funds rate target affects equity returns. Specifically, we model the 5 minute returns as a linear function of lagged values of itself and J lagged values of the unanticipated news on the federal funds target rate around FOMC announcement dates:

$$r_t = \beta_0 + \sum_{i=1}^{I} \beta_i r_{t-i} + \sum_{j=0}^{J} \eta_{\mathrm{r}j} stdS_{t-j} + \varepsilon_t, \tag{1}$$

where:

$$stdS_t = \frac{A_t - E_t}{\hat{\sigma}}$$

with E_t being the markets expectation of the federal funds target rate estimated from the futures market, A_t is the announced federal funds target rate, and $\hat{\sigma}$ is the sample standard deviation of $A_t - E_t$. Note, the variable $stdS_t$ is a discrete in that it is only measured at the time of an announcement and is zero otherwise. We chose I = 4 and J = 2 based on information criteria. We also include in the regression model year, month and day of the week dummy variables.

In estimating regression models like (1) using high-frequency data is not a trivial task. Problems like heteroscedasticity considerably enlarged by going to the 5 minute frequency, and this in turn, is augmented by a significant diurnal volatility pattern.[9] In presenting our results in Table 3 we present the cumulative impact of the estimated parameters reporting p-values for both OLS and HAC standard errors. Panel A presents the results for FOMC announcement days while Panel B presents the results for the full sample.

[9]For this reason, an appendix is available with results of several approaches to estimating (1). In particular, we estimated (1) using OLS, reporting both OLS and HAC standard errors for the coefficient estimates., as well as, the two-step weighted least-squares (WLS) procedure suggested in Andersen et al. (2003).

[Table 3 about here]

Our initial sample contains 64 regularly scheduled FOMC announcements, or, in terms of 5 minute intervals, a total of 4,992 observations. The results from (1) are consistent with this previous literature indicating the equity market reacts inversely with unanticipated moves in the federal funds target rate. However, unlike the previous studies which used daily price, the use of 5 minute interval data allows a closer inspection on the speed of the equity market's response. The speed of the response estimated in equation 1 is rapid, dissipating within 2 lagged intervals or 10 minutes. Overall, the cumulative impact of unanticipated shock to the federal funds target rate is -0.052 with an associated p-value of less than 0.01 (results not shown in Table 3). Given the mean value of $stdS_t$ as -0.16, the cumulative impact is approximately 0.83 percent, an economically significant value.

Next, we expanded the announcement impact model to include changes in the federal funds target rate announced between regularly scheduled FOMC announcement dates. Unlike previous studies which focused on the effects of regularly scheduled macroeconomic announcements our desire to model the price discovery process requires an analysis of inter-meeting announcements. Over the sample period from 1995 to 2002, there were seven inter-meeting announcements. Fitting (1) with both regularly scheduled and surprise FOMC announcements, the cumulative impact of changes in the federal funds rate target on the broad equity market deviates from expectations (see Model 1 in Table 3, Panel A). Specifically, the cumulative impact of the unanticipated shock to the federal funds target rate is now 0.39 with an associated p-value of less than 0.1 percent, suggesting inter-meeting announcements have a different impact on the price discovery process. We, therefore, introduced an interaction term to distinguish these surprise announcements (see Model 2 in Table 3, Panel A). After controlling for surprise announcements, the cumulative estimated impact of unanticipated changes in the federal funds rate target matched expectation with an estimate of -0.052 but the estimate is not statistically different from zero.

We further augment the announcement effect model to include anticipated changes in the federal funds target rate as well as changes in expectations about the federal funds target rate. The augmented model is:

$$r_t = \beta_0 + \sum_{i=1}^{I} \beta_i r_{t-i} + \sum_{j=0}^{J} \eta_{\mathrm{r}j} stdS_{t-j} + \sum_{j=0}^{J} \theta_{\mathrm{r}j} stdS_{t-j} * interFOMC$$
$$+ \sum_{j=0}^{J} \tau_{\mathrm{r}j} std\Delta A_{t-j} + \sum_{j=0}^{J} \phi_{\mathrm{r}j} std\Delta A_{t-j} * interFOMC + \sum_{j=0}^{J} \omega_{\mathrm{r}j} std\Delta E_{t-j} + \varepsilon_t, \qquad (2)$$

where

$interFOMC = 1$ if there was an inter-meeting FOMC announcement, 0 otherwise,

and

$$std\Delta A_t = \frac{A_t - A_{t-1}}{\hat{\sigma}_A} \quad \text{and} \quad std\Delta E_t = \frac{E_t - E_{t-1}}{\hat{\sigma}_E}$$

with E_t being the markets expectation of the federal funds target rate estimated from the futures market, and A_t is the announced federal funds target rate. $\hat{\sigma}_E$ and $\hat{\sigma}_A$ is the sample standard deviation of $A_t - A_{t-1}$ and $E_t - E_t$, respectively. Note that while announcement are made at discrete interval meaning $stdS_t$ and $std\Delta A_t$ are both discrete variables only measured at the time of an announcement expectations can be measured in real-time and therefore $std\Delta E_t$ is a continuous variable.

