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### **Greenspan Shrugs: Formal Pronouncements, Bond Market Volatility and Central Bank Communication**

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**Greenspan Shrugs:  
Formal Pronouncements, Bond Market Volatility, And  
Central Bank Communication**

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(Revised)

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**Greenspan Shrugs:  
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**Abstract**

This paper presents empirical evidence on one aspect of central bank communication policy – formal pronouncements by central bankers – to better understand whether this channel matters and, if so, the nature of the information being transmitted. We examine the relationship between three types of pronouncements from Chairman Alan Greenspan -- speeches, testimonies, and FOMC meetings -- and volatility in the 30-year U.S. Treasury bond futures market. By studying the reaction of financial markets with intraday data, we are able to examine several interesting aspects of the nature of central bank communication policy.

Three questions relevant to central bank communication policy are addressed (see Figure 1 for a summary): do these speeches, testimonies, and FOMC meetings (STF's) matter?; do the STF's merely create noise and agitate markets or transmit information relevant for economic decisions?; are STF's transmitting substantive content or providing a widely-observed costless signal that coordinates bond market activity?

We find that STF's matter for bond market volatility, that this impact depends on the transmission of information (rather than just noise), and that this information reflects both substantive content and a coordinating signal. We further find that speeches only deliver content, that testimonies are largely a coordinating device, and that FOMC meetings play both roles. These findings of a quantitatively important coordination channel document the relevance of the "global games" model of Morris and Shin and the "herding" model of Banerjee and the associated policy implication that pronouncements by the central bank may reduce welfare by overwhelming important private information.

*JEL* Codes: E58 (Central Banks and Their Preferences)  
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**Greenspan Shrugs:  
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...the verdict among most, if not all, our ‘watchers’ seems to be that -- broadly speaking -- the ECB has done a good job but has not been very effective in presenting and explaining itself.

Otmar Issing  
Chief Economist, ECB  
*The Economist* (January 6, 2001, p. 63)

I used to think if there was reincarnation, I wanted to come back as the president or the pope or a .400 baseball hitter. But now I want to come back as the bond market. You can intimidate everybody.

James Carville  
Campaign Advisor to President Clinton  
*Wall Street Journal* (February 25, 1993, p. A1)

In such circumstances, certain types of central bank talk might actually impinge on welfare-enhancing market pricing by being misunderstood and receiving too much weight relative to private judgments.

Donald Kohn  
Vice Chair of the Board of Governors  
Speech to the American Economic Association (2005, p. 1)

## **I. Introduction**

There is a broad consensus among central bankers and monetary policy scholars that transparency enhances economic performance. Expectations about the future course of the economy have a substantial impact on economic decisions, and monetary policy has a substantial role in influencing these expectations.<sup>1</sup> The lifting of the veil on central banking operations

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<sup>1</sup> The connection between monetary policy transparency and expectations has been analyzed by Blinder, Ehrmann, Fratzscher, de Haan, and Jansen (2008, especially sections 1 and 2), Rudebusch and Williams (2008), and Woodford (2005). Mishkin (2010) lists this channel as one of the nine basic scientific principles that guide thinking by monetary economists and policymakers.

lowers the level of uncertainty confronting firms, households, and investors, and thus enhances incentives for risk-averse agents to undertake long-term commitments. A more transparent monetary policy informs and anchors expectations. With fewer monetary surprises, economic activity becomes less volatile. Moreover, transparency is consistent with the democratic principles of accountability of public institutions to its citizens.<sup>2</sup>

While transparency is a widely held goal, how do central banks communicate? As indicated by the above quotation from Otmar Issing, communications is an essential element in the conduct of monetary policy. Blinder, Goodhart, Hildebrand, Lipton, and Wyplosz (2001) suggest that, in principle, the central bank should talk about its objectives, its methods for attaining these objectives, and its process of deliberations. There is an extensive literature on the specifics of how central banks should and do communicate -- explicit announcement of targets, immediate notification of policy decisions, prompt publication of the transcripts of central bank meetings, and detailed documentation of economic forecasts and the underlying models (see the survey by Blinder, Ehrmann, Fratzscher, de Haan, and Jansen (2008)). One communications channel that has received much less attention is the formal pronouncements made by central bankers. In this paper, we examine this aspect of communication policy, and assess the impact and content of the formal pronouncements made by Alan Greenspan.

Focusing on “Greenspan’s shrugs” affords several advantages.<sup>3</sup> The Chair of the Board of Governors of the Federal Reserve System is one of the most important economic policymakers in the world. For the period we study, Greenspan’s influence had been substantially enhanced by the exceptional performance of the U.S. economy during his long tenure and the perception that the Federal Reserve played a prominent role in generating this “Long Boom.” Greenspan communicated frequently in three different ways – in speeches to industry groups, academic audiences, and professional associations; in testimony before Congressional committees; and in Federal Open Market Committee (FOMC) decisions. Given the institutional structure and norms of the Board of Governors and his chairing of the FOMC,

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<sup>2</sup> See lively discussion of transparency, communications, and related issues and references to the literature in Blinder, Goodhart, Hildebrand, Lipton, and Wyplosz (2001) and the comprehensive survey by Geraats (2002).

<sup>3</sup> The title of the paper is not only an informal description of monetary policy pronouncements by Chairman Greenspan, but also a reference to the Ayn Rand novel *Atlas Shrugged* and Greenspan’s embrace of her free market philosophy.

Greenspan exerted substantial control over monetary policy. Thus, financial markets were particularly interested in his speeches (S) and testimonies (T) and the outcomes of the FOMC meetings (F). We refer to these formal pronouncements collectively as STF's. Studying the reaction of financial markets to STF's allows us to assess several interesting aspects of the nature of central bank communication policy.

We begin in Section II with a description of the data. We focus on the 30-year Treasury bond futures market because of its important role in connecting real and financial activity (per the above quotation from Carville) and for a variety of additional reasons discussed in Section II. Our data are based on a proprietary algorithm that determines the cheapest-to-deliver issue and its price for a given futures contract. The reaction of the bond market to STF's is evaluated in terms of two measures of information flows -- price volatility (measured by the absolute value of the excess return) and quantity volatility (measured by trading volume). The dataset consists of the 56,937 five-minute trading intervals from the beginning of January 1997 through the end of December 1999, and it includes 49 speeches, 40 testimonies, and 24 FOMC meetings.

The next three sections explore the three questions concerning communication policy summarized in Figure 1. We begin by asking what impact, if any, do the STF's have on the bond market? If this aspect of communications policy is redundant or if the bond market is strong form efficient, we would expect the effects to be nil. In contrast to these predictions, Section III reports that the bond market is positively affected both before and after the STF's. We then evaluate the separate effect of each STF and find that only testimonies and FOMC meetings before the pronouncement have significant effects.

There are two competing explanations as to why STF's impact the bond market -- they transmit substantive information relevant for economic decisions or they just create noise agitating markets. Section IV distinguishes between these two explanations by examining how much volatility increases since the last STF. We define a waiting-time (or duration) variable that captures unresolved uncertainty and is measured by the distance between the current period and the last speech measured in terms of the number of trading intervals or calendar days. If Greenspan's pronouncements merely introduce noise, we would not expect to find any systematic impact of the waiting-time variable. However, if the STF's transmit information and resolve uncertainty about monetary policy, we would expect that the waiting-time variable will

be positively associated with price volatility and trading volume in the bond market. This later implication is confirmed in our empirical work.

Section V examines the nature of the information documented in the prior section and tests whether it contains substantive content or just provides a widely-observed costless signal that coordinates activity. In the latter case, STF's are coordinating devices for private agents operating with imperfect common knowledge.<sup>4</sup> Understanding the relevance of the coordination role is important because, in the "global games" or "herding" models, rational agents may underweight private information, thus reducing welfare and suggesting that the STF's may be counterproductive. If the information is substantive in providing information about the stance of policy or the state of the economy, then the response of bond prices should occur immediately after the pronouncement. Any response before the announcement suggests a role for coordination. We examine the impact of STF's at five-minute intervals one hour before and one hour after the pronouncement and find evidence in favor of both roles that differ across STF's.

Section VI discusses our results in light of some of the literature on central bank transparency and communication, and Section VII concludes.

## **II. Data And The Basic Estimating Equation**

The impacts of "Greenspan's shrugs" on financial markets are assessed by examining the relation between Greenspan's formal pronouncements and volatility in the 30-year Treasury bond futures market. Formal pronouncements include all original speeches and testimonies made by Alan Greenspan during the period January 1, 1997 through December 31, 1999, as well as the statements (or non-statements) that follow FOMC meetings. Our dataset contains 49 speeches (S) to business, economic, social, and educational groups, 40 testimonies (T) to Congress, and 24 FOMC meetings (F). We refer to these formal pronouncements collectively as STF's. The source of the STF data and the time at which they were released to the public is the website of the Board of Governors (see Appendix A for a detailed listing). The dates for the STF's are set far in advance, and thus they can be viewed as exogenous and widely known. This three-year period provides enough STF's for the econometric analysis and reflects a reasonably consistent

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<sup>4</sup> Relevant theoretical models are discussed in Section V.

communications policy. The macroeconomy and domestic financial markets were relatively stable during this period, and thus the impact of the STF's on Treasury bonds is unlikely to change markedly over our three-year sample.<sup>5</sup> Moreover, Greenspan had been chair of the Federal Reserve and the 30-year U.S. Treasury bond had been the benchmark long-run security for many years, and thus confounding learning effects were absent from financial markets during this period.

We focus on the 30-year Treasury bond futures market for several reasons: its sensitivity to monetary policy pronouncements, its substantial effects on real spending, its long-standing role (at that time) as the benchmark long-term Treasury security, its depth, and the availability of market prices at five-minute intervals. Our data are based on a proprietary algorithm that determines the cheapest-to-deliver price for a given futures contract. In order to insure the liquidity of the 30-year Treasury bond futures market, several Treasury securities with different maturities and coupons can be used to settle a futures contract. Given the bond conversion factors (provided by the exchange) and a possibly sloping yield curve, one of these securities will dominate as the least expensive way to satisfy the futures contract. The price of this bond is the cheapest-to-deliver price. There is an important difference between the converted futures and the cheapest-to-deliver prices. The analysis by Sihvonen (2008, section II.1) of 10-year German government bonds shows that, between May 2001 and December 2006, the difference between the cheapest-to-delivery bond and the next cheapest bond ranged from about 15 to 125 basis points (comparable figures for the 30-year Treasury market were not obtainable). The dataset consists of the 56,937 five-minute trading intervals from the beginning of January 1997 through the end of December 1999.

The reaction of the bond market to STF's is evaluated in terms of information flow measured in terms of prices (IFP<sub>t</sub>, price volatility measured as the absolute value of excess returns) and quantities (IFQ<sub>t</sub>, trading volume).<sup>6</sup> These two measures are related to information flows in several asset pricing models (see Ross, 1989), but they may have differential sensitivities to information (Campbell, Grossman, Wang, 1993),

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<sup>5</sup> Andersen, Bollerslev, Diebold, and Vega (2007) show that the response of asset prices to macroeconomic announcements is sensitive to the state of the business cycle.

