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By P.C. de Goeij, W. Marquering

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TILBURG UNIVERSITY

Do Macroeconomic Announcements Cause Asymmetric Volatility?*

Peter de Goeij† Wessel Marquering‡

Abstract

In this paper we study the impact of macroeconomic news announcements on the conditional volatility of stock and bond returns. Using daily returns on the S&P 500 index, the NASDAQ index, and the 1 and 10 year U.S. Treasury bonds, some interesting results emerge. Announcement shocks appear to have a strong impact on the (dynamics of) bond and stock market volatility. Our results provide empirical evidence that asymmetric volatility in the Treasury bond market can be largely explained by these macroeconomic announcement shocks. This suggests that the asymmetric volatility found in government bond markets are likely due to misspecification of the volatility model. Because firm-specific news is the most important source of information in the stock market, the asymmetries in stock volatility do not disappear after incorporating macroeconomic announcements into the volatility model. Moreover, by distinguishing FOMC (interest rate) announcements from PPI and EMP (labor market) announcements, we find that both types of announcements are important determinants in explaining the conditional mean and dynamics in volatility.

Keywords: Multivariate GARCH, Stock and Bond Market, Time-Varying Volatility, Asymmetry, Macroeconomic Announcements.

JEL classification codes: G12, C22.

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†Department of Finance, Tilburg University, P.O.Box 90153, 5000 LE Tilburg, The Netherlands. Email: p.c.degoeij@uvt.nl

‡Department of Financial Management, F4-26, Rotterdam School of Management, Erasmus University Rotterdam, P.O.Box 1738, 3000 DR Rotterdam, The Netherlands. Email: w.marquering@fbk.eur.nl

1 Introduction

The efficient market hypothesis implies that price changes in equities and bonds reflect the arrival and processing of relevant new information. While news itself is unpredictable, in turn making changes in stock prices unpredictable, the release dates of many macroeconomic announcements are known. Often, information about macroeconomic fundamentals is released on periodic and pre-scheduled dates. Thus two types of news exist: pre-announced and non-announced news. In this paper we focus on the pre-announced news. We examine the reaction of daily stock and bond returns to the release of macroeconomic news.

While firm-specific news is the main source of information in stock markets, in Treasury bond markets macroeconomic announcements are most important. Consequently, the effects of announcements are typically more pronounced on government backed securities than on equity (see, e.g., McQueen en Roley, 1993). Changes in Treasury bond prices critically depend on the arrival of public information like inflation, interest rates, employment and fiscal and monetary policy. There appears to be little, if any, asset-specific information concerning Treasury bonds. Some recent studies examine the effects of macroeconomic news on Treasury bond volatility. Jones, Lamont and Lumsdaine (1998), for example, examine the response of Producers Price Index (PPI) and Employment (EMP) releases on Treasury bond market volatility. Their results indicate significant increases in bond market volatility on announcement days. This increase does not persist, as news is immediately incorporated in the prices.[1] In addition, Piazzesi (2000) and Bomfim (2000) show that the announcements of the Federal Open Market Committee (FOMC) are important for bond and stock market volatility respectively. In the Federal Reserve's FOMC, which is the main policymaking body in the United States[2], policy decisions are made involving the target level of the federal funds rate. Li and Engle (1998) study the effects of announcements of the consumer price index, PPI, and employment situation on the volatility of the U.S. Treasury bond futures. Using a univariate GARCH framework, they find that announcement

[1] Ederington and Lee (1993) and Flemming and Remelona (1999a), for example, find that most bond prices response within one or two minutes to major macroeconomic announcements.

[2] The policy of the FOMC is to promote economic growth, full employment, stable prices, and a sustainable pattern of international trade and payments.

shocks are not persistent, but bond market volatility responds asymmetrically to announcement shocks. In this paper we investigate the response of government bond and stock prices to regularly scheduled PPI, EMP and FOMC releases.

News impact curves show the impact of news on future volatility. There is ample empirical evidence that more accurate volatility predictions can be obtained when an asymmetric response to news is allowed for (see e.g. Engle and Ng, 1993 and Bekaert and Wu, 2000). The asymmetric volatility effect, first noted by Black (1976), refers to the tendency that good and bad news in returns have a different impact on conditional volatility in stock markets. Several explanations for this phenomenon, which is especially apparent during volatile periods, are put forward. For example, Black (1976) and Christie (1982) argue that a drop in the value of the stock increases financial leverage, which makes the stock more risky and increases its volatility: the so-called leverage effect hypothesis. Alternatively, the asymmetric response to return shocks could simply reflect the presence of time-varying risk premia (see Pindyck, 1984). If volatility is priced, an anticipated increase in volatility would result in a higher required return, which would lead to stock price decline: the "volatility feedback" effect.

Unfortunately, most empirical work has studied each of the above phenomena −announcement effects and asymmetric volatility− in isolation. This is ultimately not satisfactory. First, as announcement news is different from non-announcement news, it is an interesting question to what extent investors anticipate the announced news and to what extent volatility responds differently to these two kinds of news. Second, it might be possible that (a large part of) the asymmetric volatility can be explained by the announcement news, because investors can already anticipate before the news is released and over- or underreactions might be at stake. Third, as the model is considerably improved, it is likely that portfolio selection based on volatility forecast models with announcements effects outperform the traditional models. Additionally, risk management and derivative pricing can be ameliorated.

This paper integrates the announcement and asymmetric volatility literature. More specifically, we investigate the interaction between announcements and volatility, whether announcement news differs from non-announcement news, and to what extent asymmetric volatility is explained by macroeconomic announcements. To this end, we generalize the Asymmetric Dynamic Covariance (ADC) model (see

Kroner and Ng, 1998) in such a way that macroeconomic announcements are accounted for. We use daily data from 1982 to 2001 on the S&P 500 index, the NASDAQ Composite index, a short and a long U.S. Treasury bond. This enables us to examine the effects of macroeconomic announcements on stock and bond market volatility.

This paper differs from previous empirical investigations in the following ways. First, while many studies examine the effects of pre-announcements on volatility and the asymmetric volatility phenomenon, this paper interrelates these phenomena.[3] Second, the results of Jones, Lamont and Lumsdaine (1998) are limited in the sense that they only examine the univariate response of return to risk. The news announcements may yield insights about the shape of the term structure and about the covariance of bond returns with other assets. While Christiansen (2000) extends the approach of Jones, Lamont and Lumsdaine (1998) by studying the effects of PPI and EMP announcements on the covariance structure of Treasury bonds, she uses a restrictive constant correlation model (CCORR), introduced by Bollerslev (1990). Recent studies show that the constant correlation assumption is not valid in many cases and that this assumption should be relaxed (see, e.g., Kroner and Ng, 1998). In this paper, we adopt a more general model which nests most of the popular multivariate GARCH models. Third, whereas most announcement papers study the bond market[4], we also examine the stock market. This allows us to take a closer look at the puzzle addressed by Jones, Lamont and Lumsdaine (1998): "it remains puzzling that, in general, stock prices seem less affected by macroeconomic news than bond prices. If asset returns are driven by fundamental risk, and if (as we assume) announcement days are days of high risk, how can it be that bonds are affected more than stocks?". Fourth, this paper is the first that considers FOMC together with PPI and EMP announcements.[5] Moreover, by looking

[3] In her paper, Christiansen (2000) allows for asymmetric reactions to announcement news, but not to any other news. Li and Engle (1998) also allow for the situation in which positive and negative announcement shocks differ significantly. Their setting is a univariate GARCH model for Treasury futures. These studies do not consider asymmetries in volatility for normal, i.e. non-announcement, days, such that the question whether (the reaction of) announcements causes asymmetries can not be answered using their models.

[4] Examples of studies that examine the effects of announcements on stock market volatility are Bomfim (2000) and Flannery and Protopapadakis (2002).

[5] Jones, Lamont and Lumsdaine (1998) and Christiansen (2000), e.g., only consider the PPI and EMP announcements, whereas Piazzesi (2000) and Bomfim (2000) only include the FOMC

at them separately, we are able in this paper to distinguish FOMC (interest rate) announcements effects from PPI and EMP (labor market) announcements effects. This is interesting as financial press sometimes suggest that the NASDAQ is less influenced by changes in interest rate than the S&P 500. Fifth, whereas most studies only consider one announcement effect, we consider a *pre-announcement* and a *news effect*. Initially, there is a pre-announcement effect: investors know beforehand that there will be news, so a higher level of volatility on the day the news is released is anticipated. Next, there is a news (reaction) effect: once the news is released, investors process the newly received information (not previously incorporated into asset prices) which might raise the market volatility next day, as investors might disagree on the news consequences of the new information on asset prices (see, e.g., Varian, 1989 and Harris and Raviv, 1993). Seperating these two effects, which to our knowledge has not been done before, might result in interesting new findings.

Several interesting empirical results emerge. We find empirical evidence that announcements for a large part explain the asymmetric volatility in Treasury bond markets, but not in stock markets. We find that macroeconomic announcements raises the level of conditional stock market volatility. We also obtain some compelling results after discriminating between labor market announcements on the one hand and FOMC announcements on the other. In the stock market, for example, FOMC announcement shocks are more persistent than labor market announcements shocks. Finally, labor market announcements substantially raise the level of the mean NASDAQ return and volatility on the day of the announcement.

The remainder of this paper is organized as follows. The next section provides a brief description of the relation between news arrival and market volatility, and presents the empirical framework. We also discuss the way the forecast model deals with pre-announcements effects and feedback effects after the announcement is made. Section 3 describes the data used in the analysis and discusses some preliminary results. Moreover, we discuss the empirical results of the volatility model which is able to deal with announcements and pre-announcements effects. In Section 4, we examine whether labor market announcement have a different impact on volatility in bond and stock markets than FOMC announcements. Finally,

announcements in their models.

Section 5 concludes.

2 A Volatility Model with Announcements Effects

In a recent study, Bekaert and Wu (2000) examine asymmetric volatility in the Japanese equity market. Using a multivariate GARCH-in-mean model, they conclude that volatility feedback is the dominant cause of the asymmetry for the Japanese stock market. In addition, Wu (2001) develops a model that can separate the leverage and volatility feedback effect from each other. Using monthly and weekly S&P 500 returns, Wu concludes that the leverage effect is an important source of asymmetric volatility, but that volatility feedback is stronger than previously documented (see Campbell and Hentschel, 1992). The models constructed by Campbell and Hentschel (1992) and Wu (2001) provide a good understanding of the volatility feedback hypothesis. However, these models are based on modeling the dividend process of equity returns. Campbell and Hentschel (1992), for example, use "news about dividends" and "news about volatility", as factors in their model. Wu (2001) improves the model of Campbell and Hentschel by defining dividend volatility as a separate factor. Treasury bonds have coupon payments and although these coupon payments can be considered as some kind of dividends, they are fixed in size. Therefore they do not provide any news to investors, as stipulated in Campbell and Hentschel (1992) and Wu (2001). It is interesting to investigate to what extent macroeconomic announcements can explain asymmetric volatility, as these are reported to be the most important source of information in Treasury bond markets.