This specification is estimate for both FOMC announcements and the full sample and the cumulative returns responses are presented in Table 3 Panel A and B respectively as Model 4. The results for both models in terms of standardized surprise component are again consistent with the literature indicating surprise changes in the federal funds target rate are inversely related to equity market returns. The cumulative impacts is -0.077 and -0.099, respectively. Surprisingly though the impact of changes in expectations about the federal funds rate are not inversely related to equity market returns. Model 4 indicates that the equity market moves parallel to shocks in the federal funds futures market. The cumulative impact (0.0072 and 0.0141, respectively) while small in magnitude it is statistically significant. Furthermore, the empirical results indicate the equity market does react to announced changes in the federal funds target rate even if they are expected. Coupling these somewhat surprising results challenges the traditional announcement impact models which focus on the surprise component of macroeconomic announcements.

We now turn our attention to the stock market volatility and its reaction to FOMC announcements and the markets expectation about the target rate.

4.2. Volatility Process

Volatility can be regarded as a measure of the flow of information. Following Andersen et al. (2003), the volatility of the disturbance in (1) is approximated using the model:

$$
\begin{aligned}
|\hat{\varepsilon}_t| = c + \phi\frac{\hat{\sigma}_{d(t)}}{\sqrt{288}} + \sum_{j=0}^{J'} \eta_{\mathrm{v}j}\,|stdS_t| + \sum_{j=0}^{J'} \theta_{\mathrm{v}j}\,|stdS_t| * interFOMC \\
+ \sum_{j=0}^{J'} \tau_{\mathrm{v}j}\,|std\Delta A_t| + \sum_{j=0}^{J'} \phi_{\mathrm{v}j}\,|std\Delta A_t| * interFOMC + \sum_{j=0}^{J'} \omega_{\mathrm{v}j}\,|std\Delta E| \\
+ \sum_{q=1}^{Q}\left\{\delta_q \cos\left(\frac{q2\pi t}{78}\right) + \phi_q \sin\left(\frac{q2\pi t}{78}\right)\right\} + u_t, \qquad (3) \\
J' = 12, \quad Q = 4.
\end{aligned}
$$

Here $\hat{\sigma}_{d(t)}$ is the one-day-ahead volatility forecast for day t from a simple Gaussian GARCH(1,1) model using daily close-to-close log-returns. Hence, 5 minute volatility is modeled partly as a function of the volatility of the day in consideration and partly by a diurnal pattern designed to capture deviations from the daily average volatility. Again estimating regression models like (3) using high-frequency data is not a trivial task and similar to our analysis of the mean equation we report in the appendix the results of several approaches to estimating (3). Specifically, we tried three specifications for the lag coefficients. The first was to estimate the lag structure without any restrictions and J = 12, the second was to estimate a 3-rd order polynomial distributed lag model with no restrictions, while the third specification was a 3-rd order polynomial distributed lag model with restricted coefficients (for more details see the appendix at the end of the paper). The results are for the most part qualitatively similar therefore we report only the 3-rd order polynomial distributed lag model with restricted coefficients in Table 4, and the estimated coefficients and polynomials are presented in Figure 2. Again, similar to the mean results presented above, the volatility results are presented for a series of models starting with a baseline model similar to the existing literature and ending a complete specification including both the surprise and anticipated component of FOMC announcements and changes in expectations about the federal funds rate for both the FOMC announcement sample and the full sample from 1995 through 2002.