<sup>6</sup> An alternative measurement of price volatility, squared returns, is adversely affected by measurement

$$\text{Excess Return} \equiv \text{XR}_t \equiv [(P_t - P_{t-1}) / P_{t-1}] - [(1 + \text{RF}_t)^{(1/360)} - 1.0] \quad (1)$$

$$\text{Information Flow, Price Measure} \equiv \text{IFP}_t \equiv \text{ABS}[\text{XR}_t] \quad (2)$$

$$\text{Information Flow, Quantity Measure} \equiv \text{IFQ}_t \equiv \text{Number of Ticks}, \quad (3)$$

where  $P_t$  is the cheapest-to-deliver price for the closing contract over a five-minute interval for the period January 1, 1997 to December 31, 1999, and  $\text{RF}_t$  is the risk-free rate (90-day Treasury bills) for that day. The use of five minute intervals is a compromise between understating the impact of the STF by using lower frequency data and microstructure noise by using higher frequency data (see Aït-Sahalia, Mykland, and Zhang (2005) and Anderson, Bollerslev, Diebold, and Vega (2003) for further discussion). An advantage of focusing on price volatility is that we do not have to undertake the highly subjective and path dependent task of deciding whether a certain pronouncement is expected to raise or lower bond prices.

The regression models are specified with a set of exogenous conditioning variables,  $X_t$ , that accounts for the concentration of price volatility and trading volume during certain parts of the week of the trading day (7:30 to 2:00). The  $X_t$  vector includes a constant, a set of indicator variables for the days of the week (excluding Friday to avoid perfect collinearity), and a set of indicator variables for the time-of-day (TOD), measured as time intervals during the trading day. These latter indicator variables are for the opening 30 minutes and then hourly intervals (excluding the 11:00 interval to avoid perfect collinearity),

$$X_t = \{\text{Constant, Monday, Tuesday, Wednesday, Thursday,} \quad (4)$$

$$\text{TOD-Opening, TOD-8, TOD-9, TOD-10, TOD-12, TOD-1}\}.$$

It is important to include the day and time-of-day indicator variables to account for the possibility that the STF's may tend to be released during certain times or days with systematically low or high volatility.

We measure the effect of the STF's on bond market volatility with three measures of increasing refinement. The first measure is defined broadly for the day of a STF.

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error relative to absolute returns (Forsberg and Ghysels, 2004).

$$\text{DAY}_t = \begin{cases} 1 & \text{if a STF occurs on that day;} \\ 0 & \text{otherwise,} \end{cases} \quad (5)$$

A more refined measure assesses the effects one hour before and after the STF,

$$\text{BEFORE}_t = \begin{cases} 1 & \text{if } t^*-60 \leq t < t^*; \\ 0 & \text{otherwise,} \end{cases} \quad (6a)$$

$$\text{AFTER}_t = \begin{cases} 1 & \text{if } t^* \leq t < t^*+60; \\ 0 & \text{otherwise,} \end{cases} \quad (6b)$$

where  $t^*$  is the 5 minute interval during which the STF is released. Given our large dataset, we can use a third and more refined set of indicator variables defined for each 5-minute interval 60 minutes before and after the STF,

$$\text{BEFORE60}_t = \begin{cases} 1 & \text{if } t^*-60 \leq t < t^*-55; \\ 0 & \text{otherwise} \end{cases} \quad (7a)$$

$$\text{BEFORE55}_t = \begin{cases} 1 & \text{if } t^*-55 \leq t < t^*-50; \\ 0 & \text{otherwise} \end{cases} \quad (7b)$$

$$\dots\dots\dots \dots\dots\dots \dots\dots\dots \dots\dots\dots \quad \dots$$

$$\text{BEFORE5}_t = \begin{cases} 1 & \text{if } t^*-5 \leq t < t^*; \\ 0 & \text{otherwise} \end{cases} \quad (7l)$$

$$\text{AFTER5}_t = \begin{cases} 1 & \text{if } t^* \leq t < t^*+5; \\ 0 & \text{otherwise} \end{cases} \quad (7m)$$

$$\dots\dots\dots \dots\dots\dots \dots\dots\dots \dots\dots\dots \quad \dots$$

$$\text{AFTER60}_t = \begin{cases} 1 & \text{if } t^*+55 \leq t < t^*+60; \\ 0 & \text{otherwise} \end{cases} \quad (7x)$$

These 24 indicator variables are referred to collectively as  $Z_t$ , defined in equation (8),

$$Z_t \equiv \{\text{BEFORE60}_t, \text{BEFORE55}_t, \dots, \text{AFTER60}_t\}. \quad (8)$$

Note that the interval during which the STF is released ( $t^*$ ) is included in the  $\text{AFTER5}_t$  indicator variable, which might more accurately be referred to as  $\text{ONorAFTER5}_t$ .

The waiting-time (or duration) variables will be discussed in Section V.

Before proceeding to the substantive results, we estimate the following linear OLS regression containing the conditioning variables,

$$Y_t = G[X_t, IFQ_{t-1}] \quad Y_t = \{XR_t, IFP_t, IFQ_t\}, \quad (9)$$

where  $IFQ_{t-1}$  is included as a lagged dependent variable only in one of two models where  $IFQ_t$  is the dependent variable. Since all of these regressors are exogenous, OLS is the preferred estimation method. As shown in column 1 of Table 1, no significant relation exists between excess returns and each of the regressors, and the overall  $R^2$  is 0.00009, thus supporting the specification of the excess return variable. The remaining three columns contain regressions of the information flow variables on  $X_t$ . The residuals in the model for  $IFQ_t$  in column 3 are serially correlated, and column 4 augments this model with a lagged dependent variable, which appears only in the trading volume equation. None of the qualitative results change for the  $IFQ_t$  regressions with or without a lagged dependent variable. The only effect is to lower the coefficients on the indicator variables. However, the long-run impact of the indicator variables remains the same in most cases.<sup>7</sup>

With this one minor qualification, the results are very similar across all three models. The information flow on Monday, Tuesday, and Wednesday is less than on Fridays (the numeraire due to its absence as a regressor). The results for Thursday differ, with  $IFP_t$  being relatively lower but  $IFQ_t$  not being different from zero. The results for time-of-day are also similar across specifications and indicate that price volatility and trading volume are higher relative to the 11:00 time interval. The one exception is a “lunch break” effect for  $IFQ_t$  when trading volume is lower during the 12:00 time interval, though the difference between the 11:00 and 12:00 time intervals is not statistically different from zero.

### III. Do STF's Matter?

This section assesses the first of our three questions (cf. Figure 1), asking what impact, if any, the STF's have on the bond market. The null hypothesis of no impact is consistent with this aspect of communications policy being redundant relative to the other ways that the Federal Reserve communicates. Moreover, if the bond market is strong form efficient, then the STF's will not represent any new information, and we would again expect the effects to be nil.

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<sup>7</sup> In column 4, the long-run effect is computed as the coefficient on the indicator variable divided by one minus the coefficient on the lagged dependent variable.

We begin by estimating the following linear OLS regression to determine if there is an effect on the day of a STF and if the effect is different before and after the STF,

$$Y_t = G[\text{DAY}_t : X_t, \text{IFQ}_{t-1}] \quad Y_t = \{\text{IFP}_t, \text{IFQ}_t\}, \quad (10)$$

$$Y_t = G[\text{BEFORE}_t, \text{AFTER}_t : X_t, \text{IFQ}_{t-1}] \quad Y_t = \{\text{IFP}_t, \text{IFQ}_t\}. \quad (11)$$

The null hypothesis is evaluated by the coefficients on  $\text{DAY}_t$  or on  $\text{BEFORE}_t$ , and  $\text{AFTER}_t$ . The results are reported in Table 2. (The coefficients on the  $X_t$  variables will not be reported in any of the subsequent tables; they can be found in the full set of regression estimates in Appendix B.) For either measure of volatility, the coefficient on  $\text{DAY}_t$  in Row 1 and the coefficients on  $\text{BEFORE}_t$ , and  $\text{AFTER}_t$  in Rows 2 and 3 are positive and statistically significant at conventional levels.<sup>8</sup> The coefficient on  $\text{DAY}_t$  is smaller than the coefficients associated with the more refined measures for one hour before and after the STF (even after adjusting for the longer time span captured by  $\text{DAY}$ ). A surprising result is that the effects before the STF are much larger before than after. The results for  $\text{AFTER}$  in columns 2 and 6 are not statistically significant at the 5% level, and the statistically significant result in column 4 need to be interpreted cautiously given the substantial amount of serial correlation and the associated upward bias on t-statistics. These results are generally supportive of the importance of STF's, and they further suggest that care must be taken to differentiate before and after the STF. Thus, the  $\text{DAY}_t$  regressor is omitted in the subsequent models.

Table 3 extends the analysis by examining the separate impacts of speeches, testimonies, and FOMC meetings one hour before and after the release,

$$Y_t = G[\text{S}_t * \text{BEFORE}_t, \text{S}_t * \text{AFTER}_t, \text{T}_t * \text{BEFORE}_t, \text{T}_t * \text{AFTER}_t, \text{F}_t * \text{BEFORE}_t, \text{F}_t * \text{AFTER}_t : X_t, \text{IFQ}_{t-1}] \quad (12)$$

$$Y_t = \{\text{IFP}_t, \text{IFQ}_t\}.$$

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<sup>8</sup> The statistical significance of the coefficients in the models with the lagged dependent variable is assessed as the combination of the coefficients on the indicator variable and the lagged dependent variable with the delta method.

Three interesting results emerge from this decomposition of the STF's. First, speeches do not have a statistically nor economically significant impact on information flow. Second, by contrast, there are statistically and economically significant effects before the release of testimonies and FOMC meetings. Price volatility before the release of testimony or FOMC meetings is higher by 58% or 97%, respectively, relative to the average price volatility. Third, no effects are found after the release of STF's, though, as we will see in Section V, this result reflects the coarseness of the measure of STF influence used in this section. Table 3 suggests two general results concerning a two impact hierarchies: (i) F (FOMC meetings) > T (testimonies) > S (speeches) and (ii) BEFORE > AFTER.

#### **IV. Information Or Noise?**

There are two plausible explanations as to why STF's matter: 1) they communicate information that is relevant to bond prices or 2) they merely create noise that agitates markets. If STF's provide information to the markets either directly or indirectly, then we would expect our  $IFP_t$  and  $IFQ_t$  variables, which reflect information flows, to respond positively. Regarding case 2), Mendel and Shleifer (2010, p. 1) analyze noise in a model where there are three types of investors: "a small number of investors, called insiders, who possess valuable information and trade completely rationally, a small number of noise traders who are vulnerable to sentiment shocks and trade on those, and the vast majority of outside investors, who possess no information but learn from prices and trade rationally." Their simulations document that outside investors can get confused and chase noise and that a small amount of noise can have a substantial effect on asset price volatility. The information and noise channels are observationally equivalent.

To isolate the effects of information from noise, we examine whether the volatility associated with STF's increases since the time of the last STF. With the passage of time, questions arise and accumulate about the state of the economy and the stance of policy and, from the perspective of bond market participants, uncertainty rises. This uncertainty will be resolved if STF's provide information relevant to the bond market either directly or indirectly. The longer the length of time since the last STF, the greater will be the information flow from the release of a STF and hence the greater the impact on volatility. We define a waiting-time (or duration) variable,  $W_t$ , as the distance between the current period and the most recent STF measured in

terms of the number of calendar days or trading intervals, and then apply this value (defined at  $t^*$ ) to the one hour intervals before and after the STF,

$$\text{WAIT-D}_t = \text{Number of days (including weekends and holidays) since the last STF (or since the beginning of 1997 for the first STF). This value is applied to the one hour interval before and after the STF.} \quad (13a)$$

$$\text{WAIT-T}_t = \text{Number of five-minute trading periods since the last STF (or since the beginning of 1997 for the first STF). This value is applied to the one hour interval before and after the STF.} \quad (13b)$$

If Greenspan's pronouncements merely introduce noise or have very little impact on volatility or volume, we would not expect the coefficients on  $\text{WAIT-D}_t$  or  $\text{WAIT-T}_t$  to be close to zero. However, the alternative hypothesis that STF's are informative and resolve uncertainty about monetary policy or the economy suggests a positive effect of the waiting-time variable on bond market volatility.

