Sources of Time-Varying Risk and Risk Premia in U.S. Stock and Bond Markets

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Abstract

This paper investigates the sources of time-varying risk and risk premia for both the U.S. stock and bond markets. Although a growing literature has emerged that examines the return and volatility characteristics of the U.S. stock and bond markets separately, little work has appeared that models these markets jointly. This paper proposes a model that provides evidence concerning the sources of time varying risk and risk premia in the markets that considers both markets simultaneously. The model captures the change in the risk premium to each market's own volatility risk as well as to the covariance risk for specific events. We test for the effects of macroeconomic news on time-varying volatility as well as time-varying covariance, and whether such news induces time-varying risk premia in either of the markets. We find that stocks, as opposed to bonds exhibit a change in the risk premium on variance risk on PPI announcement dates. There is also evidence of a change in the bond risk premium on covariance risk on macroeconomic news announcement dates. Employment reports and PPI releases appear as events inducing time-varying conditional variance for stock, Treasury Notes, as well as Treasury Bond returns. Finally, the results do not support the conjecture that conditional covariance of stock and bond returns falls on announcement days.

JEL Classification: G11, G12, G14

Keywords: Time-varying volatility, macroeconomic risks, stock and bond risk premia

Introduction

Volatility, the most widely used measure of risk in finance, has been shown to bear, in an arbitrage free economy a one-to–one correspondence with by all relevant information available to investors (see e.g. Ross (1989)). Revisions of the information set are reflected in changes in volatility over time. Sources of volatility are typically divided into two broad classes: macroeconomic (including country specific risk and industry specific risk) and microeconomic (firm specific risk). Since the underlying characteristics of the macro and micro environments change through time, we should expect volatility to vary through time as well, sometimes on a purely random basis, for purely unanticipated events, and sometimes in a predictable manner.

Previous studies have examined the sensitivity to macroeconomic risks for individual asset classes. Ederington and Lee (1993) examine interest rate futures and identify abnormal volatility for these asset classes in periods surrounding macro-economic announcements. Jain (1988) using hourly data shows that stock index prices change in response to macroeconomic announcements. Much of the ensuing literature has confirmed the Ederington and Lee findings that certain macroeconomic variables tend to convey more information than others (e.g. McQueen and Roley (1993) and Connolly and Stivers (2000) who look at individual stocks, and Bollerslev, Cai and Song (2000) who look at U.S. T-bond futures contracts). Jones, Lamont, and Lumsdaine (1998) (JLL henceforth) focus on the impact of macroeconomic announcements on daily Treasury bond prices in the U.S. They find a significant risk premium on the announcement days for the bond series examined.

Surprisingly, the previous literature concentrates on the return and volatility characteristics of the U.S. stock and bond markets separately. Little effort has been given to incorporate return and volatility characteristics of these markets jointly, despite the obvious need. For example, a change in the stock market risk premium due to a change in macroeconomic environment not only impacts the demand for stocks but also affects the demand for bonds. An investor with investments in both the stock and bond markets would revise his expectations of stock returns prompting him to rebalance his portfolio. In the process of rebalancing, the investor not only considers risk and return but he also considers the covariance between the stocks and bonds. For instance, John Vail chief strategist at Mizuho Securities USA Inc. in Chicago argues that the 1.2% increase in the returns of S&P 500 in August of 2002 has reduced the demand for bonds in that month. He further states that 'The S&P 500 and the price on the 10-year note have moved in the opposite direction on more than nine of every 10 days over the past six months.' [1]

A suitable procedure for studying the transmission mechanism of mean returns, variances and covariance shocks is multivariate Generalized Autoregressive Conditional Heteroskedasticity (GARCH) model. This model relates the change in the risk premium to each market's own volatility risk as well as to the covariance risk for specific events. In addition, the multivariate GARCH model allows us to test whether stocks and bonds earn incremental positive risk premia when they are exposed to macroeconomic risks.

Our approach in this paper is to test whether major macroeconomic news, specifically the employment report, the PPI, and industrial production releases explain some of the daily

[1] Bloomberg September 1, 2002

differences in risk premia between stocks and bonds. **In addition, we examine for the first time to our knowledge, the role of covariance risk in explaining the bond and stock risk premia. Furthermore, we also test for the effects of macroeconomic news on time-varying volatility as well as time varying covariance, and whether such news induces changes in time-varying risk premia in either or both of the markets.**

For our empirical analysis, we use daily returns on the S&P 500 index, the 5, 10, and 30 Year Treasury issues for the period October 1, 1979 through July 5, 2000. Basic statistics show that S&P 500 yielded on the average .684% over the risk free asset on days with at least one announcement. Similar to stocks, mean excess returns ranged from .33% to .69% for bonds on days with at least one announcement. Our results show that stocks and bonds offer significantly higher risk premia on the macroeconomic variables release dates. Next a multivariate GARCH model is employed to study the effects of news of macroeconomic changes on the time varying volatility as well as the time-varying covariance. We find that macroeconomic announcements change the stock risk premium for bearing variance risk. Furthermore, our results also show that macro announcements raise the risk premium on covariance risk for bonds.