Following Kroner and Ng (1998), we use a VAR process to model excess returns. To prevent that we find asymmetric effects in variances and covariances due to misspecification in the mean, we include extra terms which capture possible asymmetries in first moments as well as a dummy variable which captures the effects of announcements. The resulting mean equation can be written as:[6]

$$r_{i,t}^{e} = \mu_i + \gamma_i I_t^a + \sum_{j=1}^{N}\sum_{\tau=1}^{L}\left[\alpha_{ij\tau} r_{j,t-\tau}^{e} + \beta_{ij\tau} r_{j,t-\tau}^{e-}\right] + \varepsilon_{i,t}, \qquad \text{for } i = 1, ..., N, \tag{1}$$

where

$r_{i,t}^{e}$ denotes the excess return on asset i in period t,

$r_{i,t}^{e-} = \min(0, r_{i,t}^{e})$, the *negative* excess return on asset i in period t,

$I_t^a = 1$, if there is pre-announced macroeconomic news at time t and 0 otherwise,

$\varepsilon_{i,t}$ denotes the unexpected excess return on asset i,

N denotes the number of assets and L the number of lags.

We assume that $\varepsilon_t|\mathcal{I}_{t-1} \sim N(0, H_t)$, where $\mathcal{I}_{t-1}$ denotes the information set at time $t-1$, and $H_t = [h_{ij,t}]$ is the $N \times N$ conditional covariance matrix of the unexpected excess returns; μ_i, γ_i, $\alpha_{j\tau}$ and $\beta_{j\tau}$ $i, j = 1, ..., N$ are parameters. The timing of macroeconomic news releases is known by the economic agents. We use a dummy variable equal to one on the day that the news is announced. We expect γ_i to be larger than zero, as news arrivals are often associated with higher risk. Thus, γ_i could be interpreted as a premium for bearing the news arrival risk.

To model the conditional covariance matrix we use the ADC specification of Kroner and Ng (1998).[7] This specification has two appealing features. First, it permits a certain level of asymmetry in both the conditional variance and the conditional covariance. Second, it is very general in the sense that it nests several well-known time-varying multivariate GARCH models (see Kroner and Ng, 1998).

The ADC specification implies the following conditional covariance matrix H_t:

$$H_t = D_t R D_t + \Phi \odot \Theta_t, \tag{2}$$

[6] The inclusion of conditional variances and covariances (i.e. GARCH-in-mean terms) in equation (1) leads to very similar results. Moreover, as tests showed that the in-mean terms are not statistically different from zero, we decided to follow Kroner and Ng's (1998) mean specification.

[7] A disadvantage of the ADC model is the large number of parameters. Recently, Engle (2002) proposed to use the dynamic conditional correlation (DCC) model which is much more parsimonious. Applying the DCC model led to some similar results, but unfortunately several effects cannot be examined using this parsimonious model. One drawback of the DCC model is that it cannot fully examine whether asymmetries disappear after including announcement effects, as the DCC estimates the variances and correlations in separate steps. Another drawback of the DCC is that there is only very limited room for interdependencies between the assets shocks and variances. The DCC works well compared to simple multivariate GARCH models (see Engle, 2002), but is less suitable for more complex specifications.

where $\odot$ denotes the element-by-element matrix multiplicator (the Hadamard product operator) and D_t, R, Φ and Θ_t are all $N \times N$ matrices. First, the diagonal matrix D_t is defined as

$$D_t = [d_{ij,t}],\ d_{ii,t} = \sqrt{\theta_{ii,t}} \text{ for all } i,\ d_{ij,t} = 0 \text{ for all } i \neq j, \tag{3}$$

where the elements $\theta_{ii,t}$ are defined in equation (6) below. Second, R is a symmetric matrix with ones on the diagonal and off-diagonal parameters ρ_{ij}:

$$R = [\rho_{ij}],\ \ \rho_{ii} = 1 \text{ for all } i,\ \rho_{ij} \ \neq 0 \text{ for all } i \neq j. \tag{4}$$

Third, Φ is a symmetric matrix with zeros on the diagonal:

$$\Phi = [\phi_{ij}],\ \ \phi_{ii} = 0 \text{ for all } i,\ \phi_{ij} \neq 0 \text{ for all } i \neq j, \tag{5}$$

where off-diagonal elements ϕ_{ij} are parameters. Finally, Θ_t is a symmetric matrix with elements $\theta_{ij,t}$.

$$\Theta_t = [\theta_{ij,t}].$$

The elements $\theta_{ij,t}$ are calculated as

$$\theta_{ij,t} = \omega_{ij} + \omega_{ij}^a I_t^a + b_i^{'} H_{t-1} b_j + a_i^{*'} \varepsilon_{t-1} \varepsilon_{t-1}^{'} a_j^* + g_i^{*'} \varepsilon_{t-1}^{-} \varepsilon_{t-1}^{-\ '} g_j^* \text{ for all } i, j, \tag{6}$$

where b_i, $a_i^* = a_i + a_i^a I_{t-1}^a$, $g_i^* = g_i + g_i^a I_{t-1}^a$, $i = 1, ..., N$ are $N \times 1$ vectors, $\omega_{ij}, \omega_{ij}^a$ are scalars and ε_t^- is an $N \times 1$ vector with elements $\varepsilon_{i,t}^- = \min[0, \varepsilon_{i,t}]$. The ADC model of Kroner and Ng (1998) is obtained by imposing the restrictions $\omega_{ij}^a = 0$, $a_i^a = 0$ and $g_i^a = 0$ for all i, j. The additional advantage of using this specification is that the predicted covariance matrices are positive definite by construction.

Whereas the timing of macroeconomic news is exogenous to financial markets (as it is pre-announced), the content of the news is not. Equation (6) incorporates two announcements effects: a pre-announcement and a news effect. The model predicts that on announcement days, the level of conditional volatility differs from non-announcement days, which is measured by ω_{ij}^a. Because important news might be released on these days, we expect that conditional volatility will be higher on announcement days. Next, once the news is released, investors start processing this news. The parameter vectors a_i^a and g_i^a predict the impact of news on the conditional volatility of the day after an announcement day. Varian (1989) and

Harris and Raviv (1993) show that because of differences in opinions in the market, it might take some time before the calm returns (a_i^a). Finally, we allow for the possibility that negative announcement news is more persistent than negative news ($g_i^a \neq 0$).

3 Empirical Results

Although the model for the conditional covariance structure is very general and attractive, the number of parameters becomes very large when the number of assets increases. For example, the number of parameters is 27 (excluding the mean-equation parameters) when two assets are considered, while the number of parameters becomes 60 for three assets. In addition, it is an interesting question to find out whether the impact of macroeconomic announcements differ in stock and bond markets. Therefore, we will consider only two assets at a time. The bond market volatility model will consider the 1 and 10 year Treasury bonds, whereas the stock market volatility model considers the S&P 500 and the NASDAQ index.

3.1 Estimation Methodology

We estimate mean equation (1) using OLS. Next, we estimate the parameters of the conditional covariance model using the quasi maximum likelihood (QML) method (see Bollerslev and Wooldridge, 1992), treating the vector of residuals e_t as observable data. The loglikelihood function (for the sample $1, ..., T$) is given by

$$\mathcal{L}(\tilde{\theta}) = -\frac{1}{2}TN\log 2\pi - \frac{1}{2}\sum_{t=1}^{T}\log(\det H_t(\tilde{\theta})) - \frac{1}{2}\sum_{t=1}^{T}e_t^{'}H_t^{-1}(\tilde{\theta})e_t,$$

where $\tilde{\theta}$ denotes the vector of unknown parameters. For inference, we use robust Bollerslev and Wooldridge (1992) standard errors. The Newton-Raphson gradient search algorithm is used to obtain the estimates.

3.2 Data and Preliminary Analysis

To examine the effects of macroeconomic announcements in stock and bond markets, we use daily excess returns on the S&P 500 index, the excess return on the NASDAQ Composite index and daily excess returns on the 1 and 10 year U.S.

Treasury bond. The S&P 500 data were provided by Datastream, while the data of the NASDAQ Composite index were provided by the National Association of Securities Dealers Inc. The bond market data were obtained from the federal reserve bank in Chicago. We follow the same approach as in Jones, Lamont and Lumsdaine (1998) to construct the data. The excess returns were calculated as the return of holding the bond in excess of the risk-free spot rate, approximated by the 3-month Treasury bill rate. We adjust for weekends and holidays in the daily returns calculations (Appendix A provides details on the calculations). The data cover the period January 4, 1982 through August 31, 2001, providing a total of 4908 observations. For illustrative purposes, the properties of the daily excess returns on the 1 and 10 year bonds and the S&P 500 and NASDAQ index are presented in Figure 1. The graphs suggest that a model including heteroskedasticity is required to describe the evolution of the excess returns as there are signs of volatility clustering. The magnitude of daily excess returns is sometimes quite large, with returns for the 10 year bond as high as 4.8% (on October 20, 1987, one day after the crash) and as low as -2.7% (on April 4, 1994). Neither of these two dates is an announcement date. The magnitude of the daily S&P 500 returns varies between -20.5% (October 19, 1987) and 9.1% (October 21, 1987). Some preliminary results (not reported) show that all assets exhibit significant asymmetries when assuming a univariate GARCH model without announcement effects.

We consider three different macroeconomic announcements: producers price index (PPI), employment (EMP) and Federal Open Market Committee (FOMC) announcements. These are reported to be among the most influential announcements both in the academic literature and in the press. Bureau of Labor Statistics' PPI and EMP figures are published monthly, while Federal Reserve's FOMC meetings are scheduled eight times a year. In the sample period, the number of PPI, EMP and FOMC announcements are 229, 229 and 157 respectively. Some of these announcements coincide with each other, resulting in a total of 610 announcement days. The announcements of the Bureau of Labor Statistics are usually made before the stock market opens, specifically at 9.00 A.M. before March 1982 and at 8.30 A.M. from April 1982 to the present, whereas the FOMC announcements are made public after the meetings in the afternoon. Most changes in the target of the federal funds rate have been either 25 or 50 basis points (the 75 basis-point