We introduce  $\text{WAIT-D}_t$  or  $\text{WAIT-T}_t$  into the following OLS regression equation,

$$Y_t = G[W_t * \text{BEFORE}_t, \text{BEFORE}_t, W_t * \text{AFTER}_t, \text{AFTER}_t : X_t, \text{IFQ}_{t-1}] \quad (14)$$

$$W_t = \{\text{WAIT-D}_t, \text{WAIT-T}_t\} \quad Y_t = \{\text{IFP}_t, \text{IFQ}_t\}.$$

The results presented in Table 4 differ before and after the release of the STF. The coefficients for the interaction between the  $W_t$  and  $\text{BEFORE}_t$  are positive and statistically significant at conventional levels in all models. These results reject the null hypothesis in favor of information. A different conclusion is obtained from the interaction between  $W_t$  and  $\text{AFTER}_t$ . These results are generally insignificantly different from zero,<sup>9</sup> thus either favoring the noise hypothesis or reflecting the modest impact of STF's in the after period (cf. Table 2). The weight of the evidence presented in Table 4 suggests that formal pronouncements by Chairman Greenspan generally contain information before release.

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<sup>9</sup> The exceptions are columns 4 and 6 when the waiting-time variable is defined in terms of trading periods and the information variable is volume. In these cases, the coefficients are negative and statistically significant. These results are difficult to interpret in terms of our hypotheses, but they provide no support for the information hypothesis.

## V. Content Or Coordination?

While the evidence suggests that STF's are an effective part of the Federal Reserve's communications policy, the nature of the information being transmitted remains unclear. A communication that has content -- information that relates to insights about future policy decisions or the state of the economy -- is distinguished from information that serves to coordinate the actions of private agents operating with imperfect public common knowledge. This coordination channel can arise in at least two types of theoretical models. In recent work, Allen, Morris, and Shin (2006), Amato, Morris, and Shin (2002), and Morris and Shin (2002) develop "global games" models in which rational investors coordinate their activities on a common public signal. Investors are imperfectly informed, and each observes public and private signals (the latter unobservable to all other investors) that are used to infer the true but unobservable state. In a straightforward adaptation of Morris and Shin (2002), we can assume that investor's utility depends on a weighted-average of two terms: the difference between the trading price and the true value and the trading price and the trading prices of all other investors reflecting long-run and short-run considerations, respectively. The STF's serve as a public signal that transmits substantive information about the unobserved true state of the economy and serves as a focal point. In some cases, the public signal will overwhelm private information, and the resulting equilibrium will be socially inefficient.

Herding models are also based on imperfectly informed investors and provide a second theoretical framework highlighting the potentially deleterious effects of public information. In the herding model of Banerjee (1992), trades are observed by other investors, who base their inferences on prior trades. An impending STF's (with a release date known well in advance) is the event that initiates the sequential decision problem facing investors. The resulting equilibrium is inefficient because investors will rely too little on their own information. This "herd externality" can lead to an equilibrium in which "society may actually be better off by constraining some of the people to use only their own information" (p. 798). Avery and Zemsky (1998) introduce several dimensions of uncertainty into a herding model and show that at least three dimension of uncertainty is required to lead to substantial mispricing and volatility in the short-run.

The important policy implication from either the global games or herding models is that private information may be underweighted relative to the optimum. Welfare is thus reduced, and STF's serving to coordinate this inefficient activity may be counterproductive.

To differentiate between content and coordination, we observe that, if the communication has substantive content, the response of bond prices should occur immediately after the pronouncement. Any response before the announcement suggests that the STF is serving as a coordination device. We thus examine the impact of STF's at five-minute intervals one hour before and one hour after the pronouncement based on estimates of the following OLS model,

$$Y_t = G[Z_t : X_t, IFQ_{t-1}] \quad Y_t = \{IFP_t, IFQ_t\}. \quad (15)$$

where  $Z_t$  is defined in equation (7). Results are reported in Table 5 and in Figures 2 and 3 for  $IFP_t$  and  $IFQ_t$ , respectively. We find evidence in favor of both information and coordination roles. There is a large jump 5 to 10 minutes after the announcement, a result consistent with new information being incorporated into asset prices. The response is very quick and disappears for price volatility and lingers at a lower level for trading volume. The figures also show a substantial response before the release of the STF. These coefficients are generally large and statistically significant beginning 55 minutes before the release until the release. This pattern suggests that the coordination channel is relatively more important.<sup>10</sup>

We extend this analysis by differentiating by the type of STF and run the following OLS regression,

$$Y_t = G[S_t * Z_t, T_t * Z_t, F_t * Z_t : X_t, IFQ_{t-1}] \quad Y_t = \{IFP_t, IFQ_t\}. \quad (16)$$

These results are reported for  $IFQ_t$  in Figures 4, 5, and 6 for speeches, testimonies, and FOMC meetings, respectively, as well as in Table 7 in Appendix B. (The results for  $IFP_t$  are qualitatively very similar.) The impacts of the STF's are heterogenous across types. Speeches

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<sup>10</sup> An alternative interpretation of the importance of the prior periods is that the impending STF initiates a flow of reports from companies supporting the trading community (e.g., investment banks, forecasting firms) that stimulates trading. Whether the processing of stale information leads to new information for the markets is unclear, though the resolution of this question has important welfare implications.

have an impact upon release that quickly disappears. There are no substantial effects prior to the speech (we interpret the significant impact 5 and 10 minutes prior to the release as reflecting the imprecision with which we identify the timing of the release). This pattern of coefficients suggests that speeches impact the bond market by providing content. The results in Figure 4 also suggest that the prior conclusion about the weaknesses of the speech communication channel was due to using too coarse a measure.

By contrast, testimonies have a limited impact after release. While the 5 and 10 minute intervals after the release have a heightened level of trading activity, the effect is quantitatively small, less than 40% as large as the average trading volume. The effects are substantially larger prior to the release. This statistically and economically significant pattern of coefficients suggests that testimonies largely have impact the bond market through coordination.

FOMC statements reflect both content and coordination. During the 5 minutes before and after a release, trading volume is about 1.75 times larger than on a typical day. These are the largest effects reported for either of the three STF's, and they clearly indicate that the FOMC meetings deliver valuable news to the bond market. FOMC meetings also serve as a coordinating device, as most of the coefficients prior to the release are statistically significant and approximately equal in magnitude to typical trading volume.<sup>11</sup>

The FOMC results represent a mixture of pronouncement effects and, on some occasions, actual changes in interest rates. Table 8 in Appendix B disentangles these two effects by decomposing the  $F_t$  variable between those FOMC meetings accompanied by a change in the target Federal Funds rate ( $F1_t$ ) and the complementary class of FOMC meetings ( $F2_t$ ),

$$Y_t = G[S_t*Z_t, T_t*Z_t, F1_t*Z_t, F2_t*Z_t : X_t, IFQ_{t-1}] \quad (17)$$

$$Y_t = \{IFP_t, IFQ_t\}.$$

Both  $F1_t$  and  $F2_t$  impact the information flow variables, but  $F1_t$  has stronger effects. This suggests that the bond market has expectations of whether or not the FOMC will change the target and that these expectations foment trading activity.

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<sup>11</sup> The result for the one-hour period before the release is somewhat in contrast to that of Bomfirm (2003), who finds that the day before the release, the stock market is relatively less volatile.

As robustness check on the results, we rerun the models in Table 5 by including indicator variables for each month (to account for aggregate shocks) and by dividing each observation by the average value of the dependent variable for that day-of-the-week and time-of-day (to account for any possible biases if STF's tend to be released at a particular time of day). The results largely confirm those reported in Table 5 and Figures 2 to 6.

## VI. Discussion

Perhaps the most interesting finding from our empirical analysis is the substantial effects of STF's before the release. While several studies have examined the impact of macroeconomic announcements on the Treasury market (as opposed to the futures market used in the present study), they either use daily data (Jones, Lamont, and Lumsdaine, 1998) or do not examine responses well before the release (Ederington and Lee, 1993; Fleming and Remolona, 1999). The one exception is Balduzzi, Elton, and Green (2001), who examine the impact of announcements on trading volume in two pre-release intervals, 30 to 5 minutes before the release and the 5 minutes before the release. Interestingly, they too find statistically significant impacts on the 10-year note for 8 of 23 announcements for the 30 to 5 minute interval; the monetary policy announcement is one of the 8 announcements. These results were not discussed by Balduzzi, et al and are similar to those presented in Figure 3 and columns 2 and 3 of Table 5.

Our interpretation of significant pre-release effects is that STF's affect markets through coordination in global games or herding models. The global games model developed by Morris and Shin (2002) has the particularly striking implication that central bank communication can be excessive and lower welfare. That is, central bankers can talk too much. Given this controversial conclusion, the model has received much attention. Woodford (2005, pp. 414-421) raises several concerns with the Morris and Shin model, including the appropriate specification of the social welfare function. Svensson (2006) carefully examines the original Morris and Shin model and raises an important question about the plausibility of the precisions of the public and private signals. (Other studies challenging the Morris and Shin finding are listed in Svensson's footnotes 1 and 2.) Morris, Shin, and Tong (2006) acknowledge Svensson's concern, but note that the model in question is one that assumes that the public and private signals (conditional on the true state) are independent. In more general models where these two signals are correlated (as might arise if there is a flawed conventional wisdom; e.g., that housing prices do not fall) or

where the informativeness of the aggregate price level is endogenous (Amador and Weill, 2009), the original Morris and Shin finding holds.

While rigorous examinations and critiques are always welcome, we believe that the criticism of Morris and Shin's specific model is somewhat beside the point. The key insight from their model is that public information can "crowd out" private information when investors care about the opinions of other investors, regardless of the accuracy of those opinions. This point is nicely summarized by Donald Kohn, Vice Chair of the Board of Governors (Kohn, 2005, pp. 1-2):

One consideration involves the nature of information and its relationship to market pricing. In fact, economists do not fully understand how markets incorporate information. Herding behavior, information cascades, multiple equilibria, and the amount of investment in financial research all pose puzzles about markets and information. The situation is complicated still more when an important participant is seen as having superior information owing to its investment in research or its understanding of its own behavior.

In such circumstances, certain types of central bank talk might actually impinge on welfare-enhancing market pricing by being misunderstood and receiving too much weight relative to private judgments.

There is a very large literature examining the effects of policymakers' pronouncements on a variety of economic activity. Blinder et al (2008) have surveyed part of this literature and placed the studies into two broad categories depending on whether pronouncements affect financial markets or inflation performance. Here we largely discuss studies in the former category and focus on those that relate to our findings with government bond markets.

Some early studies examine the impact of various forms of communication on the level and volatility of bond market rates. Guthrie and Wright (2000) study the effects of news articles containing phrases linked to New Zealand monetary policy, and they report a substantial effect of this form of communication on the level of interest rates. Most of their results are with daily data. One of their analyses is based on hourly data for 13 months (Figure 2, p. 507) and, in contrast to our results, they do not find any impact before the release. Kohn and Sack (1994) examine the impact of STF's on the volatility on Treasury securities with maturities up to and including 4 years. Based on daily data and conditioning on unanticipated information in the pronouncements and macroeconomic announcements (using the technique of Kuttner (2001)),

they report the following impact hierarchy -- FOMC meetings > testimonies > speeches – for maturities up to two years. For maturities of 2 to 4 years ahead, testimonies are the only STF that has a significant impact. While these and other studies with daily data are very informative, they do not permit an examination of effects before and after the release on the same day and of hypotheses contrasting information vs. noise and coordination vs. content.