The paper is organized as follow. A discussion of the data and preliminary results follows in Section I. Section II outlines the model used to test for time-varying risk premia across the markets. The results of the multivariate GARCH-M estimation follow in section III. Section IV includes some analysis of the determinants of the time varying conditional variance and covariances. The paper concludes with a summary in section V.

I. Data and Preliminary Results

We use daily returns on the S&P 500 index, the 5, 10, and 30 Year Treasury constant maturity interest rate series and on the secondary three-month T-bills market for the period October 1, 1979 through July 5, 2000 (5197 trading days). The S&P data were obtained from Bloomberg. The daily 5, 10, and 30 year Treasury constant maturity series were obtained from the Federal Reserve Bank of St. Louis. Consistent with previous work, our sample begins on October 1979, given the evidence of a structural break in interest rate data in October 1979. [2]

The daily continuously compounded excess return on the S&P 500 is simply the difference between the logarithm of daily S&P 500 return and that of three-month T-bills. We calculate daily continuously compounded returns on bonds as per Ibbotson and Associates (1994) and JLL (1998). Total returns equal capital appreciation plus the excess income that accrues over the holding period. The holding period is assumed to be one business day, which means that the holding period may vary from 1 to four days due to weekends and holidays. We first compute the end-of-period (one business day after having bought the bond) price on this bond using the end-of-period yield as the discount rate, and the current yield as the coupon rate. Then, we subtract the beginning-of-period price, which we assume to trade at par (coupon rate equal to the yield).[3]

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[2] .JLL (1998) report that the effect of announcement days on Treasury securities' volatility for the period before October 1979 is minute. Also, they do not reject the hypothesis that release dates have no effect on the volatility of bonds prior to October 1979. One of the reasons explaining this shift is the change in the U.S. Monetary Regime. In fact, the US Federal Reserve shifted its focus in October 1979 from targeting interest rates to targeting monetary aggregates.

[3] For example, for calculating the daily continuously compounded excess return from 10/01/79 to 10/02/79 on the 30-year Treasury bond, we proceed as follow:

In the multi-asset, multi-variate GARCH framework, we require market capitalization data to construct portfolio weights for each type of security. Daily market capitalization data for the S&P Index series were obtained from Morgan Stanley Capital International (MSCI). Treasury bills, Treasury notes, and Treasury bonds capitalization estimates were obtained from DRI-WEFA. Since the bond market capitalization indices were available on a monthly basis, we dynamically interpolate the observations within the month using the index returns to approximate the daily numbers. Extending the interpolations from the month end to the beginning of the month matches closely the actual beginning of the month weights reported by DRI-WEFA. Each maturity bond was also interpolated to obtain daily market capitalization estimates in a similar manner. However, as a result of various monthly bond offerings, interpolating using respective rates of each series occasionally resulted in some imprecision relative to actual end of the month figures. Optimal interpolation methods were used in such cases to minimize the difference.[4]

As with JLL (1998) we examine PPI and employment announcement dates which are obtained from the U.S. Bureau of Labor Statistics. We extend the analysis by also looking at the Industrial Production report, which is shown by Ederington and Lee (1993) to

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Date	3-month T-bill	30-year
10/01/79	10.15%	9.32%
10/02/79	10.37%	9.28%

Total Excess Return = Capital Gain/Loss+ Excess Income
= (P(9.28%,9.32%) - 100) / 100 + (9.32%- 10.15%) * (N/365)

However, to compute the continuously compounded excess return from 01/10/79 to 01/10/79, we proceed as follow:
= ((P(9.28%,9.32%) - 100) / 100))) + ln(1+((9.32%*(N/365)) – ln(1+10.15%*(N/365)))

where P(x, y) is the price of a hypothetical 30-year bond with a coupon of y trading at a yield of x, and N is the number of days in the holding period.

[4] The DP algorithm in RATS was used for this purpose.

significantly affect Treasury bond and Eurodollar futures. Industrial Production release dates are obtained from the Federal Reserve Board. We also use NYSE daily share volumes from DATASTREAM over the sample period, to account for possible equity market volume-volatility linkages.