[Table 4 and Figure 2 about here]

The baseline model or model 1 in Panel A indicates that surprise announcements by policy makers tends to boost stock market volatility significantly. However, Model 2 clearly shows this

boost is associated with announcements made between FOMC scheduled meetings. In other words, when unanticipated news is released by the FOMC volatility tends to increase, this is not surprising. What is surprising is the empirical results in Panel A for Model 4. Model 4 examines the impact of the standardized surprise, standardized changes in the announced target and standardized change in expectations. The results here show a spike in volatility surrounding unanticipated announcement even if a change in the target rate was expected in the near future. The cumulative volatility response for an unanticipated announcement is 1.97. This impact is somewhat offset by any surprise contained in the announcement as unanticipated standardized surprises has a cumulative volatility response of -0.95. Changes in expectations of the federal funds rate as proxied by the futures market also lead to increases in market volatility. A comparison of the results in Panel A and B indicate the results are consistent between FOMC announcement dates and the full sample.

5. Conclusion

This paper studies the influence of US monetary policy on asset prices and volatility in the US equity markets on an intraday basis. As monetary policy has become more transparent and a viable futures market in federal funds has developed, we are able to expand on the traditional analysis of macroeconomic policy announcements by incorporating real time expectations of future monetary policy into a price discovery model for equities. By using transaction data on the equity market and the futures market along with the exact time of the announcement, we are better able to characterize the response of the financial markets to policymakers.

Our results are intriguing and challenge some of the traditional results of event studies examining macroeconomic announcements. In particular, we find the equity market does not react to changes in expectations about the federal funds rate as predicted b financial theory but does react to the realization of changes in the federal funds target rate. The equity markets tend to respond quickly and inversely to changes in the federal funds rate target as announced following FOMC policy meetings. The same reaction is not observed following changes in expectations of the federal funds rate as proxied by the federal funds futures market. In fact the response albeit small is a positive impact contrary to financial theory.

In terms of volatility, our conclusions are consistent with the existing literature – there is a spike in market volatility immediately surrounding announcements changing the federal funds target rate. These spikes are short lived dissipating within one hour of the announcement. An

interesting direction to follow-up on this research would be to investigate the asymmetry of the response to the tightening/loosening of monetary policy.

6. Appendix

Alternative Lag Specifications

We tried three specifications for the lag coefficients:

1. Estimating $\eta_{\mathrm{v}j}$ and $\tau_{\mathrm{v}j}$ $j = 1, \ldots, 12$ without any restrictions.

2. We reduce the number of parameters to be estimated by using polynomial distributed lags (PDLs) to impose a smoothness condition on the lag coefficients. This requires that the coefficients lie on a polynomial of relatively low degree. A polynomial distributed lag model with order restricts the $\eta_{\mathrm{v}j}$ and $\tau_{\mathrm{v}j}$ coefficients (respectively for each equation) to lie on a p-th order polynomial of the form

$$\begin{aligned} \eta_{\mathrm{v}j} &= \rho_{\eta 1} + \rho_{\eta 2} j + \rho_{\eta 2} j^2 + \ldots + \rho_{\eta p+1} j^p, \quad \text{and} \\ \tau_{\mathrm{v}j} &= \rho_{\tau 1} + \rho_{\tau 2} j + \rho_{\tau 2} j^2 + \ldots + \rho_{\tau p+1} j^p, \quad \text{for } j = 1, \ldots J \end{aligned}$$

   Once we estimate from this equation, we can recover the parameters of interest $\eta_{\mathrm{v}j}$ and $\tau_{\mathrm{v}j}$. We chose $p = 3$

3. We impose a far end constraint which restricts the effect to die off beyond the number of specified lags:

$$\eta_{J+1} = \tau_1 + \tau_2(J+1) + \tau_2(J+1)^2 + \ldots + \tau_{p+1}^p (J+1) = 0,$$

   and likewise for $\tau_{\mathrm{v}j}$.

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7. Tables

Table 1: Wall Street Journal References to Federal Reserve, Alan Greenspan and FOMC.

Year	**Fed**		**Greenspan**		**FOMC**	
	Headline	Article	Headline	Article	Headline	Article
2002	149	1.046	47	436	0	90
2001	119	960	25	300	0	138
2000	105	721	25	270	1	38
1999	80	529	27	219	2	8
1998	82	462	32	228	0	6
1997	66	405	22	202	1	11
1996	96	442	23	164	0	55
1995	71	387	16	115	1	5

Source: Factiva.

Table 2: FOMC Dates.