The study by Reeves and Sawicki (2007) sheds some additional light on the relevance of using higher frequency data. They present results with data at both daily and higher frequencies (5, 15, and 60 minute intervals). They examine data for the response of 10-year spot yields on futures contracts of UK government securities of different maturities to minutes of the Monetary Policy Committee (MPC) meetings, the inflation report, speeches by MPC members, and testimonies by MPC members. For daily data, the volatility of the 3-month, 6-month, and 12 month short sterling futures and a 10-year security are increased by the release of the MPC minutes relative to the week before the release. (In contrast to the results by Kohn and Sack and in our paper, testimonies have no significant impact.) For higher frequency data, the releases of the MPC minutes and the inflation report have statistically significant impacts on the same four government securities relative to the week before the release and the full sample. Gürkaynak, Sack, and Swanson (2005, section 1.3 and Table 1) document the different results obtained from using daily data, intraday data with a wide window, and intraday data with a narrow window when assessing the effects of monetary policy actions and statements. Higher frequency data appears to be more powerful in capturing the impacts of pronouncements.

Some results suggest that communication channels depend on the current and past macroeconomic and policy environments. Clare and Courtenay (2001) find that, since the independence of the Bank of England in May 1997, the sensitivity of UK long gilt futures (among other assets) has fallen and the speed of reaction has risen. The latter development is attributed to increased transparency by the Bank of England. Joyce and Read (1999) find that the sensitivity of UK bond prices to the retail price index (RPI) announcements declined when inflation targets announced, suggesting that the relative information content declined in the inflation targeting environment. Ehrmann and Fratzscher (2007) document that the effects of pronouncements are state-dependent. Shifts in the macroeconomic and policy environments can affect communication channels, and hence estimates of the effects of pronouncements over long sample periods may be biased.

The above studies generally find that pronouncements matter for financial markets. This conclusion is confirmed by studies that directly examine monetary policy variables. Siklos and Bohl (nd) examine the behavior of the Bundesbank in a VAR framework. While actions speak louder than words, they find that communication does also play a role and serves as a substitute for interest rate smoothing (see Geraats (2010) for a related theoretical model). Sturm and de Haan (2010) examine the incremental information introduced by ECB pronouncements above that contained in a Taylor Rule. They find that ECB pronouncements add information useful in predicting policy decisions. There are dissenting opinions. Bomfirm and Reinhart (2000) study the impact of FOMC decisions on financial markets and Berger, de Haan, and Sturm (2006) examine the impact of the monetary pillar (as expressed in the ECB's monthly press conferences) on monetary policy. Both studies report that pronouncements are not effective relative to actions. These disparate results suggest that the effects of pronouncements may depend on the nature of the pronouncement, the macroeconomic and policy environments, and the history of past policies.

## VII. Summary

This paper has explored one aspect of central bank communication policy – formal pronouncements by central bankers – to get a better understanding of whether this channel matters and, if so, what is the nature of the information being transmitted. We examine the relationship between Chairman Alan Greenspan’s speeches and testimonies and the FOMC meetings and volatility in the 30-year bond market at five-minute intervals. The pattern of hypotheses tests and our results are summarized in Figure 1. We find that STF’s matter for bond market volatility, that this impact depends on the transmission of information (rather than just noise), and that this information reflects both substantive content and a coordinating signal. We further find that speeches only deliver content, that testimonies are largely a coordinating device, and that FOMC meetings play both roles. These findings of a quantitatively important coordination channel document the relevance of the “global games” model of Morris and Shin and the herding model of Banerjee.

This framework has several important policy implications including the possibility that one or more aspects of the STF’s may be counterproductive by “crowding out” private information. More generally, it raises questions about the optimal communication policy, how a central bank becomes transparent, and the trade-off between releasing information to the public and amplifying volatility in financial markets.

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## Appendix A: Detailed Listing of Speeches, Testimonies, and FOMC Meetings, 1997-1999

### Part A: Speeches and Testimony Included in the Sample

	<b>Date</b>	<b>Event Day of the Week</b>	<b>Information/market</b>		<b>Posted on Web</b>		<b>Description</b>	<b>Title</b>	<b>Location</b>
			<b>Date</b>	<b>Time</b>	<b>Date</b>	<b>Time</b>			
1	1/14/1997				9/15/97	15:00	Speech	Central banking and global finance	Catholic University Leuven, Leuven, Belgium
2	1/21/97	Tuesday	1/21/97	10:10	1/21/97	10:10	Testimony	Performance of the U.S. economy	Before the Committee on the Budget, U.S. Senate
3	1/30/97	Thursday	1/30/97	10:25	1/30/97	10:25	Testimony	The consumer price index	Before the Committee on Finance, U.S. Senate
4	2/13/97	Thursday	2/13/97	10:10	2/13/97	10:10	Testimony	Modernization of the financial system	Before the Subcommittee on Financial Institutions and Consumer Credit of the Committee on Banking and Financial Services, U.S. House of Representatives
5	2/21/97	Friday	2/21/97	8:50	2/21/97	8:50	Speech	Government regulation and derivative contracts	Financial Markets Conference of the Federal Reserve Bank of Atlanta, Coral Gables, Florida
6	2/26/97	Wednesday	2/26/97	10:00	7/21/98	10:15	Testimony	The Federal Reserve's semi-annual monetary policy report	Before the Committee on Banking, Housing, and Urban Affairs, U.S. Senate
7	3/4/97	Tuesday	3/4/97	10:00	3/4/97	10:00	Testimony		Before the Committee on the Budget, U.S. House of Representatives
8	3/7/97	Monday	3/10/97	7:30	3/7/97	3:10	Speech	Privacy in the information age	Conference on Privacy in the Information Age, Salt Lake City, Utah
9	3/19/97	Wednesday	3/19/97	10:00	3/19/97	10:00	Testimony	Supervision of banking organizations	Before the Subcommittee on Capital Markets, Securities and Government-Sponsored Enterprises of the Committee on Banking and Financial Services, U.S. House of Representatives

	<b>Date</b>	<b>Event Day of the Week</b>	<b>Information/market</b>		<b>Posted on Web</b>		<b>Description</b>	<b>Title</b>	<b>Location</b>
			<b>Date</b>	<b>Time</b>	<b>Date</b>	<b>Time</b>			
10	3/20/97	Thursday	3/20/97	10:00	3/20/97	10:00	Testimony	Performance of the U.S. economy	Before the Joint Economic Committee, U.S. Congress
11	3/22/97				3/24/97	9:00	Speech	Financial reform and the importance of a decentralized banking structure	Financial reform and the importance of a decentralized banking structure
12	4/12/97				4/14/97	9:00	Speech	The evolution of banking in a market economy	Annual Conference of the Association of Private Enterprise Education, Arlington, Virginia
13	4/29/97	Tuesday	4/29/97	13:30	4/29/97	13:30	Speech	G-7 economic summit meeting	Spring Meeting of the Institute of International Finance, Washington, D.C.
14	5/1/97	Thursday	5/1/97	9:25	5/1/97	9:25	Speech	Technological change and the design of bank supervisory policies	Conference on Bank Structure and Competition of the Federal Reserve Bank of Chicago, Chicago, Illinois
15	5/2/97				5/5/97	9:25		Financial reform and importance of the state charter	Annual Meeting and Conference of the Conference of State Bank Supervisors, San Diego, California
16	5/8/97	Friday	5/9/97	7:30	5/8/97	21:15	Speech	Current monetary policy	1997 Haskins Partners Dinner of the Stern School of Business, New York University, New York, New York
17	5/22/97	Thursday	5/22/97	10:00	5/22/97	10:00	Testimony	H.R. 10, the Financial Services Competitiveness Act of 1997	Before the Committee on Banking and Financial Services, U.S. House of Representatives
18	6/10/97	Wednesday	6/11/97	7:30	6/10/97	21:00	Speech	The embrace of free markets	Woodrow Wilson Award Dinner of the Woodrow Wilson International Center for Scholars, New York, New York
19	7/17/97	Thursday	7/17/97	10:00	7/17/97	10:00	Testimony	The Financial Services Competition Act of 1997	Before the Subcommittee on Finance and Hazardous Materials of the Committee on Commerce, U.S. House of Representatives

	<b>Date</b>	<b>Event Day of the Week</b>	<b>Information/market Date Time</b>		<b>Posted on Web Date Time</b>		<b>Description</b>	<b>Title</b>	<b>Location</b>
20	7/22/97	Wednesday	7/23/97	7:30	7/21/98	10:15	Testimony	The Federal Reserve's semiannual monetary policy report	Before the Subcommittee on Domestic and International Monetary Policy of the Committee on Banking and Financial Services, U.S. House of Representatives
21	9/5/97	Monday	9/8/97	7:30	9/5/97	23:30	Speech	Rules vs. discretionary monetary policy	15 <sup>th</sup> Anniversary Conference of the Center for Economic Policy Research at Stanford University, Stanford, California
22	9/12/97	Friday	9/12/97	12:20	9/12/97	12:20	Speech	Education, technology, and economic growth	Building Dedication Ceremonies Kenan-Flagler Business School, University of North Carolina, Chapel Hill, North Carolina
23	10/5/97	Monday	10/6/97	7:30	10/8/97	10:00	Speech	Technological change and the economy	Annual Convention of the American Bankers Association, Boston, Massachusetts
24	10/8/97	Wednesday	10/8/97	10:00	10/8/97	10:00	Testimony	Economic and budgetary outlook	Before the Committee on the Budget, U.S. House of Representatives
24	10/11/97	Friday	10/14/97	7:30	10/14/97	16:00	Speech	Consumer credit and financial modernization	Economic Development Conference of the Greenlining Institute, San Francisco, California
26	10/14/97	Tuesday	10/14/97	9:00	10/14/97	9:00	Speech	Globalization of finance	15 <sup>th</sup> Annual Monetary Conference of the Cato Institute, Washington, D.C.
27	10/14/97	Wednesday	10/15/97	7:30	10/14/97	14:30	Speech	Inaugural speech for economic seminar series	University of Connecticut, Storrs, Connecticut
28	10/29/97	Wednesday	10/29/97	10:00	10/29/97	10:00	Testimony	Turbulence in world financial markets	Before the Joint Economic Committee, U.S. Congress
29	11/7/97	Friday	11/7/97	8:45	11/7/97	8:45	Speech	Price measurement	Center for Financial Studies Frankfurt, Germany
30	11/20/97	Thursday	11/20/97	10:00	11/20/97	10:00	Testimony	Social security	Before the Task Force on Social Security of the Committee on the Budget, U.S. Senate