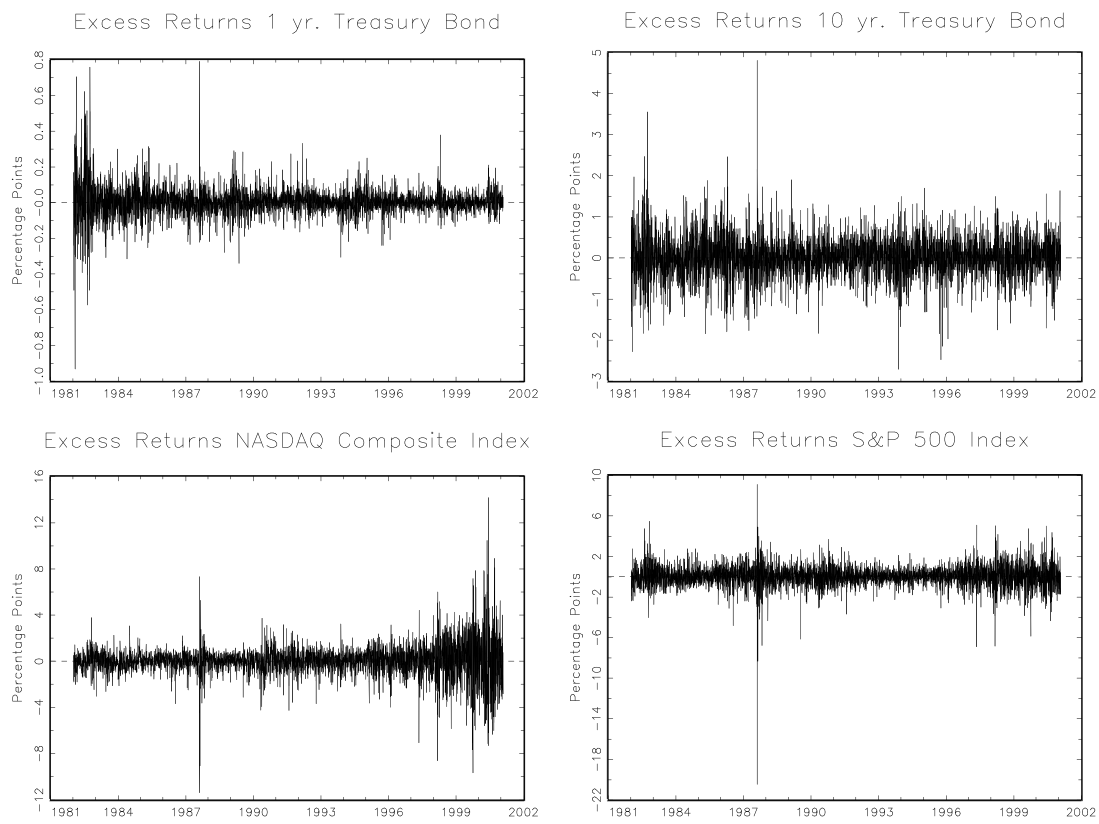


Figure 1: **Daily Excess Returns on 1 and 10 Year Treasury Bonds, NASDAQ Composite and S&P 500 Indices**

increase on November 15, 1994 is a notable exception). The Federal Reserve typically announces rate decisions at their regularly scheduled meetings. However, they may announce rate cuts between meetings if they believe they need to act quickly. This occurred recently in April 2001, and in September 2001 after the terrorist attack on the Pentagon and the World Trade Center.[8]

Table 1 presents summary statistics for daily excess returns. Panel A through C provide statistics for the full sample as well as only on announcement and non-announcement days. From the table it is evident that the average excess returns on all assets are greater on announcement days. The differences in the mean on announcement and non-announcement days are remarkable. For example, the mean return on the S&P 500 index is 0.12% on announcement days, while on

[8]Note that the latter event is not in our sample.

Table 1: **Summary Statistics for Stock and Bond Excess Returns, Panel A-C**

	S&P 500	NASDAQ	1 yr bond	10 yr bond
Panel A: Full sample (4898 obs.)				
Mean	0.0388	0.0296	0.0040	0.0202
Std. Dev.	1.0397	1.3068	0.0746	0.4749
Minimum	−20.4598	−11.4052	−0.9306	−2.7149
Maximum	9.0979	14.1576	0.7905	4.8037
	Covariances and **Correlations**			
S&P 500	1.0808	0.9932	0.0120	0.1265
NASDAQ	**0.7311**	1.7072	0.0036	0.0476
1 yr bond	**0.1543**	**0.0365**	0.0056	0.0265
10 yr bond	**0.2562**	**0.0768**	**0.7476**	0.2255
Panel B: PPI, EMP and FOMC announcement days (610 obs.)				
Mean	0.1157	0.1744	0.0132	0.0712
Std. Dev.	1.1224	1.3073	0.0928	0.5862
Minimum	−6.7724	−6.2154	−0.3396	−2.4781
Maximum	4.7527	7.8567	0.4861	2.4556
	Covariances and **Correlations**			
S&P 500	1.2576	1.1455	0.0244	0.2377
NASDAQ	**0.7820**	1.7062	0.0114	0.1381
1 yr bond	**0.2348**	**0.0940**	0.0086	0.0438
10 yr bond	**0.3618**	**0.1805**	**0.8064**	0.3431
Panel C: Non-announcement days (4288 obs.)				
Mean	0.0278	0.0091	0.0027	0.0129
Std. Dev.	1.0271	1.3055	0.0715	0.4565
Minimum	−20.4598	−11.4052	−0.9306	−2.7149
Maximum	9.0979	14.1576	0.7905	4.8037
	Covariances and **Correlations**			
S&P 500	1.0547	0.9697	0.0101	0.1100
NASDAQ	**0.7233**	1.7040	0.0022	0.0336
1 yr bond	**0.1372**	**0.0239**	0.0051	0.0239
10 yr bond	**0.2347**	**0.0564**	**0.7332**	0.2084

Notes: Summary statistics for the excess return on the S&P 500 index, the NASDAQ Composite index, the 1 year Treasury bond and the 10 year Treasury bond for the period January 4, 1982 - August 31, 2001. All returns are daily returns in percentages (see Appendix A). Bold numbers are correlation coefficients.

Table 1: **Summary Statistics for Stock and Bond Excess Returns, Panel D-E**

	S&P 500	NASDAQ	1 yr bond	10 yr bond
Panel D: 1 day BEFORE announcement days (610 obs.)				
Mean	0.0115	0.0293	0.0023	0.0295
Std. Dev.	0.9297	1.2692	0.0834	0.4539
Minimum	−4.8109	−7.0741	−0.9306	−2.2806
Maximum	4.3624	8.9099	0.7596	3.5464
	Covariances and **Correlations**			
S&P 500	0.8628	0.8724	0.0110	0.1285
NASDAQ	**0.7406**	1.6081	0.0055	0.0911
1 yr bond	**0.1419**	**0.0522**	0.0069	0.0290
10 yr bond	**0.3050**	**0.1583**	**0.7664**	0.2057
Panel E: 1 day AFTER announcement days (610 obs.)				
Mean	0.0314	−0.0524	0.0028	0.0150
Std. Dev.	1.3089	1.4088	0.0729	0.4579
Minimum	−20.4598	−11.4052	−0.3256	−1.9748
Maximum	5.0490	5.9681	0.5090	1.8600
	Covariances and **Correlations**			
S&P 500	1.7104	1.4350	−0.0009	0.0932
NASDAQ	**0.7795**	1.9814	−0.0037	0.0417
1 yr bond	**−0.0095**	**−0.0361**	0.0053	0.0243
10 yr bond	**0.1558**	**0.0647**	**0.7293**	0.2093

Notes: Summary statistics for the excess return on the S&P 500 index, the NASDAQ Composite index, the 1 year Treasury bond and the 10 year Treasury bond for the period January 4, 1982 - August 31, 2001. All returns are daily returns in percentages (see Appendix A). Bold numbers are correlation coefficients.

Table 2: **Covariance Matrix Test**

	test-statistic	*df*	*p*-value
1 yr, 10 yr bond	44.21	3	0.000
1 yr bond, S&P 500	38.31	3	0.000
10 yr bond, S&P500	35.08	3	0.000
1 yr bond, NASDAQ	36.04	3	0.000
10 yr bond, NASDAQ	35.51	3	0.000
S&P500, NASDAQ	7.71	3	0.052

Notes: This table reports the results of tests on differences in the unconditional covariance matrices. The test statistic follows a χ^2_{df}-distribution, where *df* denotes the degrees of freedom.

non-announcement days it is only about 0.03%. This difference about 23% on an annual basis. For the 10 year bond we find an annual difference of about 15%. It is also clear that (co)variances are higher on announcement days, which indicates that there is a higher associated risk on announcement days. However, the difference between the standard deviation of the NASDAQ returns on announcement and non-announcement days is quite small. Overall, the summary statistics of the bond returns are in line with the findings of Jones, Lamont and Lumsdaine (1998) and Christiansen (2000). Like Christiansen (2000) we find that unconditional correlations on announcement days are higher than on non-announcement days. This indicates that the advantage of diversification is less pronounced when the investor needs it most: at times when risk is high. In addition, the correlations between the bond returns and the NASDAQ index are close to zero on announcement and non-announcement days. This suggests that, even on announcement days, portfolio risk can be reduced by diversifying between stocks and bonds. As the variances and covariances on announcement days are greater than those on non-announcement days, we conduct a joint test for the null hypotheses that the covariance matrixes are identical in the two subsamples, cf. Basilevsky (1994, pp. 194-198). The resulting test statistics (see Table 2) show that covariances differ significantly on announcement and non-announcement days. Only the difference for the covariance between the S&P500 and NASDAQ only marginally significant. Thus, we conclude that the covariance matrix for announcement days differs from the one for non-announcement days.

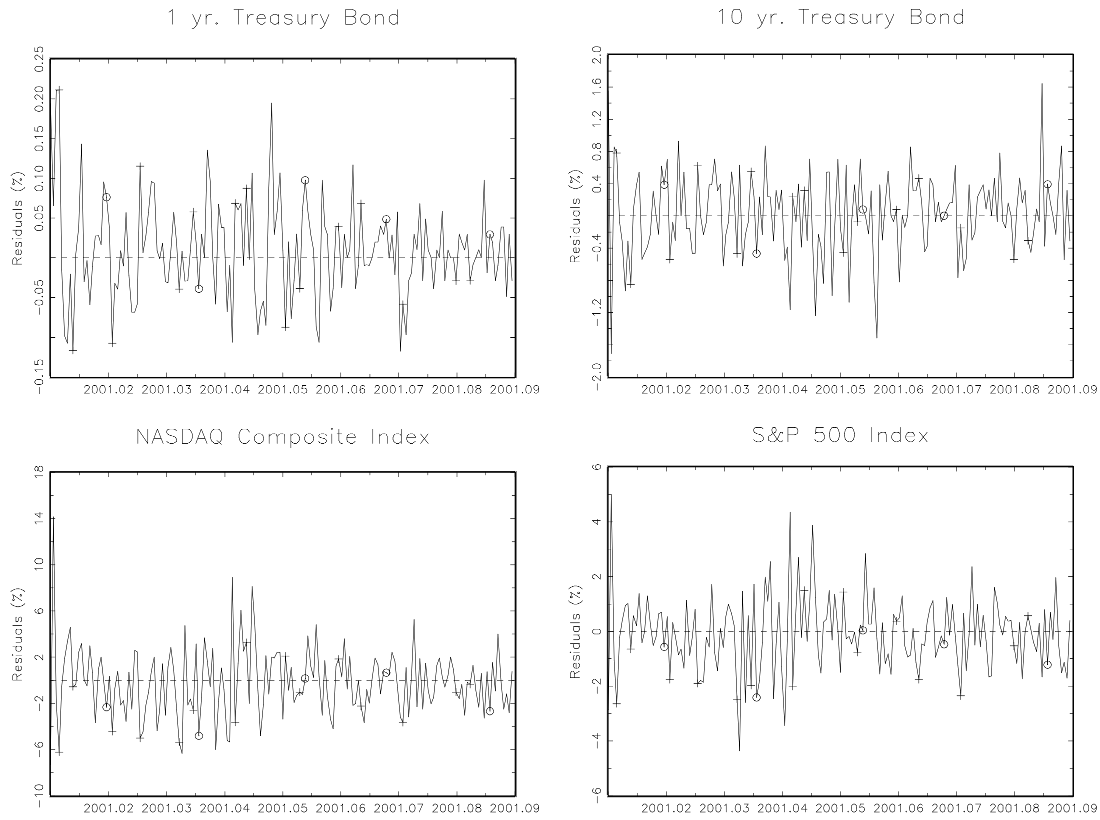
Finally, as reports that financial markets are particularly quiet on the days prior to macroeconomic announcements are commonplace in the financial press, we consider the standard deviations on the day before an announcement. Several studies (e.g. Jones, Lamont and Lumsdaine, 1998) find support of this "calm before the storm" effect for bond returns. To obtain some indication of possible persistence in the announcement shocks, we also consider the returns on the day after an announcement. The results are reported in Panel D and E of Table 1. The standard deviation is in general lower on days preceding macroeconomic announcements. However, the standard deviations are not much lower than the standard deviations on non-announcement days. Thus we find only moderate support for the "calm before the storm" effect. If the shocks to volatility on announcement days generate persistent volatility, we would expect that the day after an announcement day would have higher than average volatility. The literature shows (see, e.g., Jones, Lamont and Lumsdaine, 1998) that announcement shocks in the bond markets do typically not persist. The results in Panel E indicate that the shocks to volatility on announcement days generate persistent volatility in the stock market, but not in the bond market. The standard deviation of the S&P 500 one day after the announcement is especially high. In the next sections we will consider the persistency of announcement shocks in more detail.