Announcement Date	**FOMC Meeting Date**	**Fed Funds Rate Target**	**Change in the Fed Funds Rate Target**
01-feb-95	✓	6,00	0,25
06-jul-95	✓	5,75	-0,25
22-aug-95	✓	5,75	0,00
26-sep-95	✓	5,75	0,00
15-nov-95	✓	5,75	0,00
19-dec-95	✓	5,50	-0,25
31-jan-96	✓	5,25	-0,25
26-mar-96	✓	5,25	0,00
21-maj-96	✓	5,25	0,00
03-jul-96	✓	5,25	0,00
20-aug-96	✓	5,25	0,00
24-sep-96	✓	5,25	0,00
13-nov-96	✓	5,25	0,00
17-dec-96	✓	5,25	0,00
05-feb-97	✓	5,25	0,00
25-mar-97	✓	5,50	0,25
20-maj-97	✓	5,50	0,00
02-jul-97	✓	5,50	0,00
19-aug-97	✓	5,50	0,00
30-sep-97	✓	5,50	0,00
12-nov-97	✓	5,50	0,00
16-dec-97	✓	5,50	0,00
04-feb-98	✓	5,50	0,00
31-mar-98	✓	5,50	0,00
19-maj-98	✓	5,50	0,00
01-jul-98	✓	5,50	0,00
18-aug-98	✓	5,50	0,00
29-sep-98	✓	5,25	-0,25
15-okt-98	-	*5,00*	*-0,25*
17-nov-98	✓	4,75	-0,25
22-dec-98	✓	4,75	0,00
03-feb-99	✓	4,75	0,00
30-mar-99	✓	4,75	0,00
18-maj-99	✓	4,75	0,00
30-jun-99	✓	5,00	0,25

Announcement Date	**FOMC Meeting Date**	**Fed Funds Rate Target**	**Change in the Fed Funds Rate Target**
24-aug-99	✓	5,25	0,25
05-okt-99	✓	5,25	0,00
16-nov-99	✓	5,50	0,25
16-nov-99	✓	5,50	0,00
21-dec-99	✓	5,50	0,00
02-feb-00	✓	5,75	0,25
03-mar-00	✓	5,75	0,00
21-mar-00	-	*6,00*	*0,25*
16-maj-00	✓	6,50	0,50
16-maj-00	✓	6,50	0,00
28-jun-00	✓	6,50	0,00
22-aug-00	✓	6,50	0,00
03-okt-00	✓	6,50	0,00
15-nov-00	✓	6,50	0,00
19-dec-00	✓	6,50	0,00
03-jan-01	-	*6,00*	*-0,50*
31-jan-01	✓	5,50	-0,50
20-mar-01	✓	5,00	-0,50
18-apr-01	-	*4,50*	*-0,50*
15-maj-01	✓	4,00	-0,50
27-jun-01	✓	3,75	-0,25
21-aug-01	✓	3,50	-0,25
17-sep-01	-	*3,00*	*-0,50*
02-okt-01	✓	2,50	-0,50
06-nov-01	✓	2,00	-0,50
1-dec-01	✓	1,75	-0,25
30-jan-02	✓	1,75	0,00
19-mar-02	✓	1,75	0,00
07-maj-02	✓	1,75	0,00
26-jun-02	✓	1,75	0,00
13-aug-02	✓	1,75	0,00
24-sep-02	✓	1,75	0,00
06-nov-02	✓	1,25	-0,50
10-dec-02	✓	1,25	0,00

Table 3: Cumulative Return Response for SPY.

Panel A: FOMC Announcements

	Model 1	Model 2	Model 3	Model 4
stdS	0.3931 (<.0001) [0.2467]	-0.0522 (0.2493) [0.3620]	-0.0704 (0.1184) [0.2381]	-0.0774 (0.0839) [0.2007]
stdS · (interFOMC)		1.7350 (<.0001) [0.0004]	1.5740 (<.0001) [0.0001]	1.5440 (<.0001) [0.0006]
stdΔE			0.0126 (<.0001) [0.1105]	0.0072 (0.0013) [0.3488]
stdΔA				-0.0967 (0.0296) [0.3103]
StdΔA · (interFOMC)				0.3898 (0.0016) [0.5883]

Panel B: Full sample

	Model 1	Model 2	Model 3	Model 4
stdS				-0.0988 (0.0047) [0.0529]
stdS · (interFOMC)				1.2930 (<.0001) [0.0004]
stdΔE				0.0141 (<.0001) [<.0001]
stdΔA				-0.1647 (<.0001) [0.0197]
StdΔA · (interFOMC)				0.2461 (0.0046) [0.6648]