	<b>Date</b>	<b>Event Day of the Week</b>	<b>Information/market</b>		<b>Posted on Web</b>		<b>Description</b>	<b>Title</b>	<b>Location</b>
			<b>Date</b>	<b>Time</b>	<b>Date</b>	<b>Time</b>			
31	12/2/97	Wednesday	12/3/97	7:30	12/2/97	20:30	Speech	Growth and flexibility: Lessons from Asia	Economic Club of New York, New York, N.Y.
32	12/3/97	Thursday	12/4/97	7:30	12/3/97	14:30	Speech	The role of education during rapid economic change	At Syracuse University, Syracuse, New York
33	1/3/98	Saturday			1/5/98	15:30		The problems of price measurement	Annual meeting of the American Economic Association in Chicago
34	1/12/98	Monday	1/12/98	13:00	1/12/98	13:00	Speech	Economic development in low- and moderate-income communities	At a Community Forum on Community Reinvestment and Access to Credit: California's Challenge, Los Angeles, California
35	1/29/98	Thursday	1/29/98	10:00	1/29/98	10:00	Testimony	The current fiscal situation	Before the Committee on the Budget, U.S. Senate
36	2/12/98	Thursday	2/13/97	7:30	2/12/98	14:00	Testimony	The current Asian crisis and the dynamics of international finance	Before the Committee on Foreign Relations, U.S. Senate
37	2/24/98	Tuesday	2/24/98	10:00	7/21/98	10:15	Testimony	The Federal Reserve's semiannual report on economic conditions and the conduct of monetary policy	Before the Subcommittee on Domestic and International Monetary Policy of the Committee on Banking and Financial Services, U.S. House of Representatives
38	2/26/98	Friday	2/27/98	7:30	2/27/98	17:45	Speech	The role of capital in optimal banking supervision and regulation	Before the Conference on Capital Regulation in the 21 <sup>st</sup> Century, Federal Reserve Bank of New York, New York, NY
39	2/27/98	Friday	2/27/98	11:30	12/27/98	11:30	Speech	Risk management in the global financial system	Before the Annual Financial Markets Conference of the Federal Reserve Bank of Atlanta, Miami Beach, Florida

	<b>Date</b>	<b>Event Day of the Week</b>	<b>Information/market Date Time</b>		<b>Posted on Web Date Time</b>		<b>Description</b>	<b>Title</b>	<b>Location</b>
40	3/3/98	Tuesday	3/4/98	7:30	3/3/98	14:05	Speech	Implications of recent Asian developments for community banking	Before the Annual Convention of the Independent Bankers Association of America, Honolulu, Hawaii
41	3/3/98	Tuesday	3/3/98	10:30	3/3/98	10:30	Testimony	The current Asian crisis	Before the Subcommittee on Foreign Operations of the Committee on Appropriations, U.S. Senate
42	3/4/98	Wednesday	3/4/98	10:00	3/4/98	10:00	Testimony	Coming budgetary challenges	Before the Committee on the Budget, U.S. House of Representatives
43	4/2/98	Thursday	4/3/98	7:30	4/2/98	14:30	Speech	The ascendance of market capitalism	Before the Annual Convention of the American Society of Newspaper Editors, Washington, D.C.
	4/20/98	Monday			4/20/98	13:00	Testimony	The allocation of the economy's resources between Medicare and competing needs	Before the National Bipartisan Commission on the Future of Medicare
44	5/2/98	Saturday	5/4/98	7:30	5/2/98	12:15	Speech	Our banking history	Before the Annual Meeting and Conference of the Conference of State Bank Supervisors, Nashville, Tennessee
45	5/7/1998	Thursday			5/7/98	12:00		Understanding today's international financial system	Before the 34th Annual Conference on Bank Structure and Competition of the Federal Reserve Bank of Chicago
46	5/20/98	Wednesday	5/20/98	11:15	5/20/98	11:15	Speech	On the announcement of a new currency design	Bureau of Engraving and Printing, Washington, D.C.
47	5/21/98	Thursday	5/21/98	10:30	5/21/98	10:30	Testimony	The current Asian crisis and the financial resources of the IMF	Before the Committee on Agriculture, U.S. House of Representatives

	<b>Date</b>	<b>Event Day of the Week</b>	<b>Information/market Date Time</b>		<b>Posted on Web Date Time</b>		<b>Description</b>	<b>Title</b>	<b>Location</b>
48	6/10/98	Wednesday	6/10/98	11:00	6/10/98	11:00	Testimony	An update on economic conditions in the United States	Before the Joint Economic Committee, U.S. Congress
49	6/16/98	Tuesday	6/16/98	10:00	6/16/98	10:00	Testimony	The effects of mergers	Before the Committee on the Judiciary, U.S. Senate
50	6/17/98	Wednesday			6/17/98	11:00	Testimony	H.R. 10, the Financial Services Act of 1998	Before the Committee on Banking, Housing, and Urban Affairs, U.S. Senate
51	6/24/98				6/24/98	10:00	Testimony	The regulation of OTC derivatives	Before the Committee on Banking and Financial Services, U.S. House of Representatives
52	7/10/98	Friday	7/10/98	12:30	7/10/98	12:30	Speech	The implications of technological changes	Charlotte Chamber of Commerce, Charlotte, North Carolina
53	7/21/98	Tuesday	7/21/98	10:15	7/22/98	10:00	Testimony	The Federal Reserve's midyear report on monetary policy	Before the Committee on Banking, Housing, and Urban Affairs, U.S. Senate <i>Chairman Greenspan presented identical testimony before the Subcommittee on Domestic and International Monetary Policy of the Committee on Banking and Financial Services, U.S. House of Representatives, July 22, 1998</i>
54	7/30/98				7/30/98	10:00	Testimony	<i>The Commodity Exchange Act and OTC derivatives</i>	Before the Committee on Agriculture, Nutrition, and Forestry, U.S. Senate
55	9/4/98	Tuesday	9/8/98	7:30	9/4/98	19:00	Speech	Is there a new economy?	Haas Annual Business Faculty Research Dialogue, University of California, Berkeley, California
56	9/16/98	Wednesday	9/16/98	13:00	9/16/98	13:00	Testimony	International economic and financial system	Before the Committee on Banking and Financial Services, U.S. House of Representatives
57	9/23/98	Thursday	9/24/98	7:30	9/23/98	14:00	Testimony	The crisis in emerging market economies	Before the Committee on the Budget, U.S. Senate

	<b>Date</b>	<b>Event Day of the Week</b>	<b>Information/market Date Time</b>		<b>Posted on Web Date Time</b>		<b>Description</b>	<b>Title</b>	<b>Location</b>
58	10/1/98	Thursday	10/1/98	10:00	10/1/98	10:00	Testimony	Private-sector refinancing of the large hedge fund, Long-Term Capital Management	Before the Committee on Banking and Financial Services, U.S. House of Representatives
59	11/5/98	Thursday	11/5/98	12:15	11/5/98	12:15	Speech	The structure of the international financial system	Annual Meeting of the Securities Industry Association, Boca Raton, Florida
60	1/20/99				1/20/99	10:00	Testimony	State of the Economy	Before the Committee on Ways and Means, U.S. House of Representatives
61	1/28/1999				1/28/1999	8:30	Testimony	Social Security	Before the Committee on the Budget, U.S. Senate
62	2/11/1999				2/11/1999	10:00	Testimony	H.R. 10 and the need for financial reform	Before the Committee on Banking and Financial Services, U.S. House of Representatives
63	2/23/99				2/23/99	10:00	Testimony	Need for financial modernization	Before the Committee on Banking, Housing, and Urban Affairs, U.S. Senate
64	2/16/99	Tuesday	2/16/99	12:00	2/16/99	12:00	Speech	The interaction of education and economic change	81st Annual Meeting of the American Council on Education, Washington, D.C.
65	2/23/99	Tuesday	2/23/99	10:00	2/24/99	10:00	Testimony	The Federal Reserve's semiannual report on monetary policy	Before the Committee on Banking, Housing, and Urban Affairs, U.S. Senate <i>Chairman Greenspan presented identical testimony before the Committee on Banking and Financial Services, U.S. House of Representatives, February 24, 1999</i>
66	3/3/99	Wednesday	3/3/99	10:00	3/.99	10:00	Testimony	On investing the social security trust fund in equities	Before the Subcommittee on Finance and Hazardous Materials, Committee on Commerce, U.S. House of Representatives
67	3/8/1999				3/8/99	15:00	Speech	Mortgage finance	At the Mortgage Bankers Association, Washington, D.C.

Date	Event Day of the Week	Information/market		Posted on Web		Description	Title	Location
		Date	Time	Date	Time			
68 3/9/1999				3/9/1999	12:00	Speech	Changes in small business finance	At the Federal Reserve System Research Conference on Business Access to Capital and Credit, Arlington, Virginia
69 3/16/1999				3/18/99	16:30	Speech	The farm economy	At the Annual Convention of the Independent Bankers Association of America, San Francisco, California
70 3/19/99	Friday	3/19/99	9:15	3/19/99	9:15	Speech	Financial derivatives	Before the Futures Industry Association, Boca Raton, Florida
71 4/16/99	Friday	4/16/99	14:00	4/16/99	14:00	Speech	Technology and trade	Before the Dallas Ambassadors Forum, Dallas, Texas
72 4/28/1999				4/28/1999	10:00	Testimony	H.R. 10 and financial modernization	Before the Subcommittee on Finance and Hazardous Materials, Committee on Commerce, U.S. House of Representatives
73 4/29/99	Friday	4/30/99	7:30	4/29/99	16:00	Speech	Currency reserves and debt	Before the World Bank Conference on Recent Trends in Reserves Management, Washington, D.C.
74 5/6/99	Thursday	5/6/99	9:25	5/6/99	9:25	Speech	The American economy in a world context	35th Annual Conference on Bank Structure and Competition of the Federal Reserve Bank of Chicago, Chicago, Illinois
75 5/20/99	Thursday	5/20/99	10:00	5/20/99	10:00	Testimony	Efforts to improve the "architecture" of the international financial system	Before the Committee on Banking and Financial Services, U.S. House of Representatives
76 6/2/1999				6/2/99	13:00	Speech	Trade and technology	Before the Alliance for the Commonwealth, Conference on International Business, Boston, Massachusetts
77 6/10/1999				3/10/99	15:30	Speech	Commencement address	Harvard University, Boston, Massachusetts
78 6/14/99	Monday	6/14/99	10:00	6/14/99	10:00	Testimony	High-tech industry in the U.S. economy	Before the Joint Economic Committee, U.S. Congress

	<b>Date</b>	<b>Event Day of the Week</b>	<b>Information/market Date Time</b>		<b>Posted on Web Date Time</b>		<b>Description</b>	<b>Title</b>	<b>Location</b>
79	6/17/99	Thursday	6/17/99	10:00	6/17/99	10:00	Testimony	Monetary policy and the economic outlook	Before the Joint Economic Committee, U.S. Congress
80	7/22/99	Thursday	7/22/99	11:00	7/28/99	10:00	Testimony	The Federal Reserve's semiannual report on monetary policy	Before the Committee on Banking and Financial Services, U.S. House of Representatives <i>Chairman Greenspan presented identical testimony before the Committee on Banking, Housing, and Urban Affairs, U.S. Senate, on July 28, 1999</i>
81	8/27/99	Friday	8/27/99	10:00	8/27/99	10:00	Speech	New challenges for monetary policy	Before a symposium sponsored by the Federal Reserve Bank of Kansas City, Jackson Hole, Wyoming
82	9/8/99	Wednesday	9/8/99	11:45	9/8/99	11:45	Speech	Maintaining economic vitality	Millennium Lecture Series, sponsored by the Gerald R. Ford Foundation and Grand Valley State University, Grand Rapids, Michigan
83	9/17/99	Friday	9/17/99	8:45	9/17/99	8:45	Speech	Status of Y2K preparedness	Before the President's Council on Year 2000 Conversion, Financial Sector Group, Year 2000 Summit, Washington, D.C.
84	9/27/99	Tuesday	9/28/99	7:30	9/27/99	17:15	Speech	Lessons from the global crises	Before the World Bank Group and the International Monetary Fund, Program of Seminars, Washington, D.C.
85	9/30/1999				9/30/1999	21:30	Speech	Trade and technology	Before Minnesota Meeting, Minneapolis, Minnesota
86	10/11/1999				10/11/98	11:00	Speech	The evolution of bank supervision	Before American Bankers Association, Phoenix, Arizona
87	10/14/99	Friday	10/15/99	7:30	10/14/99	19:00	Speech	Measuring financial risk in the twenty-first century	Before a conference sponsored by the Office of the Comptroller of the Currency, Washington, D.C.
88	10/19/99	Tuesday	10/19/99	13:00	10/19/99	13:00	Speech	Do efficient financial markets mitigate financial crises?	Before the 1999 Financial Markets Conference of the Federal Reserve Bank of Atlanta, Sea Island, Georgia

	<b>Date</b>	<b>Event Day of the Week</b>	<b>Information/market</b>		<b>Posted on Web</b>		<b>Description</b>	<b>Title</b>	<b>Location</b>
			<b>Date</b>	<b>Time</b>	<b>Date</b>	<b>Time</b>			
89	10/28/99	Friday	10/29/99	7:30	10/28/99	19:30	Speech	Information, productivity, and capital investment	Before The Business Council, Boca Raton, Florida
90	11/2/99	Tuesday	11/2/99	9:15	11/2/99	9:15	Speech	Mortgage markets and economic activity	Before a conference on Mortgage Markets and Economic Activity sponsored by America's Community Bankers, Washington, D.C.
91	11/15/99	Monday	11/15/99	9:15	11/15/99	9:15	Speech	Insurance companies and banks under the new regulatory law	Before the Annual Meeting of the American Council of Life Insurance, Washington, D.C.