Table 1 shows the distribution of the macroeconomic release dates across days of the week for each announcement. The preponderance of announcements (501/747) occur on Fridays. This is more pronounced for the employment report (238/249). Industrial Production release dates are more evenly distributed across days of the week. [5]

Summary statistics of the four financial series for the period are shown in Table 2. Based on the Jarque-Bera statistics we reject the assumption of normality for the three bond series and for the S&P 500 series[6]

Panel A of Table 2 also shows the mean excess return on announcement days and non-announcement days for each asset over the complete sample period. Although announcement days account for only 13% of the sample, they account for a large proportion of the returns earned during the entire period. On the average S&P 500 yielded .684% over the risk free asset on days with at least one announcement versus .43% on days with no announcements.

[5] Two employment reports were released on a Saturday (March 5, 1983 and November 1, 1986) whereas the PPI was released once on a Saturday (February 15, 1986) and once on a Sunday (February 12, 1989). Finally, one industrial production statistic was released on a Saturday (December 14, 1985). We classify those releases as if they were announced on the next trading day. It is also important to mention that only 15 days include both announcements - the employment report and the PPI - on the same day since October 1979. The PPI and the industrial production numbers were released 52 times during the same day. Finally, the employment report and industrial production numbers were never released the same day, at least, since October 1979. Thus, for the complete sample, there are 680 of the 5197 days (13.1%) with at least one announcement, and 4517 of the 5197 days (86.9%) with no announcement.

Also, most of the 30-year bond excess returns were earned during days with at least one announcement (.693%) compared to days with no announcements (.099%).

In panel B we present the autocorrelation of the excess return (XR), squared excess return (XRSQ) and absolute value of excess return series (XRABS). The significant first-order autocorrelation coefficients for the three bond series may be symptomatic of non-synchronous trading effects. The large autocorrelations of the squared excess return and absolute excess return series provide support for the use of GARCH class of models to characterize the interactions between the markets.[7]

In panel C of Table 2 we present the cross correlation between the S&P 500 excess return and the three bond excess return series and the respective squared excess return series. The significant contemporaneous correlations between the stock and bond return and squared series is supportive of integration of the markets, as well as the use of multivariate GARCH approach. This also provides evidence of a strong volatility linkage between the stock and the bond markets. The significant one day lead term for bonds suggests that innovations to bond volatility lead innovations to stock volatility by one day.

Announcement Days

Next we examine how stocks and bonds react on the announcement days. The basic statistics are presented in panels A,B, and C of Table 3. From panels A and B of Table 3, we note that the S&P 500 exhibits significantly higher than average unconditional volatility on

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[6] Note that the Jarque Bera statistic follows a Chi-square distribution with 2 degrees of freedom. At the 5% level, the critical value is 5.99.

[7] We have also conducted formal ARCH LM tests to test the null hypothesis of no ARCH in each of the series. The null hypothesis is rejected for each of the series.

employment report and PPI announcement dates (1.097% and 1.168% respectively versus 1.037% for the complete sample period). In addition the S&P 500 stock index offers a significantly higher risk premium on each of the macroeconomic variables release dates. The Sharpe measure ranges from .054 to .062 compared to .022 over the entire period (as shown in Panel A of Table 2).

The 5-, 10-, and 30-year bonds experience significantly higher volatility on employment and PPI release dates (at the 1% level). Thus, our results seem consistent with previous studies which find that the employment and PPI releases have more impact than industrial production releases on both bonds and stock volatility. Similar to stocks, the risk premia of bonds are unusually high on any of the three macroeconomic announcement days. In fact, bonds risk premia rise considerably more than the S&P 500 risk premium on employment, PPI, and industrial production release dates. Note that PPI announcements provide the highest risk premia of all three announcements. The Sharpe measures range from .154 to .17 on PPI announcement dates compared to about .02 for the whole sample period. Overall, we can say that macroeconomic risks are compensated with higher risk premia but more for bonds than stocks.

Stock return and bond return covariances experience significant increases on announcement days. Compared the to full sample, the covariances double on employment report release dates, increase by half on PPI announcement dates, while they slightly decrease on industrial production announcement days. These results suggest that macro economic announcements force investors to rebalance their portfolio causing simultaneous reaction in the stock and bond markets. To the extent that conditional covariances behave similarly to these unconditional series, these results are not consistent with JLL (1998)'s conjecture that the conditional covariance of stock and bond returns fall on announcement days. Formal examination of the conditional covariances follows in section IV.