The table presents the cumulative return response results estimated for model 1-4 using OLS. p-values based on OLS standard errors are given in parentheses, and HAC based p-values computed using the method suggested in Newey & West (1987) are given in square brackets. The full specification of model 4 is given by

$$r_t = \beta_0 + \sum_{i=1}^{I} \beta_i r_{t-i} + \sum_{j=0}^{J} \eta_{\mathrm{r}j} stdS_{t-j} + \sum_{j=0}^{J} \theta_{\mathrm{r}j} stdS_{t-j} * interFOMC + \sum_{j=0}^{J} \tau_{\mathrm{r}j} std\Delta A_{t-j} + \sum_{j=0}^{J} \phi_{\mathrm{r}j} std\Delta A_{t-j} * interFOMC + \sum_{j=0}^{J} \omega_{\mathrm{r}j} std\Delta E_{t-j} + \varepsilon_t,$$

Table 4: Cumulative Volatility Response for SPY, PDL-zero-at-end restricted coeficients.

Panel A: FOMC Announcements

	Model 1	Model 2	Model 3	Model 4
|stdS|	0.8998 (<.0001) [0.0016]	0.0369 (0.7006) [0.7511]	-0.0235 (0.8044) [0.8419]	-0.0855 (0.3404) [0.5415]
|stdS| · (interFOMC)		1.5710 (<.0001) [0.0006]	0.7263 (0.0001) [0.1228]	-0.9477 (0.0318) [0.4118]
|stdΔE|			0.0223 (<.0001) [<.0001]	0.0100 (0.0138) [0.0774]
|stdΔA|				0.4107 (<.0001) [0.0013]
|StdΔA| · (interFOMC)				1.9690 (0.0003) [0.2464]

Panel B: Full sample

	Model 1	Model 2	Model 3	Model 4
|stdS|				0.0052 (0.9312) [0.9711]
|stdS| · (interFOMC)				-2.2810 (<.0001) [0.0738]
|stdΔE|				0.0299 (<.0001) [<.0001]
|stdΔA|				0.2553 (<.0001) [0.0210]
|StdΔA| · (interFOMC)				3.0920 (<.0001) [0.1092]

The table presents the cumulative return response results estimated for model 1-4 using OLS. p-values based on OLS standard errors are given in parentheses, and HAC based p-values computed using the method suggested in Newey & West (1987) are given in square brackets. The full specification of model 4 is given by

$$|\hat{\varepsilon}_t| = c + \phi\frac{\hat{\sigma}_{d(t)}}{\sqrt{288}} + \sum_{j=0}^{J'}\eta_{\mathrm{v}j}\,|stdS_t| + \sum_{j=0}^{J'}\theta_{\mathrm{v}j}\,|stdS_t| * interFOMC + \sum_{j=0}^{J'}\tau_{\mathrm{v}j}\,|std\Delta A_t| + \sum_{j=0}^{J'}\phi_{\mathrm{v}j}\,|std\Delta A_t| * interFOMC + \sum_{j=0}^{J'}\omega_{\mathrm{v}j}\,|std\Delta E| + \sum_{q=1}^{Q}\left\{\delta_q\cos\left(\frac{q2\pi t}{78}\right) + \phi_q\sin\left(\frac{q2\pi t}{78}\right)\right\} + u_t$$

Table 5: Contemporaneous Return Response for SPY.

Panel A: FOMC Announcements

	Model 1	Model 2	Model 3	Model 4
stdS	0.0250 (0.2938) [0.7148]	-0.0461 (0.0774) [0.2633]	-0.0504 (0.0528) [0.2009]	-0.0604 (0.0179) [0.1662]
stdS · (interFOMC)		0.2729 (<.0001) [0.3166]	0.3163 (<.0001) [0.2694]	0.5827 (<.0001) [0.1596]
stdΔE			0.0045 (<.0001) [0.2407]	0.0074 (<.0001) [0.2630]
stdΔA				-0.0752 (0.0019) [0.3077]
StdΔA · (interFOMC)				-0.7919 (<.0001) [0.2084]

Panel B: Full sample

	Model 1	Model 2	Model 3	Model 4
stdS				-0.0616 (0.0023) [0.1710]
stdS · (interFOMC)				0.5916 (<.0001) [0.1130]
stdΔE				0.0130 (<.0001) [<.0001]
stdΔA				-0.1108 (<.0001) [0.1205]
StdΔA · (interFOMC)				-0.7646 (<.0001) [0.1905]

The table presents the contemporaneous return impacts estimated for model 1-4 using OLS. p-values based on OLS standard errors are given in parentheses, and HAC based p-values computed using the method suggested in Newey & West (1987) are given in square brackets.