Part B: FOMC Meetings Included in the Sample

Meeting date	Policy result as presented in a policy statement	F1 <sup>#</sup>	F2 <sup>#</sup>
February 4/5, 1997	No statement	0	1
March 25, 1997	“The Federal Open Market Committee decided today to tighten money market conditions slightly, expecting the federal funds rate to rise 1/4 percentage point to around 5-1/2 percent.... No change was made in the Federal Reserve discount rate, which remains at 5 percent.”	1	0
May 20, 1997	No statement	0	1
July 1/2, 1997	No statement	0	1
August 19, 1997	No statement	0	1
September 30, 1997	No statement	0	1
November 12, 1997	No statement	0	1
December 16, 1997	No statement	0	1
February 3/4, 1998	No statement	0	1
March 31, 1998	No statement	0	1
May 19, 1998	No statement	0	1
June30/July 1, 1998	No statement	0	1
August 18, 1998	No statement; this meeting is excluded because there are no bond market data for August of 1998.	NR	NR
September 29, 1998	The Federal Open Market Committee decided today to ease the stance of monetary policy slightly, expecting the federal funds rate to decline 1/4 percentage point to around 5-1/4 percent.... The discount rate remains unchanged at 5 percent.	1	0
October 15, 1998	“The Federal Reserve today announced the following set of policy actions: <ul style="list-style-type: none"> <li>• The Board of Governors approved a reduction in the discount rate by 25 basis points from 5 percent to 4-3/4 percent.</li> <li>• The federal funds rate is expected to fall 25 basis points from around 5-1/4 percent to around 5 percent”</li> </ul>	1	0
November 17, 1998	“The Federal Reserve today announced the following set of policy actions: <ul style="list-style-type: none"> <li>• The Board of Governors approved a reduction in the discount rate by 25 basis points from 4-3/4 percent to 4-1/2 percent.</li> <li>• The federal funds rate is expected to fall 25 basis points from around 5 percent to around 4-3/4 percent.”</li> </ul>	1	0
December 22, 1998	No statement	0	1
February 2/3, 1999	No statement	0	1
March 30, 1999	No statement	0	1
May 18, 1999	“While the FOMC did not take action today to alter the stance of monetary policy, the Committee was concerned about the potential for a buildup of inflationary imbalances that could undermine the favorable performance of the economy and therefore adopted a directive that is tilted toward the possibility of a firming in the stance of monetary policy.”	1	0
June 29/30, 1999	“The Federal Open Market Committee today voted to raise its target for the federal funds rate 25 basis points to 5 percent. Last fall the Committee reduced interest rates to counter a significant seizing-up of financial markets in the United States. Since then much of the financial strain has eased, foreign economies have firmed, and economic activity in the United States has moved forward at a brisk pace. Accordingly, the full degree of adjustment is judged no longer necessary.”	1	0
August 24, 1999	“The Federal Open Market Committee today voted to raise its target for the federal funds rate by 25 basis points to 5-1/4 percent. In a related action, the Board of Governors approved a 25 basis point increase in the discount rate to 4-3/4 percent.”	1	0
October 5, 1999	“The Federal Open Market Committee decided today to leave its target for the federal funds rate unchanged.”	0	1

<b>Meeting date</b>	<b>Policy result as presented in a policy statement</b>	<b>F1<sup>#</sup></b>	<b>F2<sup>#</sup></b>
November 16, 1999	“The Federal Open Market Committee today voted to raise its target for the federal funds rate by 25 basis points to 5-1/2 percent. In a related action, the Board of Governors approved a 25 basis point increase in the discount rate to 5 percent.”	1	0
December 21, 1999	“The Federal Open Market Committee made no change today in its target for the federal funds rate.”	0	1

# F1 equals 1 if the FOMC statements is accompanied by a change in the target Federal Funds rate,; 0 otherwise.

F2 is the complementary class of FOMC statements and equals 1 - F1.

**Table 1. Estimates of Equation (9). No STF's**

	Dependent Variable			
	XR (1)	IFP (2)	IFQ (3)	IFQ (4)
Intercept	-0.00013 (-18.97)	3.75381 (76.69)	16.76571 (107.80)	6.91579 (48.36)
Monday	2.79E-07 (0.04)	-0.97137 (-18.22)	-5.96772 (-34.60)	-2.45874 (-17.26)
Tuesday	6.95E-07 (0.09)	-0.59262 (-10.50)	-2.71667 (-15.49)	-1.03912 (-7.33)
Wednesday	3.14E-06 (0.41)	-0.47563 (-8.41)	-1.96125 (-11.16)	-0.79208 (-5.65)
Thursday	2.36E-06 (0.30)	-0.31835 (-5.56)	0.00877 (0.05)	0.01169 (0.08)
Trade occurs in first 30 minutes of the day	1.73E-05 (1.17)	2.45155 (21.27)	23.88411 (66.05)	8.63347 (25.47)
Trade occurs between 8:00 and 8:55	-5.77E-07 (-0.08)	0.61420 (13.17)	9.26053 (55.58)	3.49005 (25.65)
Trade occurs between 9:00 and 9:55	-3.42E-06 (-0.45)	0.86933 (16.21)	9.55345 (54.94)	3.80196 (26.51)
Trade occurs between 10:00 and 10:55	2.39E-06 (0.37)	0.25801 (5.80)	2.05807 (13.58)	0.48915 (4.14)
Trade occurs between 12:00 and 12:55	1.74E-06 (0.27)	0.13587 (3.16)	-0.20799 (-1.40)	-0.14545 (-1.24)
Trade occurs between 1:00 and 1:55	-1.43E-06 (-0.20)	0.64788 (13.46)	6.86636 (40.43)	3.91150 (29.20)
LDVIFQ	—	—	—	0.58915 (117.48)
R <sup>2</sup>	0.00009	0.03159	0.22292	0.48301
Log likelihood	348,310	-157,247	-225,725	-214,113
Durbin-Watson	1.94	1.65	0.79	2.10
Sample size	56,936	56,936	56,936	56,936
<u>Dependent Variable</u>				
Mean	- 1.2637	3.8643	20.78	20.78
Standard Deviation	5.3328	3.8922	14.46	14.46

Notes: OLS estimates. Standard errors are heteroskedasticity-consistent using the White correction; t-statistics are in parentheses. The mean and standard deviation for XR and IFP are multiplied by 10<sup>4</sup>.

**Table 2. Estimates of Equations (10) and (11). Indicator variables for the day of the STF (Row 1) and the one hour periods before and after a STF (Rows 2 and 3)**

Variable	Dependent					
	IFP		IFQ		IFQ	
	(1)	(2)	(3)	(4)	(5)	(6)
Day	0.16691 (3.16)		0.86352 (5.45)		0.36669 (2.93)	
Before		1.57883 (8.77)		7.12866 (15.19)		3.16904 (9.33)
After		0.23079 (1.84)		2.05765 (4.93)		0.55437 (1.59)
LDVIFQ					0.58890 (117.47)	0.58573 (116.89)
R <sup>2</sup>	0.03182	0.03555	0.22337	0.22909	0.48310	0.48417
Log likelihood	-157,241	-157,131	-225,708	-225,498	-214,109	-214,050
Durbin-Watson	1.65	1.66	0.79	0.80	2.10	2.10

Notes: OLS estimates. Standard errors are heteroskedasticity-consistent using the White correction; t-statistics are in parentheses. The  $X_t$  conditioning variables are included; see Appendix B for a full set of regression estimates.

**Table 3. Estimates of Equation (12). Indicator variables for the one hour periods before and after a speech (S), testimony (T), or a Federal Open Market Committee (F) statement interacting with the type of STF**

	Dependent Variable		
	IFP	IFQ	
	IFQ	(1)	(2)
S*Before	0.21521 (1.34)	0.71413 (1.36)	0.45796 (1.11)
S*After	0.28045 (1.30)	1.28334 (1.89)	0.42967 (0.76)
T*Before	2.25538 (6.14)	10.40239 (12.82)	4.41975 (7.22)
T*After	0.18141 (1.25)	2.31185 (4.41)	0.67396 (1.63)
F*Before	3.73846 (7.44)	17.29470 (14.16)	7.88463 (8.87)
F*After	0.24001 (0.79)	3.66349 (3.38)	0.74271 (0.77)
LDVIFQ	—	—	0.58286 (116.15)
R <sup>2</sup>	0.03863	0.23420	0.48514
Log likelihood	-157,040	-225,309	-213,997
Durbin-Watson	1.66	0.80	2.09

Notes: OLS estimates. Standard errors are heteroskedasticity-consistent using the White correction; t-statistics are in parentheses. The  $X_t$  conditioning variables are included; see Appendix B for a full set of regression estimates.

**Table 4. Estimates of Equation (14). Indicator variables for the one hour periods before and after a STF interacting with the number of days since the last STF (WAIT-D, equation (13a), displayed in columns 1, 3, 5) or with the number of five minute trading periods since the last STF (WAIT-T, equation (13b), displayed in columns 2, 4, 6)**

	Dependent Variable					
	IFP		IFQ		IFQ	
	(1)	(2)	(3)	(4)	(5)	(6)
Before	0.15106 (2.07)	0.14779 (1.92)	0.14327 (4.68)	0.14465 (4.50)	0.05928 (2.61)	0.06068 (2.56)
W*Before	0.03060 (3.33)	0.00054 (3.18)	0.02310 (7.66)	0.00040 (7.06)	0.00966 (4.37)	0.00017 (4.01)
After	0.05790 (2.18)	0.12053 (2.23)	0.11896 (6.89)	0.19643 (5.84)	0.03821 (2.91)	0.08555 (3.38)
W*After	-0.07857 (-1.44)	-0.01213 (-1.60)	-0.04627 (-1.28)	-0.01453 (-3.10)	-0.00039 (-0.01)	-0.00862 (-2.39)
LDVIFQ	—	—	—	—	0.60640 (134.73)	0.60645 (134.79)
R <sup>2</sup>	0.00726	0.00713	0.01214	0.01200	0.37574	0.37574
Log likelihood	-75758.6	-75762.5	-51064.1	-51068.2	-37997.8	-37997.7
Durbin-Watson statistic	1.69	1.69	0.79	0.79	2.23	2.23

Notes: OLS estimates. Standard errors are heteroskedasticity-consistent using the White correction; t-statistics are in parentheses. The  $X_t$  conditioning variables are included; see Appendix B for a full set of regression estimates.