Let us first consider the effects of announcements in conditional stock and bond market returns and the relation between announcements and unexpected returns to obtain an idea of the importance of the announcement effects. Table 3 presents the OLS estimation results for the announcement dummy parameter in mean equation (1). Because Table 1 shows that excess returns are higher on announcement days, we expect a positive sign on the estimate of the announcement dummy parameter.

Table 3: **Estimation Results of Mean Equation**

	Stock Market		*Bond Market*	
	NASDAQ	S&P 500	1 yr bond	10 yr bond
I_t^a	0.1763*	0.0993*	0.0110*	0.0601*
std. error	0.0567	0.0487	0.0039	0.0245

Notes: The table shows estimation results of equation (1) for the stock and bond market separately. The estimates of the constants, 10 lags of excess returns and 10 lags of negative excess returns are not reported. White (1980) standard errors are presented. "*" indicates that the corresponding coefficient is statistically significant at the 5% level.



Notes: Each panel shows the residuals from the mean equation (1) in daily percentage points for each asset, from January 2001 until September 2001. The plus signs indicate PPI and EMP announcement days, while the circles indicate FOMC announcement days.

Figure 2: **Residuals of the Mean Equation**

Looking at the results in Table 3, we see that the model predicts that on announcement days the excess returns are significantly higher than on non-announcement days. The estimated coefficient corresponding to the announcement dummy can be interpreted as the estimates for the announcement risk premia. If market prices fully reflect all information, then this pre-announced news would not be news at all. The announcement effects on the level of the conditional means of bond returns are very similar to those usually found in the literature (see, e.g., Jones, Lamont and Lumsdaine, 1998). Before discussing the results of estimating the covariance model, it is of interest to see whether there is a relation between the unexpected excess returns (the residuals from the mean equation) and the announcement days. Figure 2 shows that there is a distinct effect of announcements on the unexpected returns. Most extreme residuals are associated with announcements.

3.3 Estimation Results

This section presents the results of estimating the conditional volatility in the U.S. Treasury bond and stock market. Because we only consider two assets (or asset classes) at the time, say 1 and 2, the ADC model can be written in a more comprehensible way. Equations (2) - (6) simplify to:

$$\begin{aligned} h_{11,t} &= \theta_{11,t} \\ h_{22,t} &= \theta_{22,t} \\ h_{12,t} &= \rho_{12}\sqrt{\theta_{11,t}}\sqrt{\theta_{22,t}} + \quad {}_{12}\theta_{12,t} \qquad (7) \\ \theta_{ij,t} &= \omega_{ij} + \omega_{ij}^{a} I_t^a + b_i^{'} H_{t-1} b_j + a_i^{*'} \varepsilon_{t-1}\varepsilon_{t-1}^{'} a_j^{*} + g_i^{*'} \varepsilon_{t-1}^{-}\varepsilon_{t-1}^{-}{}^{'} g_j^{*} \text{ for all } i,j = 1,2, \end{aligned}$$

where b_i, $a_i^* = a_i + a_i^a I_{t-1}^a$, $g_i^* = g_i + g_i^a I_{t-1}^a$, $i = 1,2$ are 2×1 vectors, $\omega_{ij}, \omega_{ij}^a$ are scalars and ε_t^- is a 2×1 vector with elements $\varepsilon_{i,t}^- = \min[0, \varepsilon_{i,t}]$. Remember that I_t^a is one if there is pre-announced macroeconomic news at time t and zero otherwise.

3.3.1 Dynamic Volatility in Bond Markets: 1 and 10 Year Treasury Bond

In this subsection, we consider the conditional volatility in the government bond market. More specifically, we study the interaction between 1 and 10 year Treasury bonds. In order to forecast the impact of announcements on the conditional bond market volatility, we estimate the ADC specification with and without announcement effects. The results are presented in Table 4. Let us briefly comment on the results. The time-series behavior of the conditional covariance between bond returns is partly determined by the time-series behavior of the conditional variances, but is mainly determined by the time-varying covariance.[9] The estimates of the lagged volatility parameters b_{11} and b_{22} are around 0.96 and highly statistically significant. This implies a high volatility clustering.

[9] More technically, the parameter ρ_{12} indicates to what extent the covariance between two assets is related to the asset's individual variances: θ_{11} and θ_{22}, while ϕ_{12} indicates to what extent this can be attributed to θ_{12}. The estimated coefficients for ρ_{12} differ significantly from zero at the 5 percent level for the specifications with announcements. The estimated coefficients for ϕ_{12} are rather close to one and significantly different from zero.

Table 4: **Estimation Results: Conditional Covariance Between the 1 and 10 Year Treasury Bond**

	ADC Model		ADC Model with Ann.	
	Estimate	Std. Err.	Estimate	Std. Err.
ρ_{12}	0.0358	0.0240	0.1256*	0.0644
ϕ_{12}	0.9594*	0.0277	0.8572*	0.0760
$w_{11}(\times 1000)$	0.0267*	0.0119	−0.0005	0.0190
$w_{12}(\times 1000)$	0.1860	0.1051	0.0646	0.1680
$w_{22}(\times 1000)$	4.1569*	1.0719	3.7183*	1.5450
$w_{11}^a(\times 1000)$	.	.	0.4399*	0.1676
$w_{12}^a(\times 1000)$	.	.	1.1585	1.0103
$w_{22}^a(\times 1000)$	.	.	8.7452	8.8011
b_{11}	0.9568*	0.0086	0.9574*	0.0095
b_{12}	0.0018	0.0011	−0.0003	0.0014
b_{22}	0.9668*	0.0050	0.9602*	0.0059
a_{11}	0.3035*	0.0364	0.3318*	0.0385
a_{21}	0.2203	0.1653	0.2027	0.1981
a_{12}	−0.0112*	0.0036	−0.0058	0.0046
a_{22}	0.1785*	0.0276	0.2349*	0.0275
a_{11}^a	.	.	−0.1810*	0.0624
a_{21}^a	.	.	−1.1613*	0.4538
a_{12}^a	.	.	−0.0039	0.0070
a_{22}^a	.	.	−0.0435	0.0609
g_{11}	−0.1118	0.1109	−0.1251	0.1596
g_{21}	−0.7946*	0.3657	−0.2829	0.7693
g_{12}	0.0111	0.0111	0.0204	0.0106
g_{22}	0.1623*	0.0517	−0.0182	0.1120
g_{11}^a	.	.	−0.0609	0.1907
g_{21}^a	.	.	0.1276	0.8941
g_{12}^a	.	.	−0.0083	0.0138
g_{22}^a	.	.	−0.0664	0.1399
Log Likelihood	6,117.28		6,171.30	

Notes: Index 1 refers to the 1 year Treasury Bond, whereas index 2 refers to the 10 year Treasury Bond. There are 4,898 observations used in the estimation. Standard errors are robust Bollerslev-Wooldridge (1992) standard errors. "*" indicates that the corresponding coefficient is statistically significant at the 5% level.

Looking at the effects of macroeconomic announcements, we see that the level of conditional volatility is higher on announcement days than on non-announcement days (the estimates for the w^a-parameters are positive). Note that only the estimate for w^a_{11} is statistically different from zero at the 5 percent level. This is in accordance with Jones, Lamont and Lumsdaine (1998), Fleming and Remolona (1999b) and Christiansen (2000) who find that the reaction to macroeconomic announcements is strongest for the 2-year bond and, subsequently, declining for longer maturities. A joint test revealed that the w^a-parameters are jointly significant at the 1 percent level. Next, we look at the effects of announcements when the magnitude of the announcement is known: the so-called news effect. It is of interest whether the persistency of announcement shocks differs from regular shocks. The estimates for a^a_{11} and a^a_{21}, the parameters that measure whether the degree of persistency of announcement shocks differ from non-announcement shocks, are significantly different from zero at the 5 percent level. Moreover, a joint test (not presented here) revealed that the a^a_{ij}-parameters, for $i, j = 1, 2$, are jointly significant at conventional significance levels. This indicates that the persistency of announcement shocks is different from regular shocks. It is more complicated to see whether the persistency is lower or higher. This is due to the non-linear nature of the covariance model, which makes the estimates more difficult to interpret. We can however determine the impact by looking at the difference between the effect on announcement and non-announcement days for identical shocks, such that regular shocks have an impact on the variance of asset 1 of $a^2_{11}+2a_{11}a_{12}+a^2_{12} = (a_{11}+a_{12})^2$ on a non-announcement day and $(a_{11} + a^a_{11} + a_{12} + a^a_{12})^2$ on an announcement day. From the results in Table 4, we obtain for the 1 year bond that the estimated impact on announcement days is $(0.3318-0.1810-0.0058-0.0039)^2 = 0.0199$, whereas the corresponding impact on non-announcement days is $(0.3318 - 0.0058)^2 = 0.1062$, such that announcements shocks on 1 year bonds are less persistent than regular shocks. The fact that announcement shocks do not tend to persist suggests that announcement shocks do not cause the high degree of persistency observed in the government bond market. Furthermore, our findings suggest that the bond market learns the implications of macroeconomic announcements quicker than other information. On the other hand, the announcement shocks seem to result in a higher than average persistency for 10 year bonds. This is mainly caused by the high spill-over effect of shocks in the 1 year bond returns. This is a novel result, and could not be found using other volatility models that do not allow for a general volatility specification including spill-over effects.

Looking at the differences between positive and negative announcement shocks, we see that the estimates for the asymmetric announcement effects are not individually significantly different from zero. Formal testing shows that the g_{ij}^a-parameters for $i, j = 1, 2$, were not jointly significant from zero at the 5% significance level. While Li and Engle (1998) and Christiansen (2000) find that persistence is significantly stronger after bad news is released than after good news, we do not find this. Thus negative announcement shocks do not have a significantly larger impact on the subsequent bond market volatility than positive announcement shocks. More importantly, after including announcement dummies, none of the estimated coefficients of the asymmetry parameter-vectors g and g^a is individually significant anymore. This confirms our hypothesis that announcement effects are for a large part responsible for asymmetric volatility in Treasury bond markets.