Table 6: Contemporaneous Volatility Response for SPY.

Panel A: FOMC Announcements

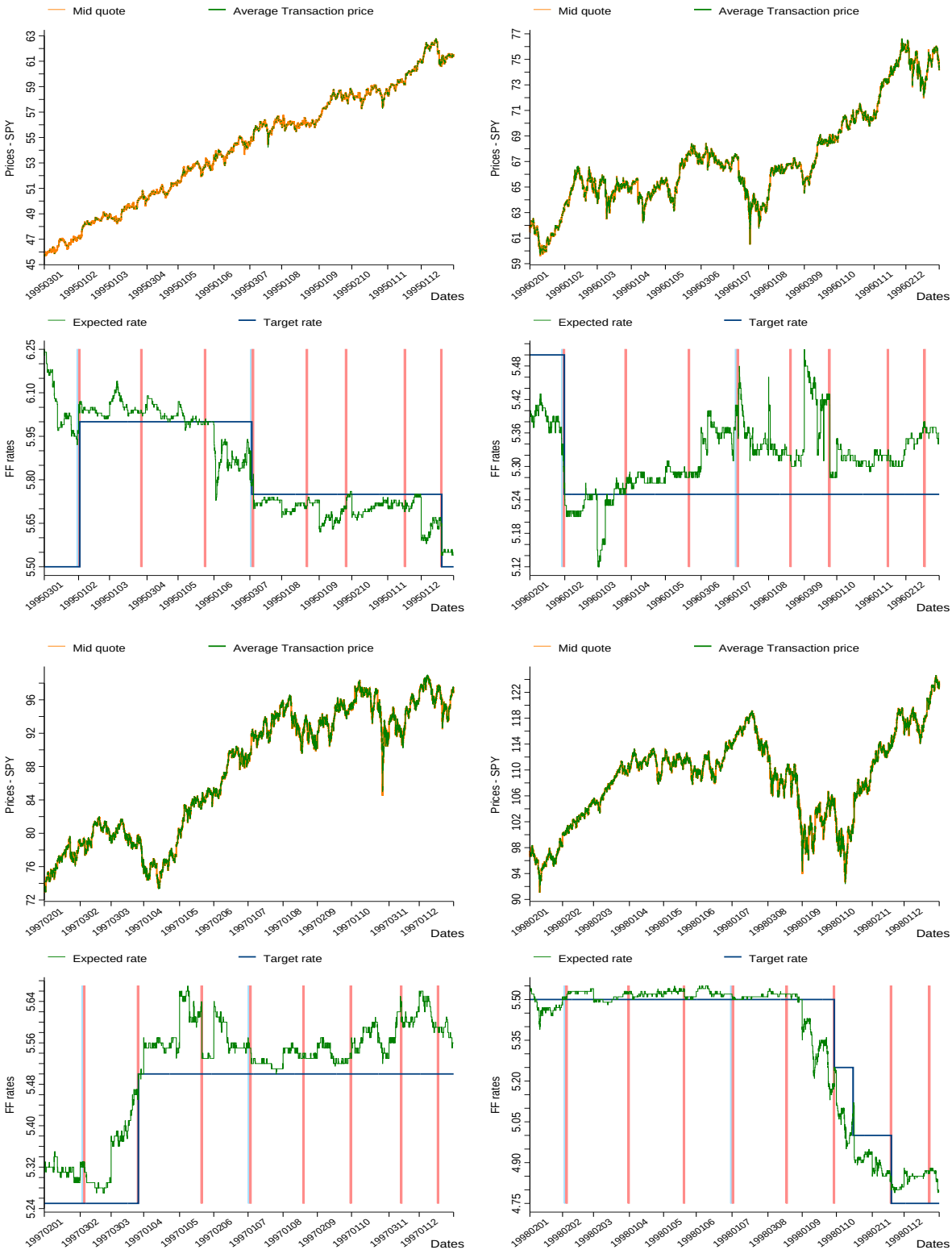
	Model 1	Model 2	Model 3	Model 4
|stdS|	0.1411 (<.0001) [0.0415]	0.0897 (<.0001) [0.0123]	0.0633 (0.0029) [0.1452]	0.0460 (0.0268) [0.2843]
|stdS| · (interFOMC)		0.2559 (<.0001) [0.2601]	0.2343 (<.0001) [0.2796]	-1.3560 (<.0001) [0.0566]
|stdΔE|			0.0063 (<.0001) [0.1063]	0.0108 (<.0001) [0.0005]
|stdΔA|				0.0279 (0.1402) [0.5521]
|StdΔA| · (interFOMC)				2.0390 (<.0001) [0.0521]