Post-Announcement days

Should volatility remain high following macroeconomic news announcements? Persistence of high volatility on days following such announcements might suggest that the market is unable to fully price the new information as uncertainties remain to be resolved. On the other hand, if these announcements do not cause permanent shocks to stocks and/or bonds, we should observe falling volatility on post-announcement dates. In this case, we may conclude that market quickly adjusts to public information. However, this does not necessarily suggest that the market is efficient as lower volatility does not necessarily imply more accurate pricing.

We find that stock volatility reverts to normal on employment report post release days, as the volatility is no longer significantly different from volatility on average days (1.037% from Table 2). On the other hand, stock volatility soars on PPI and industrial production post-announcement days. Bond volatilities decrease on employment report and PPI post-announcement days, but are still significantly higher than average. Similar to stocks, bonds volatilities increase on industrial production post-announcement days relative to announcement days. It seems reasonable to assert that such announcements cause a shock which is at least temporarily autocorrelated for most of the securities. The shock seems higher for stocks on PPI and industrial production release periods.

As we see from the three panels of Table 3, the covariances of stock and bond returns decrease on all three macroeconomic post-announcement days. Not surprisingly, the highest decrease happens on PPI post-announcement days as stock volatility increases while bonds volatilities decrease. Covariances fall on post-announcement days to lower than average levels suggesting completion of portfolio rebalancing.

Finally, stock and bond risk premia experience a significant drop on each macroeconomic post-announcement day compared to announcement days. In fact, the stock risk premium is negative and lower the than bonds' risk premia on the three macroeconomic post-announcement days. The bond risk premia are also negative on employment report post-announcement days and close to average on PPI and industrial production post-announcement days suggesting over reaction on announcement days followed by an adjustment the following day.

Using the F test, we show in panels A, B, and C whether or not variance on announcement days, as well as on post-announcement days, is significantly different from the variance for the entire period. However, due to the nonnormality of most of the return series, we will now present more robust tests.

Nonparametric Tests

We first present the Mann-Whitney U-test (see Sheskin, 1997), which is a median equality test for two subgroups. To perform this test, we first rank the series from the smallest value (rank 1) to largest, and compare the sum of the ranks from subgroup 1 to the sum of the ranks from subgroup 2. If the groups have the same median, the values should be similar. The null hypothesis is that the two distributions are the same. The Mann-Whitney U statistic is computed as follow:

$$U = N_1(N_2) + \frac{N_1(N_1+1)}{2} - \sum R_1$$

Where $\sum R_1$ is the observed sum of ranks for sample 1, and $N_1(N_2) + [N_1(N_1+1)]/2$ is the maximum possible value of $\sum R_1$.

We also present the Brown-Forsythe (modified Levene) test (Brown and Forsythe, 1974), which is useful for testing the null hypothesis of the equality of variances between subgroups. The test statistic is computed as follow:

Let $\hat{e}_1$ and $\hat{e}_2$ denote the median of the residuals in each group. Define

$d_{i1} = | e_{i1} - \hat{e}_1 |$ and $d_{i2} = | e_{i2} - \hat{e}_2 |$

$$t^* = \frac{\overline{d_1} - \overline{d_2}}{s\sqrt{\frac{1}{n_1} + \frac{1}{n_2}}}$$

and the statistic with

$$\overline{d_j} = \sum d_{ij} \text{ for j = 1, 2 and } s^2 = \frac{\sum\sum\left(d_{ij} - \overline{d_j}\right)^2}{(n-2)}$$

Since these tests assume that the subsamples are independent, we delete all announcement days from the complete sample period. This allows us to compare the post-, and announcement day samples to an independent sample. We report the test statistics in Tables 4 and 5 for each asset group on announcement and post-announcement days.

As we see, the median of the 5-, 10-, and 30-year bond returns are significantly higher on PPI (1% level) and industrial production (10% level or less) announcement days than on nonannouncement days. This is somewhat surprising as we found earlier that excess returns on industrial production release days (panel C of table 3) are lower than excess returns on employment report release days (panels A & B of table 3). On the other hand, there is only weak evidence that median stock return is significantly higher on macroeconomic news release days than on other days. However, we must keep in mind that the Mann-Whitney U-test is a conservative test.

Concerning the variance equality tests, we see from table 5 that the Brown-Forsythe test yields similar results to the F test, at least when we compare the employment report and industrial production announcement days to the nonannouncement days. More specifically, stock return variance as well as the 5-, 10-, and 30-year bond return variances are significantly higher (at the 5% level or less) on employment report announcement days than on nonannouncement days. The variances of returns on industrial production release days are not significantly different from those on nonannouncement days for all of the securities. Only on industrial production post-announcement days do we find the variances of stocks, 10-, and 30-year bond returns to be significantly higher than other days. Finally, bonds return variances are statistically significantly higher (at 1% level) on PPI announcement days than on nonannouncement days whereas stock return variance is not. However, all four securities experience significantly higher variances on PPI post-announcement days.