Because the obtained estimated coefficients are not easily interpreted, it is often more helpful to consider plots in which the reactions to return shocks are presented. To visualize the reactions to bond market shocks, let us pay attention to the news impact surfaces in Figures 3 - 5. These are bivariate generalizations of Engle and Ng's (1993) news impact curves. Figure 3 shows that the surfaces of the conditional variance of the 1 year Treasury bond return are quite symmetric. Consistent with term structure modeling results, we find that shocks in the 10 year bond returns do not influence the conditional variances of the 1 year bond. However, shocks in the 1 year bond return do influence the conditional variance of the 10 year bond return (see Figure 4). Note that, by construction, the second and third plot only differ by a constant level. Thus, the shapes are exactly the same. The only notable asymmetry arises in the last plot. The steepness of the conditional covariance a day after the announcement, i.e. when the magnitude of the announcement is known, is less than the ones on other days. This reflects the lower than average persistency of announcement shocks. Moreover, the conditional covariance is asymmetric with respect to 1 year bond shocks. That indicates that if news turns out to be worse than expected, the volatility becomes relatively high, while if the news is better than expected the variance of the 1 year bonds remains

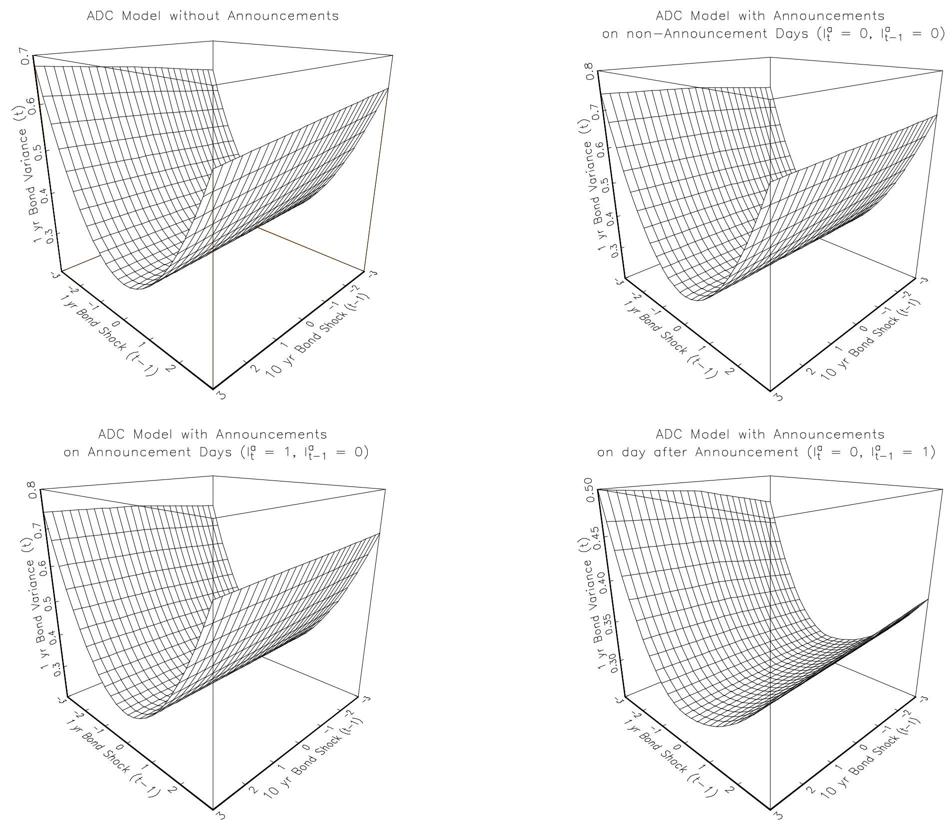


Figure 3: **News Impact Surfaces for the Conditional Variance of 1 Year Treasury Bond Returns With and Without Macroeconomic Announcement Effects**

moderate. We refer to this effect as the news effect.

Figure 4 shows news impact surfaces of the conditional 10 year bond variance. We clearly see in the first plot that a return shock in the 1 year bond and the 10 year bond in the same direction (both positive or negative), and of the same magnitude, do not have an identical impact on the conditional variance. Negative 1 year bond shocks are followed by much higher variances than positive 1 year bond shocks. The other three plots are roughly symmetric. This means that only the model without macroeconomic announcements exhibits asymmetries in volatility. Once asymmetries are introduced, the news impact surfaces become symmetric. Note that the higher than average persistency of announcement shocks (cf. Table 4) is reflected in the relatively high steepness of the conditional covariance a day after the announcement.

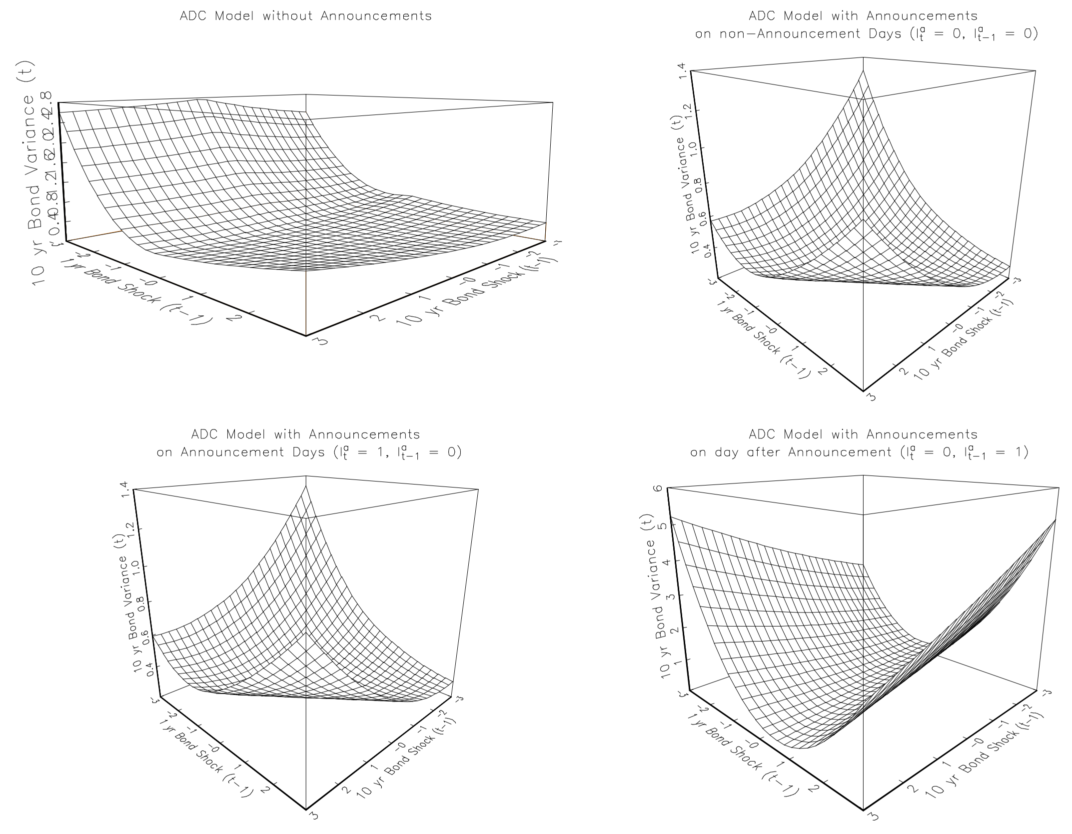


Figure 4: **News Impact Surfaces for the Conditional Variance of 10 Year Treasury Bond Returns With and Without Macroeconomic Announcement Effects**

Finally, Figure 5 presents the news impact surfaces for the conditional covariance between bond returns. The first plot shows that the conditional covariance is asymmetric for the model without macroeconomic announcements. Negative shocks in the short bond returns especially result in high conditional covariance. After introducing announcement effects into the volatility model, the news impact surfaces of the conditional covariance are much more symmetric. The decomposition of the shocks in announcements, non-announcements and news effects leads to more symmetric news impact curves. Finally, note that the steepness of the conditional covariance a day after the announcement is lower than on other days, suggesting that the persistency of announcement shocks on the covariance between the 1 and 10 year bond is low.

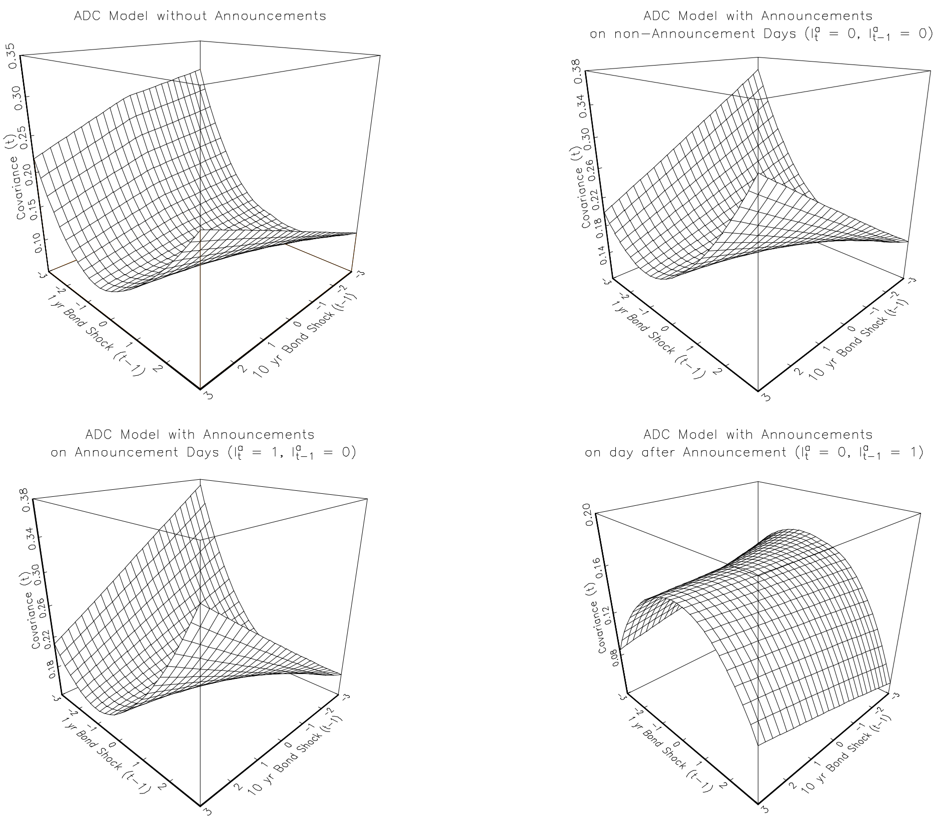


Figure 5: **News Impact Surfaces for the Conditional Covariance between 1 and 10 Year Treasury Bond Returns With and Without Macroeconomic Announcement Effects**

3.3.2 Dynamic Volatility in Stock Markets: S&P 500 and NASDAQ Index

In this subsection we examine whether macroeconomic announcement shocks have a significant impact on conditional stock market volatility, and we study the interrelation between these announcement shocks with asymmetric volatility in stock markets. Moreover, we examine whether stock prices are less affected by macroeconomic news than bond prices. The estimation results of the covariance between S&P 500 and NASDAQ returns (see Table 5) show that the estimates for the dummies on announcement days are very high and significantly different from zero. A test showed that the set of w^a-parameters were jointly significant at the 1 percent level. Thus announcement days are associated with higher stock market volatility. These results confirm the findings of Bomfim (2000) and Flannery and Protopa-