Panel B: Full sample

	Model 1	Model 2	Model 3	Model 4
|stdS|				0.0286 (0.0634) [0.5338]
|stdS| · (interFOMC)				-1.1680 (<.0001) [0.0693]
|stdΔE|				0.0198 (<.0001) [<.0001]
|stdΔA|				-0.0076 (0.5812) [0.9074]
|StdΔA| · (interFOMC)				1.7330 (<.0001) [0.0761]

The table presents the contemporaneous volatility impacts estimated for model 1-4 using OLS. p-values based on OLS standard errors are given in parentheses, and HAC based p-values computed using the method suggested in Newey & West (1987) are given in square brackets.

8. Figures


Mid quote
Average Transaction price
Prices - SPY
Dates
Expected rate
Target rate
FF rates

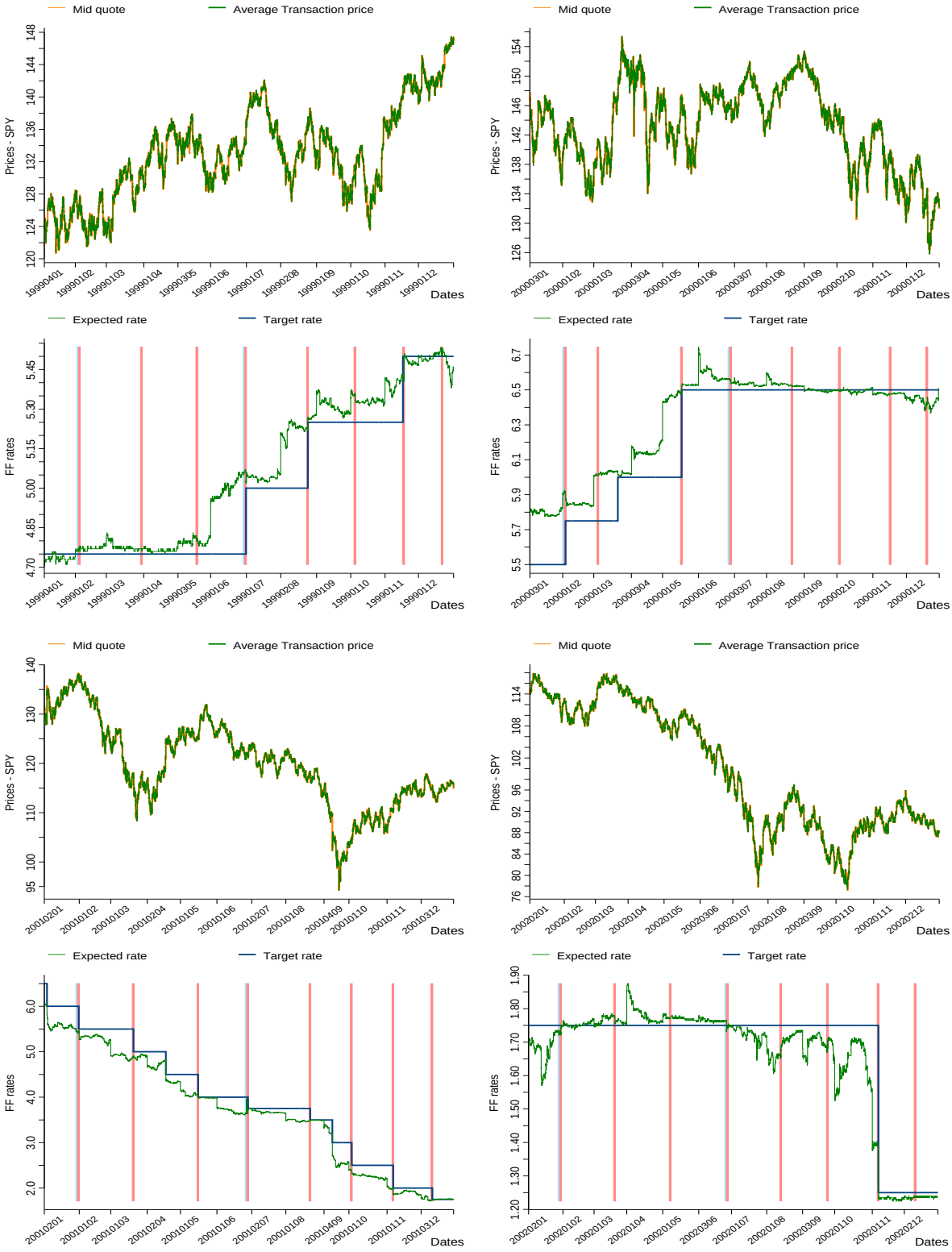


Figure 1: Top panel:Mid quotes and transaction prices. Bottom panel: Federal funds target rate, and expectations from futures market.