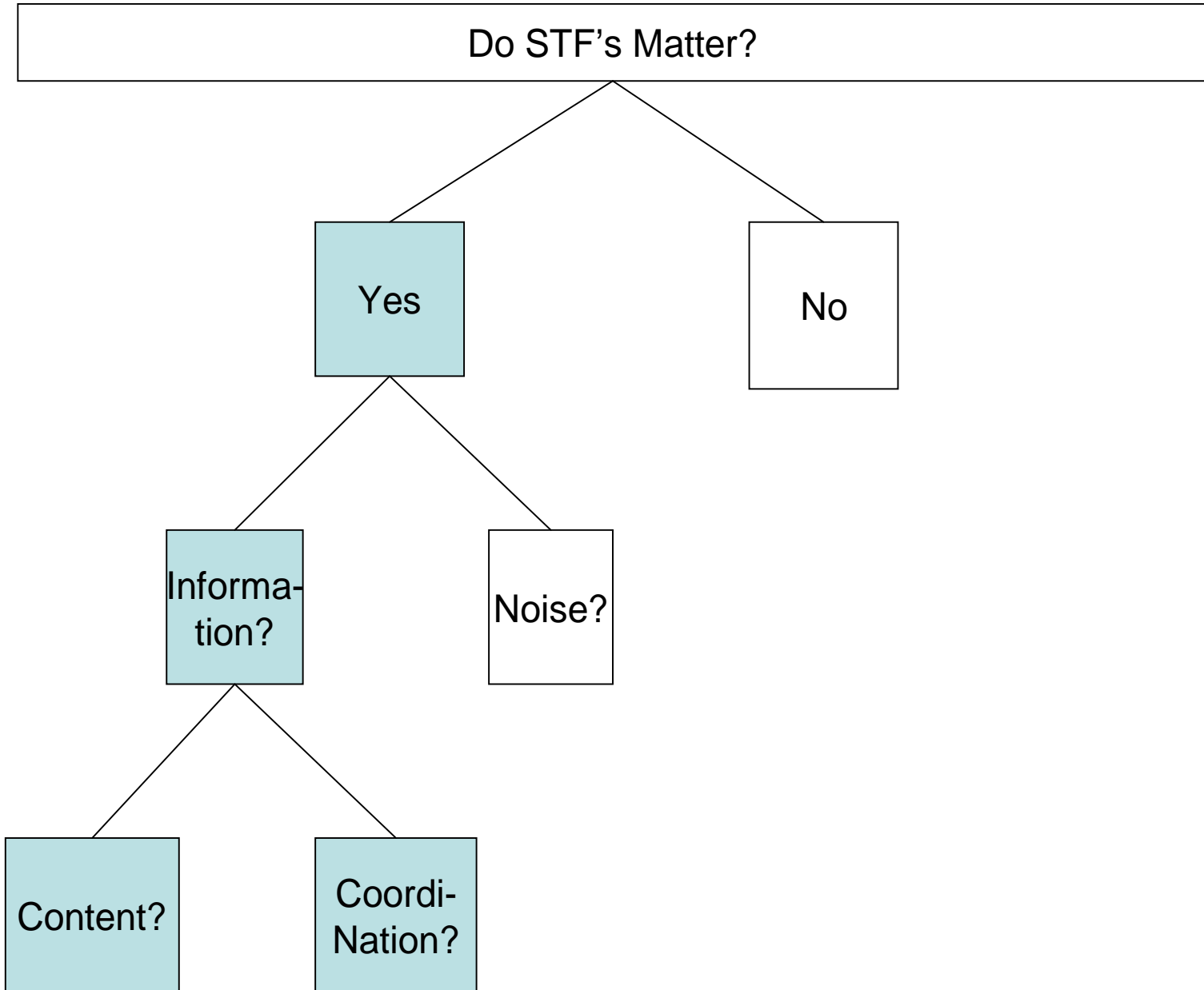
**Table 5. Estimates of Equations (10) and (11). Indicator variables for the one hour periods before and after a STF at five-minute intervals**

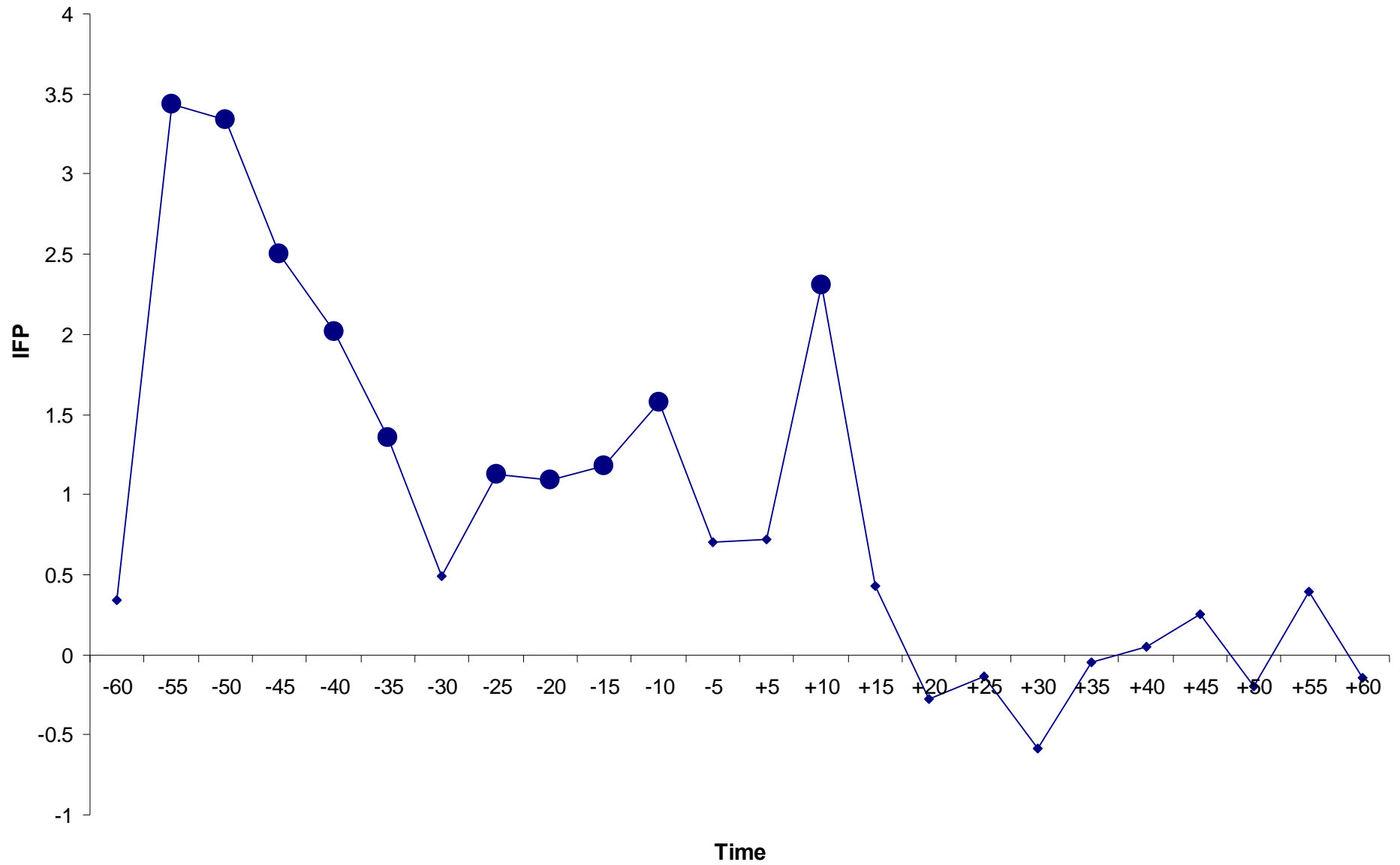
	Dependent Variable		
	IFP (1)	IFQ (2)	IFQ (3)
Before 60 minutes	0.34006 (0.87)	0.14943 (0.11)	0.97085 (0.81)
Before 55 minutes	3.43937 (3.17)	8.12853 (4.19)	7.63258 (4.57)
Before 50 minutes	3.34288 (3.67)	7.29797 (4.56)	2.04193 (1.96)
Before 45 minutes	2.50386 (3.59)	9.46144 (5.18)	4.59304 (3.39)
Before 40 minutes	2.01809 (3.31)	8.34338 (5.05)	2.36148 (2.25)
Before 35 minutes	1.35544 (2.26)	7.65044 (4.56)	2.32402 (2.23)
Before 30 minutes	0.49469 (1.19)	5.60166 (4.00)	0.54515 (0.68)
Before 25 minutes	1.12756 (2.76)	6.79959 (4.39)	3.02935 (2.96)
Before 20 minutes	1.08818 (2.57)	6.26842 (4.35)	1.82936 (1.94)
Before 15 minutes	1.17763 (2.44)	7.14274 (4.71)	2.96793 (2.54)
Before 10 minutes	1.57101 (3.05)	7.82318 (5.65)	3.11265 (3.26)
Before 5 minutes	0.69963 (1.54)	12.28760 (7.03)	7.27499 (5.59)
After 5 minutes	0.71829 (1.65)	18.95987 (8.72)	16.01057 (7.52)
After 10 minutes	2.30348 (2.62)	4.36590 (2.61)	-6.15024 (-3.87)
After 15 minutes	0.43207 (0.95)	-0.30140 (-0.21)	-2.31798 (-2.28)
After 20 minutes	-0.27491 (-0.77)	-1.44614 (-1.12)	-0.72877 (-0.97)
After 25 minutes	-0.13277 (-0.34)	-3.00170 (-2.21)	-1.61270 (-1.69)
After 30 minutes	-0.58674 (-1.47)	-2.04443 (-1.49)	0.25678 (0.29)
After 35 minutes	-0.04990 (-0.16)	2.61124 (2.27)	0.08976 (0.10)
After 40 minutes	0.04971 (0.16)	3.05629 (2.84)	1.61126 (1.70)
After 45 minutes	0.25524 (0.80)	2.76712 (2.46)	1.15092 (1.24)

After 50 minutes	-0.19483 (-0.82)	0.70987 (0.73)	-0.86348 (-1.07)
After 55 minutes	0.39253 (1.19)	-0.47720 (-0.53)	-0.78383 (-1.12)
After 60 minutes	-0.14683 (-0.52)	-0.40290 (-0.44)	0.00662 (0.01)
LDVIFQ	—	—	0.58642 (117.66)
<hr/>			
R <sup>2</sup>	0.03802	0.23369	0.48773
Log likelihood	-157,058	-225,328	-213,853
Durbin-Watson	1.66	0.80	2.10