Table 5: **Estimation Results: Conditional Covariance Between the NASDAQ Composite Index and the S&P 500 Index**

	ADC Model		ADC Model with Ann.	
	Estimate	Std. Err.	Estimate	Std. Err.
ρ_{12}	0.1013*	0.0257	0.1073*	0.0332
ϕ_{12}	0.8957*	0.0278	0.8892*	0.0358
$w_{11}(\times 1000)$	8.5698*	2.5957	−0.6968	2.4215
$w_{12}(\times 1000)$	3.0728	2.8683	−6.0231*	2.9275
$w_{22}(\times 1000)$	9.9833*	3.0779	−0.4965	3.2044
$w_{11}^a(\times 1000)$	.	.	73.8048*	19.6461
$w_{12}^a(\times 1000)$	.	.	69.8943*	22.2640
$w_{22}^a(\times 1000)$	.	.	82.3535*	31.2839
b_{11}	0.9563*	0.0068	0.9559*	0.0065
b_{12}	−0.0039	0.0024	−0.0038	0.0024
b_{22}	0.9677*	0.0061	0.9671*	0.0060
a_{11}	0.2438*	0.0236	0.2428*	0.0258
a_{21}	−0.0640*	0.0162	−0.0696*	0.0186
a_{12}	0.0217	0.0216	0.0213	0.0221
a_{22}	0.2488*	0.0231	0.2494*	0.0251
a_{11}^a	.	.	0.0299	0.0831
a_{21}^a	.	.	0.0240	0.0724
a_{12}^a	.	.	−0.0162	0.0839
a_{22}^a	.	.	0.0314	0.1009
g_{11}	0.3011*	0.0382	0.3089*	0.0406
g_{21}	0.0845*	0.0275	0.0786*	0.0297
g_{12}	−0.1582*	0.0535	−0.1659*	0.0504
g_{22}	0.1265	0.0688	0.1379*	0.0531
g_{11}^a	.	.	−0.0398	0.1477
g_{21}^a	.	.	0.0696	0.1751
g_{12}^a	.	.	−0.0300	0.2101
g_{22}^a	.	.	−0.1527	0.3881
Log Likelihood	−10,308.90		−10,293.52	

Notes: Index 1 refers to the NASDAQ Composite Index, whereas index 2 refers to the S&P 500 Index. There are 4,898 observations used in the estimation. Standard errors are robust Bollerslev-Wooldridge (1992) standard errors. "*" indicates that the corresponding coefficient is statistically significant at the 5% level.

padakis (2002). Next, announcement shocks do not seem to be very persistent. All the individual estimates considering the announcement shocks (a_{ij}^a and g_{ij}^a, $i, j = 1, 2$) are not significantly different from zero. In addition, tests showed that each of the set of parameters (a_{ij}^a and/or g_{ij}^a, for $i, j = 1, 2$) were not jointly significant at conventional significance levels. Thus, announcement shocks are not more persistent than regular shocks, which suggests that the stock market does not incorporate the implications of macroeconomic announcement news slower than other information. Further, in line with many empirical studies we find that the conditional variance and covariance of stock returns are asymmetric in response to good and bad news (see also, e.g., Kroner and Ng, 1998). The estimation results further show that, in contrast with regular shocks, negative announcements do not affect stock market volatility more than positive announcements. Thus negative announcement shocks do not have a significantly greater impact on the subsequent volatility than positive announcement shocks. A possible explanation is that macroeconomic news is not necessarily more important or more influential than firm-specific news in stock markets. We know that volatility mainly responses asymmetrically after big shocks, i.e. very good or very bad news. These big shocks in the stock market are usually not related to macroeconomic news. On the other hand, in bond markets, macroeconomic news is the most important source of news, such that big shifts in bond prices are typically related to macroeconomic news.

4 Discriminating Between Announcements

The results in Section 3 are based on the restriction that the three announcements, PPI, EMP and FOMC, have identical impact on conditional volatility. One might argue that allowing explicitly for different sources of announcements would be more appropriate because especially PPI and EMP announcements are reported to have strong impact on bond market volatility (see, e.g., Fleming and Remolona, 1999a, Jones, Lamont and Lumsdaine, 1998, and Balduzzi, Elton and Green, 2001), while the announcements on short-term interest rate decisions made by the FOMC seems the most influential announcement in the stock market (see, e.g., Bomfim, 2000). Therefore, it is an interesting question to examine whether FOMC announcements really differ from PPI and EMP announcements.[10]

Table 6 and 7 presents some summary statistics for the excess returns on (and around) PPI and EMP announcement days and FOMC announcement days respectively. Table 6 shows that on PPI and EMP announcement days all means, covariances and correlations are larger than on non-announcement days (see Table 1). The mean on the S&P 500 index return is considerably higher on FOMC announcement days than on PPI and EMP announcement days: 0.20% vs. 0.08% (Table 7), whereas the mean on non-announcement days is only 0.04% (see Table 1). The NASDAQ returns are on average highest on PPI and EMP announcement days: 0.18%, while the mean return is 0.13% on FOMC announcement days and 0.01% on other days. Obviously, FOMC announcements have a greater impact on stocks in the S&P 500 than stocks in the NASDAQ. Next, we see that the mean of the 1 year bond returns are basically the same for both announcement types, whereas the mean of the 10 year bond returns are especially high on FOMC announcement days. Finally, note that for both types of announcements the correlation coefficients are similar, but remain larger than on non-announcement days. Therefore, diversification among asset classes seems less beneficial at times the investor needs it the most.

Looking at the summary statistics one day before the announcement, we see that there is no notable difference in the standard deviation of returns after discriminating between the announcements. Only the standard deviation of the 10 year government bond is strikingly high one day before FOMC announcements. Especially in the stock market we find indication for a "calm before the storm" effect. The standard deviation of the stock returns are quite different for days after labor market and FOMC announcements. Contrary to labor market announcements, the results indicate that the shocks on FOMC announcement days are followed by a relatively low volatility in the stock market.

In order to predict the impact of the different announcements on the conditional volatility, we make two changes to the model. First, we include two dummy

[10] Ideally, we would like to consider the PPI and EMP announcement separately as well, but the number of parameters become too large to estimate. Moreover, we find like Jones, Lamont and Lumsdaine (1998) that PPI and EMP announcement days produce very similar means and standard deviations, such that we follow Jones, Lamont and Lumsdaine (1998) and pool these announcement days.

Table 6: **Summary Statistics for Stock and Bond Excess Returns Around Labour Market Announcement Days**

	S&P 500	NASDAQ	1 yr bond	10 yr bond
Panel A: PPI and EMP announcement days (457 obs.)				
Mean	0.0791	0.1810	0.0132	0.0596
Std. Dev.	1.1764	1.3480	0.1016	0.6339
Minumum	−6.7724	−6.2155	−0.3396	−2.4781
Maximum	4.7527	7.8567	0.4861	2.4556
	Covariances and **Correlations**			
S&P 500	1.3808	1.2597	0.0297	0.2675
NASDAQ	**0.7962**	1.8131	0.0133	0.1505
1 yr bond	**0.2492**	**0.0973**	0.0103	0.0531
10 yr bond	**0.3595**	**0.1765**	**0.8261**	0.4010
Panel B: 1 day BEFORE PPI and EMP announcement days				
Mean	−0.0243	0.0458	0.0079	0.0428
Std. Dev.	0.9347	1.2767	0.0735	0.4553
Minumum	−4.8109	−7.0741	−0.3144	−1.5177
Maximum	4.3624	8.9099	0.7596	3.5464
	Covariances and **Correlations**			
S&P 500	0.8717	0.8749	0.0101	0.1217
NASDAQ	**0.7348**	1.6264	0.0043	0.0783
1 yr bond	**0.1474**	**0.0457**	0.0054	0.0260
10 yr bond	**0.2867**	**0.1350**	**0.7790**	0.2068
Panel C: 1 day AFTER PPI and EMP announcement days				
Mean	0.0136	−0.1138	−0.0004	0.0084
Std. Dev.	1.4013	1.4562	0.0758	0.4583
Minumum	−20.4598	−11.4052	−0.3256	−1.8346
Maximum	5.0490	5.9681	0.5090	1.8600
	Covariances and **Correlations**			
S&P 500	1.9593	1.5956	−0.0034	0.0862
NASDAQ	**0.7837**	2.1160	−0.0039	0.0439
1 yr bond	**−0.0325**	**−0.0351**	0.0057	0.0253
10 yr bond	**0.1346**	**0.0659**	**0.7308**	0.2095

Notes: Summary statistics for the excess return on the S&P 500 index, the NASDAQ Composite index, the 1 year Treasury bond and the 10 year Treasury bond for the period January 4, 1982 - August 31, 2001. All returns are daily returns in percentages (see Appendix A). Bold numbers are the correlation coefficients.

Table 7: **Summary Statistics for Stock and Bond Excess Returns Around FOMC Announcement Days**

	S&P 500	NASDAQ	1 yr bond	10 yr bond
Panel A: FOMC announcement days (157 obs.)				
Mean	0.2044	0.1289	0.0133	0.0972
Std. Dev.	0.9550	1.1990	0.0601	0.4162
Minimum	−2.4577	−4.8166	−0.1248	−1.1118
Maximum	2.8779	3.3484	0.3065	1.4978
		Covariances and **Correlations**		
S&P 500	0.9062	0.8508	0.0099	0.1593
NASDAQ	**0.7478**	1.4283	0.0069	0.1211
1 yr bond	**0.1737**	**0.0968**	0.0036	0.0164
10 yr bond	**0.4033**	**0.2443**	**0.6613**	0.1721
Panel B: 1 day BEFORE FOMC announcement days				
Mean	0.1066	−0.0258	−0.0146	−0.0067
Std. Dev.	0.9143	1.2406	0.1057	0.4505
Minimum	−2.3944	−3.9698	−0.9306	−2.2806
Maximum	2.8601	5.7650	0.2318	1.7292
		Covariances and **Correlations**		
S&P 500	0.8305	0.8730	0.0170	0.1570
NASDAQ	**0.7746**	1.5293	0.0091	0.1295
1 yr bond	**0.1773**	**0.0699**	0.0111	0.0368
10 yr bond	**0.3835**	**0.2331**	**0.7776**	0.2017
Panel C: 1 day AFTER FOMC announcement days				
Mean	0.1032	0.1472	0.0126	0.0370
Std. Dev.	0.9837	1.2322	0.0618	0.4549
Minimum	−3.1409	−7.1398	−0.2069	−1.9748
Maximum	3.2701	3.8673	0.3319	1.2218
		Covariances and **Correlations**		
S&P 500	0.9615	0.9338	0.0060	0.1154
NASDAQ	**0.7753**	1.5088	−0.0053	0.0325
1 yr bond	**0.0989**	**−0.0703**	0.0038	0.0205
10 yr bond	**0.2595**	**0.0584**	**0.7327**	0.2056

Notes: Summary statistics for the excess return on the S&P 500 index, the NASDAQ Composite index, the 1 year Treasury bond and the 10 year Treasury bond for the period January 4, 1982 - August 31, 2001. All returns are daily returns in percentages (see Appendix A). Bold numbers are the correlation coefficients.

variables in the mean equation. One dummy that is equal to one on PPI and EMP announcement days and a second one that is equal to one on FOMC announcement days. Second, we let parameter vectors a_i^L and g_i^L measure the impact of PPI and EMP announcements, while a_i^F and g_i^F measure the impact of FOMC announcements in equation (6).