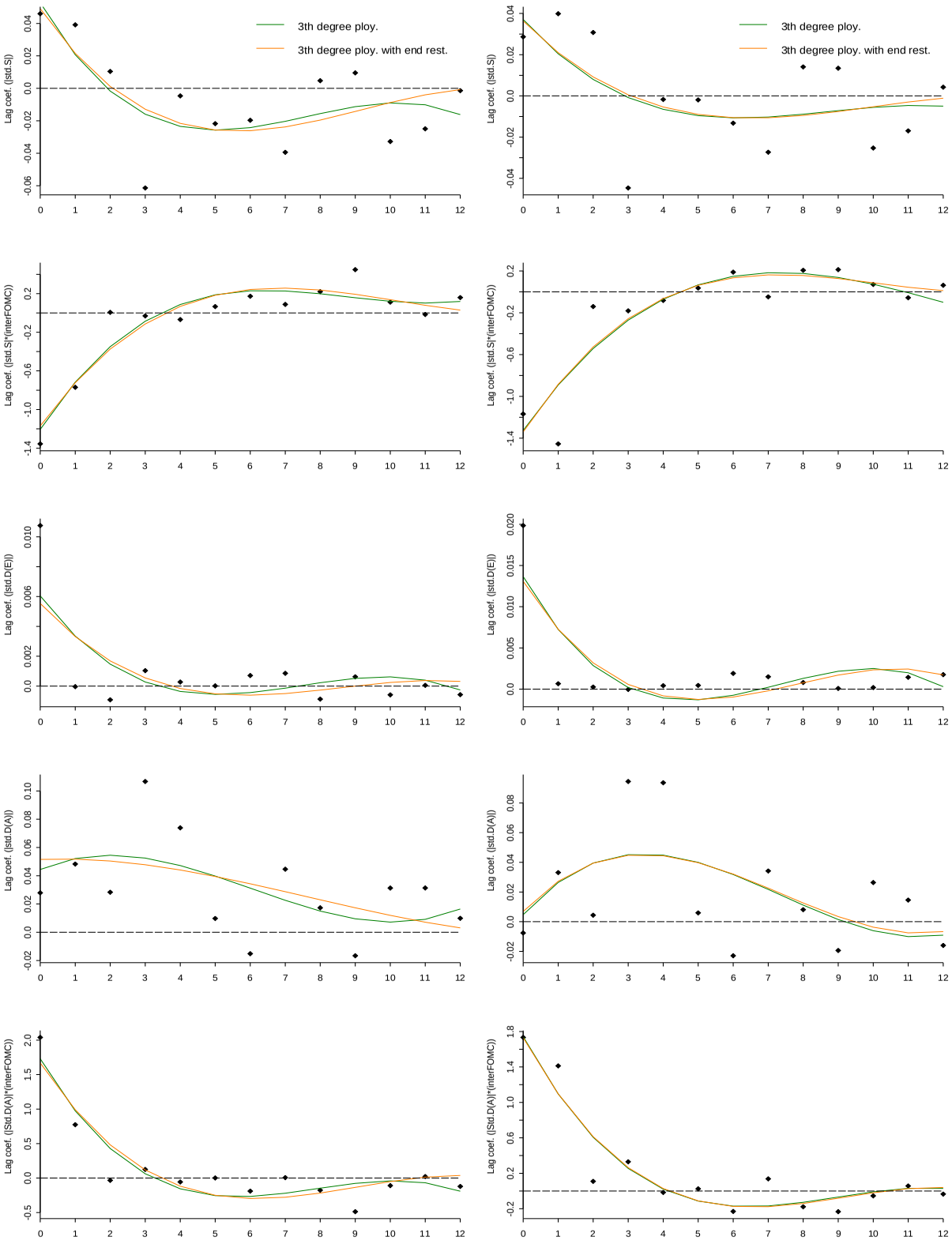


Figure 2: Regression (lag) coefficients and polynomial distributed lags for SPY. The left column are for the subsample estimation, whereas the right column is based on the full sample of returns.