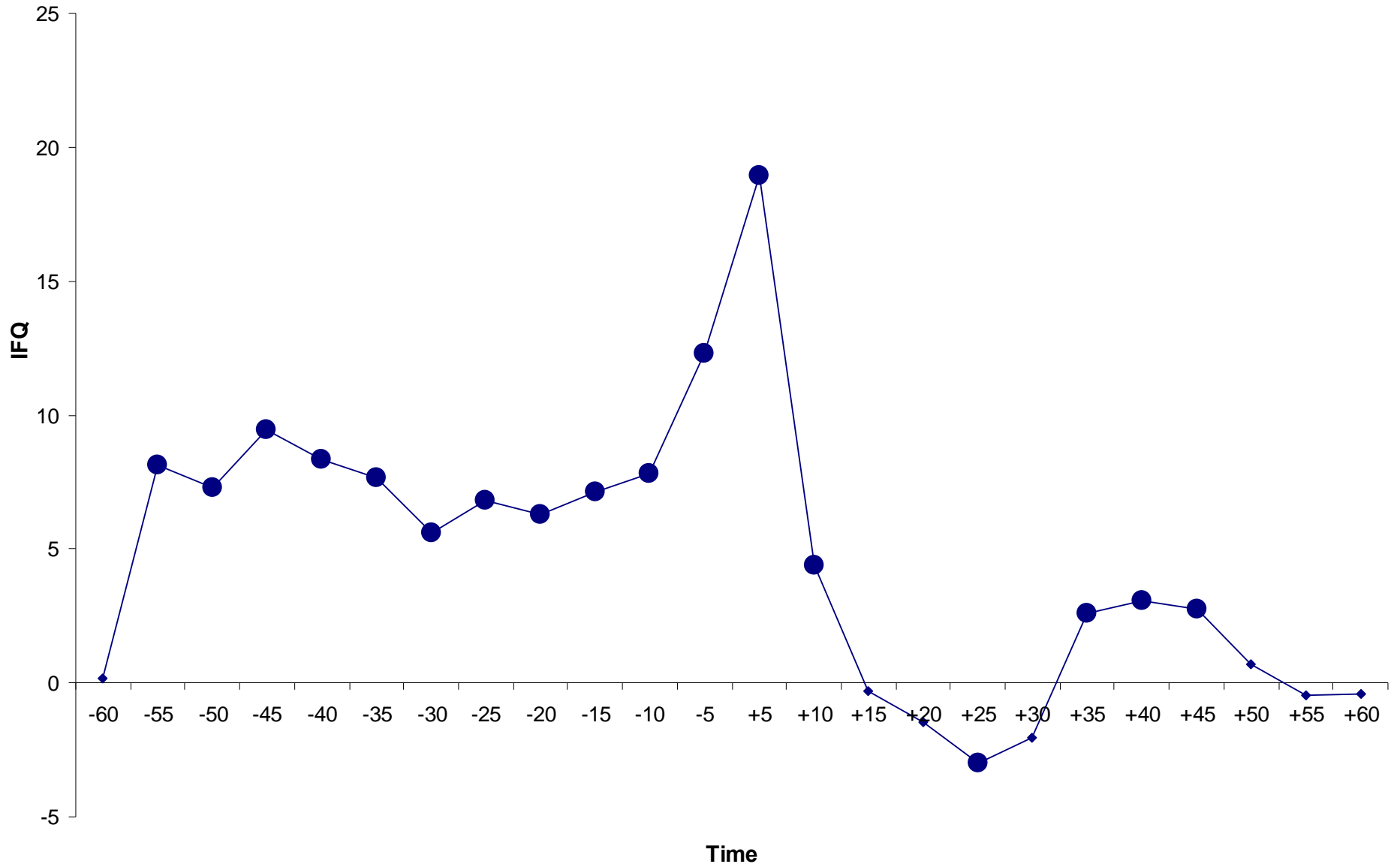
Notes: OLS estimates. Standard errors are heteroskedasticity-consistent using the White correction; t-statistics are in parentheses.

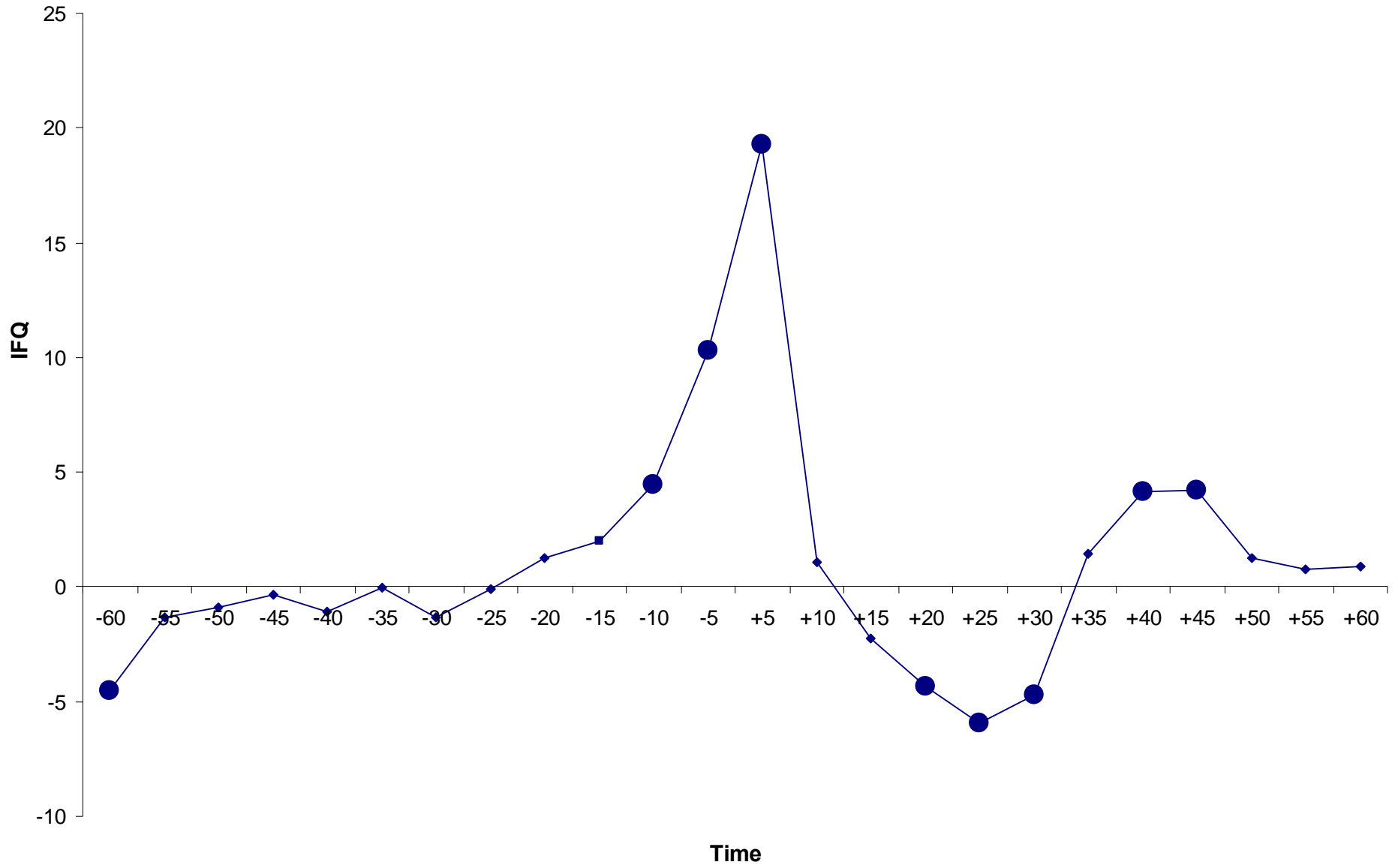
**Figure 1: Summary of Empirical Results  
(Shaded Boxes Indicate Our Empirical Findings)**

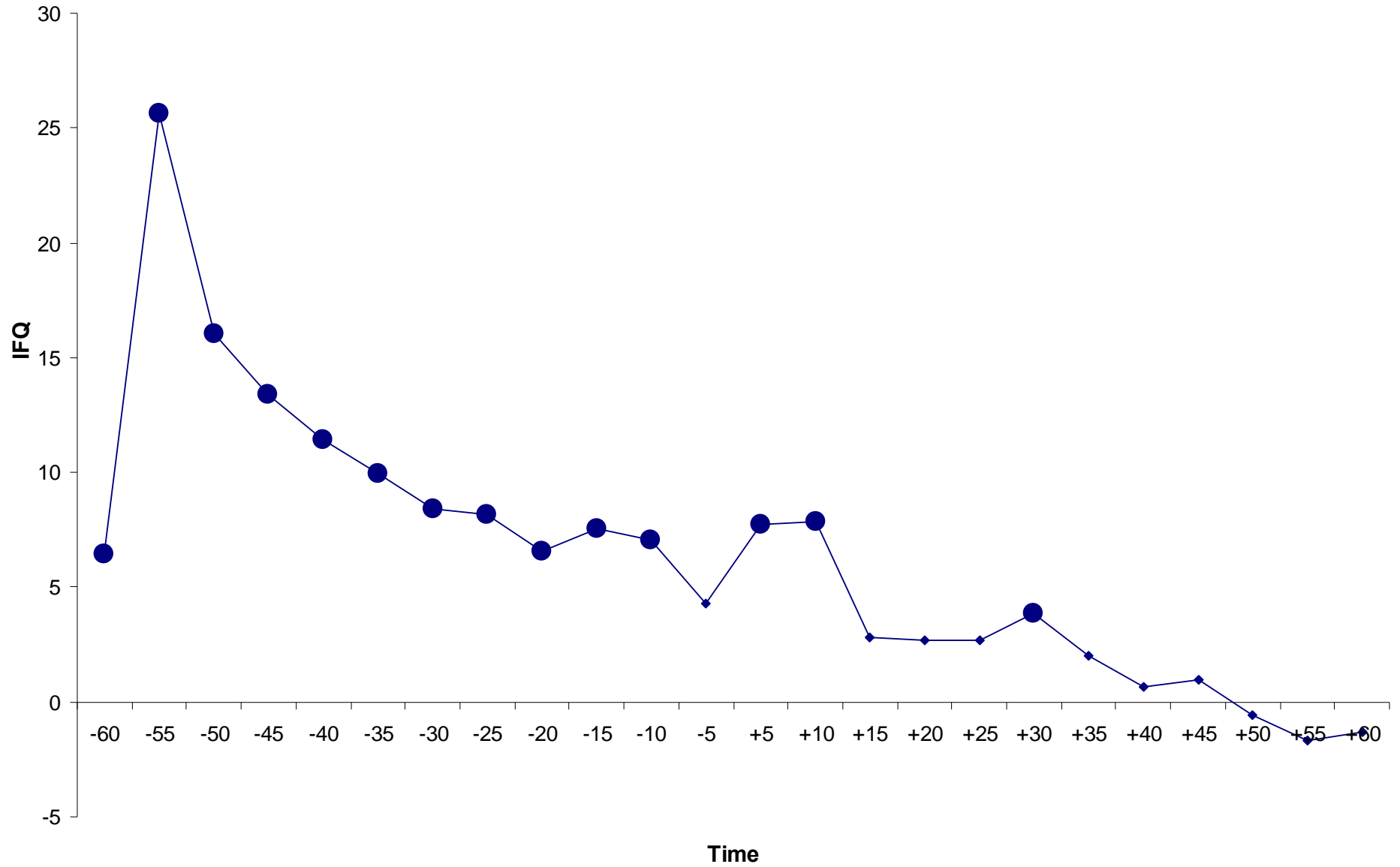


**Figure 2: IFP Point Estimates Before and After a STF's****(●'s denote significance at the 5% level)**

**Figure 3: IFQ Point Estimates Before and After a STF's**  
**(●'s denote significance at the 5% level)**



**Figure 4: IFQ Point Estimates Before and After a Speech****(●'s denote significance at the 5% level)**

**Figure 5: IFQ Point Estimates Before and After a Testimony****(●'s denote significance at the 5% level)**

**Figure 6: IFQ Point Estimates Before and After a FOMC Meeting****(●'s denote significance at the 5% level)**