Table 8 shows that the two types of announcements have a different effect on the conditional mean returns. For all indices, except the NASDAQ, the FOMC announcements have a greater impact than PPI and EMP announcements. A possible explanation is that there are only few financial corporations (which are very sensitive to interest changes) in the NASDAQ Composite. Note that labor market announcements affect the conditional mean return of the NASDAQ index considerably. This is possible due to the fact that the NASDAQ includes relatively many young companies which are more likely to go bankrupt than old companies. As the PPI and EMP are traditionally good predictors of recessions, it makes sense that announcements in these two figures affect the volatility of the NASDAQ companies the most.

Table 8: **OLS Estimation Results of Mean Equation**

	Stock Market		*Bond Market*	
	NASDAQ	S&P 500	1 yr bond	10 yr bond
$I_t(PPI\&EMP)$	0.1945*	0.0652	0.0104*	0.0451
Std. Error	0.0656	0.0577	0.0048	0.0300
$I_t(FOMC)$	0.0885	0.1729*	0.0121*	0.0918*
Std. Error	0.1014	0.0794	0.0049	0.0344

Notes: The table shows estimation results of equation (1) for the stock and bond market separately. The estimates of the constants, 10 lags of excess returns and 10 lags of negative excess returns are not reported. White (1980) standard errors are presented. "*" indicates that the corresponding coefficient is statistically significant at the 5% level.

The results of estimating the conditional volatility models, using two announcement types, are shown in Table 9. Striking is the difference in the level of volatility on PPI and EMP announcement days and on FOMC announcement days. The FOMC announcements do not influence the level of volatility in the stock and bond market. However, a joint test for the combination of all w^L and w^F-parameters is significant at the 1 percent level. Hence, the pre-announcement effect is significant

Table 9: **Conditional Volatility Estimates**

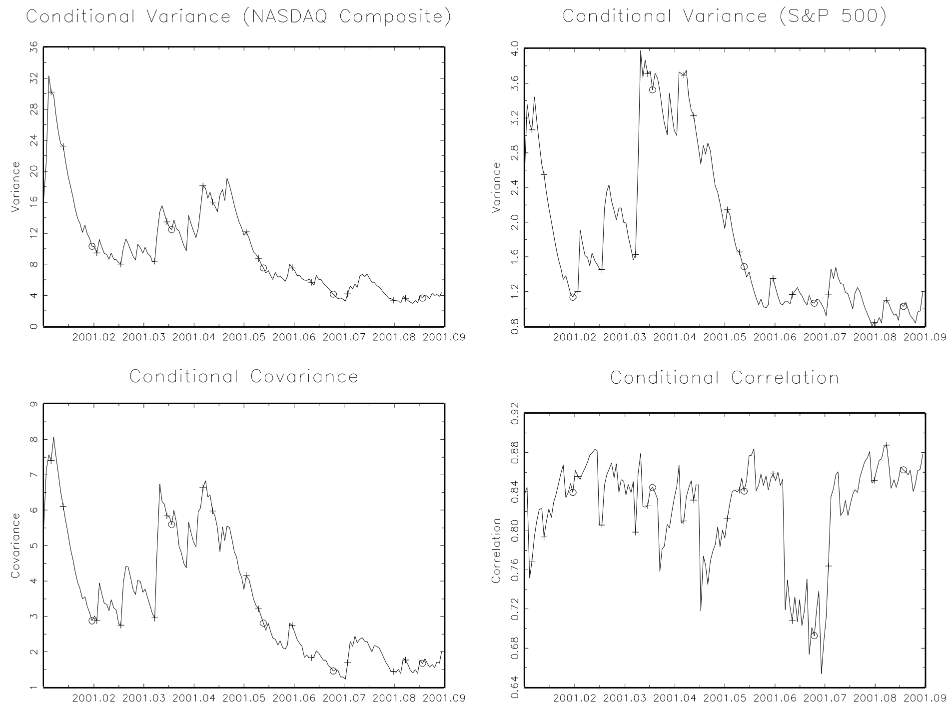
asset 1:	NASDAQ		1 yr bond	
asset 2:	S&P 500		10 yr bond	
	Estimate	Std. Err.	Estimate	Std. Err.
ρ_{12}	0.1060*	0.0250	0.1404*	0.0653
ϕ_{12}	0.8918*	0.0266	0.8400*	0.0769
$w_{11}(\times 1000)$	−1.6074	4.1084	−0.0019	0.0230
$w_{12}(\times 1000)$	−6.8163	5.1302	0.0340	0.2365
$w_{22}(\times 1000)$	−0.7462	6.1240	3.7450	1.8391
$w_{11}^L(\times 1000)$	105.2820*	27.5542	0.7053*	0.2391
$w_{12}^L(\times 1000)$	99.0901*	31.3595	2.5001	1.3554
$w_{22}^L(\times 1000)$	100.1708*	43.5246	19.4743	10.7983
$w_{11}^F(\times 1000)$	4.7385	63.8588	−0.1133	0.2942
$w_{12}^F(\times 1000)$	8.4749	70.0885	−1.8688	2.1263
$w_{22}^F(\times 1000)$	39.3076	72.2710	−18.4013	18.7975
b_{11}	0.9565*	0.0063	0.9546*	0.0103
b_{12}	−0.0040	0.0025	−0.0004	0.0020
b_{22}	0.9670*	0.0057	0.9580*	0.0077
a_{11}	0.2436*	0.0297	0.3350*	0.0415
a_{21}	−0.0680*	0.0186	0.1458	0.2158
a_{12}	0.0206	0.0243	−0.0052	0.0052
a_{22}	0.2422*	0.0247	0.2472*	0.0340
a_{11}^L	0.0296	0.1191	−0.1818*	0.0724
a_{21}^L	0.0215	0.0788	−1.1933*	0.4569
a_{12}^L	−0.0824	0.0992	−0.0052	0.0080
a_{22}^L	0.0249	0.0835	−0.0479	0.0627
a_{11}^F	0.1537	0.1078	−0.0135	0.2998
a_{21}^F	0.3012*	0.1290	0.6095	1.2929
a_{12}^F	−0.2516*	0.0820	−0.0144	0.0373
a_{22}^F	−0.5771*	0.1554	−0.4112*	0.1715
g_{11}	0.3061*	0.0404	−0.1706	0.1801
g_{21}	0.0784*	0.0292	−0.5343	0.7570
g_{12}	−0.1592*	0.0493	0.0244	0.0140
g_{22}	0.1471*	0.0505	0.0135	0.1267
g_{11}^L	0.0972	0.1963	0.0181	0.3253
g_{21}^L	0.2558*	0.1302	0.7787	1.4302
g_{12}^L	−0.2346	0.1593	−0.0153	0.0286
g_{22}^L	−0.5296*	0.2632	−0.1374	0.2071
g_{11}^F	−0.1653	0.2394	−0.2196	0.2948
g_{21}^F	−0.0688	0.2125	−2.4710	1.5376
g_{12}^F	0.1391	0.1625	0.0243	0.0316
g_{22}^F	0.0595	0.2435	0.3934	0.2712
Log Likelihood	−10,269.89		6,180.34	

Notes: Superscript L refers to PPI and EMP announcement days, while superscript F refers to FOMC announcement days. There are 4,898 observations used in the estimation. Standard errors are robust Bollerslev-Wooldridge (1992) standard errors. "*" indicates that the corresponding coefficient is statistically significant at the 5% level.

in both markets. Another compelling result is that in the stock market FOMC announcement shocks are more persistent than other shocks, while the estimation results without discriminating between the announcements (Table 5) showed that the announcement shocks were not persistent. Obviously, it is important to allow that different types of announcements have a different impact on volatility. We further find that the response to good and bad labor market news in the stock market differ significantly, which is another novel result. Note that the asymmetries in variances and covariance do not disappear, such that our conclusion about the interaction between asymmetries and macroeconomic announcements for the stock market remains unchanged. Finally, the estimated parameters that govern the dynamics in bond market volatility are quite similar to the estimations in the previous section (Table 4).[11] Some of the estimates that measure the persistence of the announcement shocks are individually significant. Volatility on announcement days does not persist for the short bond, consistent with the immediate incorporation of information into prices. However, announcement shocks on the 10 year government bond seem to persist more than regular shocks. While Christiansen (2000) asserts that it is highly unlikely that macroeconomic announcements other than the most prominent PPI and EMP announcements cause a high degree of persistency in the government bond market, we find that the announcement made by the FOMC results in a relatively high degree of persistency in 10 year Treasury bond returns. None of the estimates that measure asymmetric volatility are individually significant at the 5 percent level. Moreover, a joint test corresponding to the null hypothesis that the announcement asymmetry parameters are zero does not reject the null at the 5 percent level. Thus negative macroeconomic announcement shocks in bond markets do not results in a higher than usual subsequent volatility.

Figures 6 and 7 present plots of the conditional (co)variances and correlation for the bond market as implied by the ADC model, from January until September 2001. The plus signs indicate PPI and EMP announcement days, while the circles indicate FOMC announcement days. In the bond market we see that a peak in the variance or covariance goes hand in hand with the timing of an announcement.

[11] From the likelihood ratio tests in Section 4 we see that, at the 5% level, discriminating between announcements does not lead into a significant better model for the bond market.



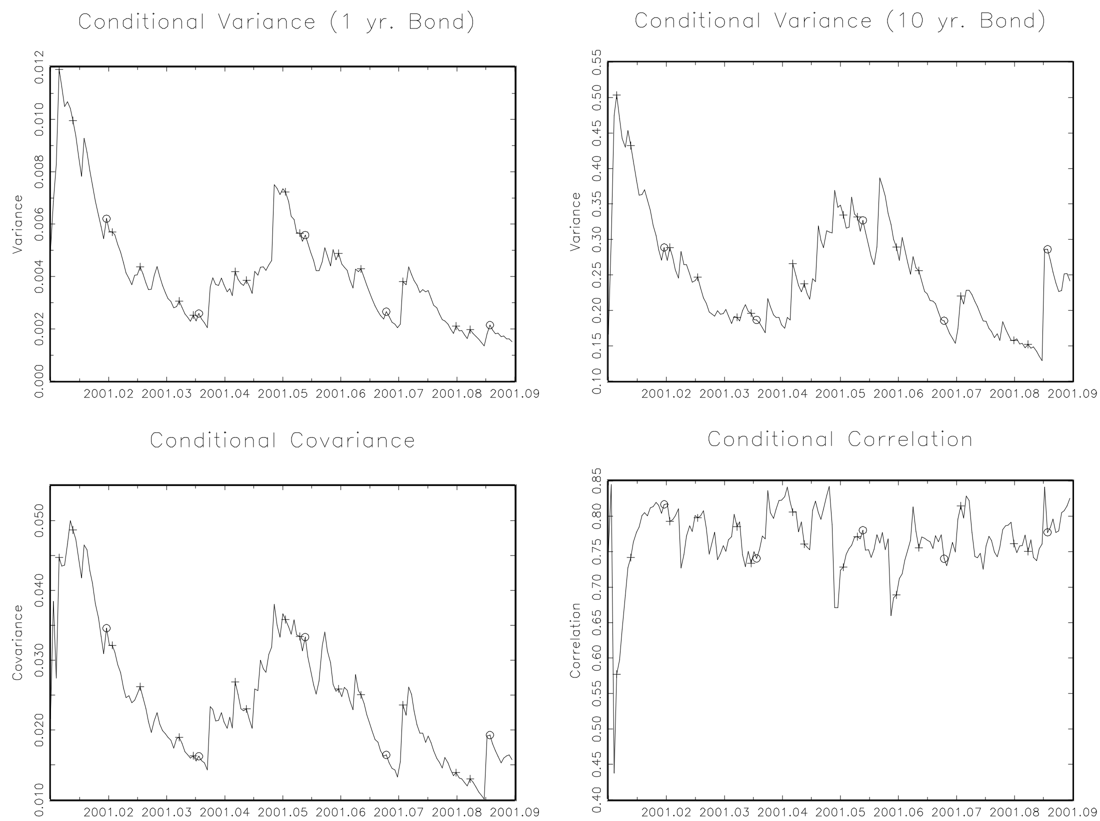
Notes: The conditional (co)variances and correlation for the stock market, from January 2001 until September 2001. The plus signs indicate PPI and EMP announcement days, while the circles indicate FOMC announcement days.

Figure 6: **Conditional (Co)variances and Correlation for the Stock Market**

Finally, we see that the correlations vary considerably over time, which indicates that the gains of diversifying between assets also vary a lot over time.

In February 1994, the Fed began the practice of announcing changes in its target for the federal funds rate immediately after FOMC meetings. Since then most changes in the Fed's target for the federal funds rate have been made at the FOMC meetings. Prior to this, changes in the target were often made between regularly scheduled meetings. This suggests that FOMC meeting days have become more important in the eyes of the market participants since February 1994. To allow for the possibility that the effects of FOMC announcements have a different impact on the mean return and volatility after February 1994, we include the dummy I_t^{94} into the model which takes the value 1 after February 1994 and 0 before. Equation (7) becomes

$$\theta_{ij,t} = \omega_{ij} + \omega_{ij}^L I_t^L + \omega_{ij}^F I_t^F + \omega_{ij}^{F,94} I_t^F I_t^{F,94} + b_i' H_{t-1} b_j + a_i^{*'} \varepsilon_{t-1} \varepsilon_{t-1}' a_j^* + g_i^{*'} \varepsilon_{t-1}^- \varepsilon_{t-1}^{-\,'} g_j^*$$



Notes: The conditional (co)variances and correlation for the bond market, from January 2001 until September 2001. The plus signs indicate PPI and EMP announcement days, while the circles indicate FOMC announcement days.

Figure 7: **Conditional (Co)variances and Correlation for the Bond Market**

for all $i, j = 1, 2$, where b_i, $a_i^* = a_i + a_i^L I_{t-1}^L + a_i^F I_{t-1}^F + a_i^{F,94} I_{t-1}^F I_{t-1}^{F,94}$, $g_i^* = g_i + g_i^F I_{t-1}^F + g_i^F I_{t-1}^F + g_i^{F,94} I_{t-1}^F I_{t-1}^{F,94}$, $i = 1, 2$ are 2×1 vectors and $\omega_{ij}, \omega_{ij}^L$, ω_{ij}^F and $\omega_{ij}^{F,94}$ are scalars. The results[12] show that this extension has virtually no effect in the bond market. Only the magnitude of the news effects change somewhat in the stock market. Especially FOMC announcement shocks in the NASDAQ become less persistence, such that the market learns the implications of FOMC announcements quicker after 1994.

Finally, we test the three different models against each other: the ADC model, the ADC model with announcements effects (ADC I) and the ADC model in which we discriminate between the announcements (ADC II). A convenient feature of the

[12] The results can be obtained from the authors upon request.

Table 10: **Likelihood Ratio Tests**

		Bond Market		Stock Market	
	df	test-statistic	p-value	test-statistic	p-value
ADC vs. ADC I	11	108.04	0.000	30.76	0.001
ADC vs. ADC II	22	126.12	0.000	78.02	0.000
ADC I vs. ADC II	11	18.08	0.080	47.26	0.000

Notes: The table reports the likelihood ratio tests of hypotheses that impose parameter restrictions on the ADC model with announcements. The test-statistic follows a χ^2_{df}-distribution where *df* is the degrees of freedom.

models is that they are nested. This permits us to compare the models using simple likelihood ratio (LR) tests. The LR test statistics, reported in Table 10, indicate that ADC II best describes the volatility of stock and bond returns at the 10% level. The ADC model without announcements is outperformed by the models with announcements at all conventional significance levels. At the 5% level, ADC II does not significantly outperform ADC I for bond returns. Obviously, it is especially important for stock returns to discriminate between announcements.

5 Concluding Remarks

This paper investigates the interaction between announcements and volatility in stock and bond markets, whether announcement news differ from non-announcement news, and to what extent asymmetric volatility is explained by macroeconomic announcements. To this end, we accommodate the Asymmetric Dynamic Covariance (ADC) model of Kroner and Ng (1998) in such a way that macroeconomic announcements, which are reported to be very important in Treasury bond markets, are accounted for. We use daily returns on the S&P 500 index, the NASDAQ Composite index, and a short and long U.S. Treasury bond, for the period January 1982 - August 2001. This enables us to examine the effects of macroeconomic announcements on stock and bond market volatility. We consider the following macroeconomic announcements: producers price index (PPI) and employment (EMP) reports, i.e. labour market announcements, that are published monthly by the Bureau of Labor Statistics, and Federal Open Market Committee (FOMC) announcements involving the target fed funds rate.

The main empirical findings can be summarized as follows. Consistent with previous findings, we find that means, unconditional variances and unconditional covariances are greater on announcement days than on non-announcement days. The order of magnitude of the difference in the mean on announcement and non-announcement days is remarkable. For example, the mean return on the S&P 500 index is 0.12% on announcement days, while on non-announcement days it is only about 0.03%. This difference about 23% on an annual basis. For the 10 year bond we find an annual difference of about 15%. Likewise, releases of macroeconomic news also induce common movements in the stock and bond market, which strengthen the correlations between the returns. Further, we find moderate support for the "calm before the storm" effect; for most assets the standard deviation the day before an announcement is lower than average.

We strongly reject models that assume that announcements shocks do not differ from regular shocks. The most important reason that macroeconomic announcement shocks have a different impact on volatility is because they are pre-announced and regularly scheduled, such that the timing of these announcements is known in advance. The results indicate that the anticipated conditional variances and covariances are greater on macroeconomic announcement days, especially for labor market announcements. In stock markets, macroeconomic announcements only have a level effect on conditional volatility, which is in line with the findings of Flannery and Protopapadakis (2002). However, after discriminating between labor market announcements and FOMC announcements, especially FOMC announcement shocks turn out to be less persistent than regular shocks. Moreover, the persistency of labor market shocks on the stock market does not significantly differ from other shocks. Thus investors process new information about the target fund rate faster than new information about the labor market. Only labor market announcement shocks results in less asymmetric S&P 500 volatility than regular shocks: a negative announcement in PPI or EMP yields a lower than usual volatility, resulting in a more symmetric response to volatility. Finally, the bond market results show that volatility on announcement days does not persist for the short bond, consistent with the immediate incorporation of information into prices. However, announcement shocks on the 10 year government bond seem to persist more than regular shocks. This result is remarkably as literature usually finds that macroeconomic announcement shocks do not persist. The bond market results further show that negative macroeconomic announcements do not results in a higher than usual volatility. After introducing macroeconomic announcements, none of the asymmetric volatility parameter estimates is individually significant anymore, while the stock market results show that introducing announcements effects do not influence the asymmetric stock market volatility. Because volatility mainly responds asymmetrically after big shocks, and these big shocks observed in the stock market are usually not related to macroeconomic news, introducing macroeconomic announcements has not much influence on the asymmetric stock market volatility. On the other hand, in bond markets macroeconomic news is the most important source of news, such that big shifts in bond prices are typically related to macroeconomic news. Consequently, the asymmetric volatility found in government bond markets are likely due to misspecification of the volatility model. After including macroeconomic announcements into the model, the asymmetry disappears.

To come back to Jones, Lamont and Lumsdaine's (1998) puzzle mentioned in the introduction, we do not find that stock prices are less affected by macroeconomic news than bond prices. Especially after drawing a distinction between FOMC and labor market announcements, stocks seem to be more affected than bonds. Thus the results addressed by McQueen and Roley (1993) that bonds have a higher variance on announcement days than stocks might be because of model misspecification.

The results of this study give raise to interesting future research topics. As some industries depend more on macroeconomic factors than others, it is interesting to investigate portfolios of stocks within various industries. Moreover, as suggested by McQueen and Roley (1993) and Veronesi (1999) it is likely that the impact of macroeconomic news releases on stock and bond returns depends on the state of the economy, i.e. whether we are in a recession or an expansion. Further research may elaborate on these issues in more detail.

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Appendix A: Calculation of the Returns

We obtained the "daily constant maturity interest rate series" from the federal reserve bank in Chicago. We have followed the method in Jones, Lamont and Lumsdaine (1998) to calculate the bond returns.[13] The U.S. Treasury bonds have semi-annual coupon payments, and the coupon on the hypothetical bonds is half the stated coupon yield. Hence, the price of the bond at the beginning of the holding period is equal to its face value. We have calculated an end-of-period price on this bond using the next day's yield augmented with the accrued interest rate:

$$P_{n-\#hd,t+1} = \sum_{i=1}^{2n-1} \frac{\frac{1}{2}y_{nt}}{(1+\frac{1}{2}y_{n,t+1})^i} + \frac{1+\frac{1}{2}y_{nt}}{(1+\frac{1}{2}y_{n,t+1})^{2n}} + \frac{\#\text{ holding days}}{365}y_{nt}, \tag{8}$$

where $P_{n-\#hd,t+1}$ is the end-of-period price of the bond, n is the number of years the bond is referring to, t is the time and y_{nt} is the yield of an n-period bond at time t. The $\#hd-$return, is calculated as

$$r_{t+1} = P_{n-\#hd,t+1} - 1. \tag{9}$$

Finally, the excess returns are calculated using the 3-month interest rate as the risk free rate that accrues over the holding period, which varies from one to five days due to weekends and holidays.

$$r^e_{t+1} = r_{t+1} - \frac{\#\text{ holding days}}{365}y_{3mo,t}.$$

The S&P 500 index data are obtained from Datastream, while the NASDAQ Composite index data are obtained from the National Association of Security Dealers. The returns on the S&P 500 index and the NASDAQ Composite index are calculated as

$$r_{index,t+1} = \frac{P_{index,t+1} - P_{index,t}}{P_{index,t}}. \tag{10}$$

Excess returns are calculated by substracting the risk free rate that accrues over the holding period

$$r^e_{index,t+1} = r_{index,t+1} - \frac{\#\text{ holding days}}{365}y_{3mo,t}. \tag{11}$$

[13] We thank Charles Jones, Owen Lamont and Charlotte Christiansen for their help with the program to construct the data.