Weekend Effect or Macroeconomic News Releases Effect?

One possible explanation for the return reversal on macroeconomic post-announcement days might be that market participants overreact on announcement days and adjust the following day. However, one interesting question is whether the abnormally high stock and bond returns on macroeconomic news release dates are due to the releases themselves or because the announcements are confounded by other phenomena causing weekend effects? On the other hand, one could argue that the weekend effect is due to the large portion of important macroeconomic variables to be released on Fridays.

In other words, if we find that announcements made on Fridays yield relatively higher returns than releases made on other days of the week, then this might suggest that one effect causes the other. More research would be needed to tell whether or not there is a true causality relationship. On the other hand, if we find no evidence that returns are higher for macroeconomic news announcements made on Fridays, then we cannot conclude that macroeconomic news releases cause the weekend effect nor can we conclude that the higher returns on macroeconomic news release days are due to the weekend effect.

We report in table 6-A the mean daily excess return of stock and bonds on announcement days classified by the day of the week. In tables 6-B and 6-C, we report the test statistics (and their p-values) for the mean test (T-test) and the median test (Wilcoxon/Mann-Whitney test), respectively. More specifically, we test whether or not excess returns on weekdays with announcement are significantly different from excess returns on nonannouncement days.

As is evident from Table 6-A, returns do not appear to be higher for announcements made on Fridays compared to announcements made on other days. Table 6-B suggests that the S&P 500 index returns are significantly higher when announcements are made on Mondays, Wednesdays and Thursdays than on nonannouncement days. On the other hand, Tuesdays, Thursdays, and Fridays seem to be favourable announcement days for bonds as the mean excess returns are significantly different from nonannouncement days, as suggested by mean tests. However, median tests (see table 6-C) do not indicate that bond excess returns are higher for announcements made on Fridays compared to nonannouncement days. This suggests no relationship between macroeconomic announcements and the weekend effect.

II. Modeling Time-Varying Risk Premia

As opposed to Engle et al. (1987) and others that use ARCH-in-means to test whether risk premia of securities change over time, we use a multivariate GARCH-in-mean model similar to the one used by Chan et al. (1992). This type of model allows the conditionally expected returns of one type of security to be a function of its own return variance as well as its covariance with another security's returns, which is not the case for ARCH-in-mean models. It is an excellent tool to capture time-varying risk premium. The model suggests that if two securities have different risk sensitivity, then each market will be compensated differently, i.e., the expected return of each market will be determined by its return variance times the price of variance. The price of variance depends on the weighted relative risk aversion of market participants in each market. If both markets share the same risk sensitivity, then both markets will be compensated equally according to their return covariance times the price of covariance.

Similarly to Bekaert and Harvey (1995), our models have three sources of time-variation in expected returns: variation in the prices of risk (coefficients), variations in the conditional risk measures (variances and covariance), and variations in the weights. Note that the weights for the S&P500/30-year bonds bivariate GARCH model vary from a minimum of 54.2% (December 1987) to a maximum of 94.2% (June 2000) in favour of the S&P 500. For the S&P500/5-year notes and S&P500/10-year notes bivariate GARCH models, the weights vary from a minimum of 71.3% (October 1990) to a maximum of 92.5% (June 2000) in favour of the S&P 500.

Our model also allows for time-varying correlation. We use the structure proposed by Engle and Kroner (1995), i.e. the BEKK parameterization, of the multivariate GARCH process. This ensures a positive semi-definite H_t (Variance-Covariance) matrix, which is necessary for the estimated variance to be greater than or equal to zero. This is the case since the BEKK parameterization uses quadratic forms in a way that no restrictions are required to ensure a positive semi-definite H_t matrix. The H_t matrix evolution is written as:

$\varepsilon_t \sim N(0, H_t)$,

$$H_t = \begin{bmatrix} h_{Stocks,t} & h_{(Stocks,Bond),t} \\ h_{(Stocks,Bonds),t} & h_{Bonds,t} \end{bmatrix}$$

$$= C'C + A'H_{t-K}A + B'\varepsilon_t\varepsilon_t'B,$$

Where H_t is the 2X2 variance-covariance matrix, A and B are matrices of coefficients, and C is an upper triangular matrix of coefficients. ε_t is the vector of residuals with conditional mean 0 and conditional variance-covariance H_t. H_t is a linear function of its own K past values as well as of values of squared shocks.

Because this methodology implies no restriction of constant correlation between the S&P 500 and bonds, it allows us to check whether the correlations across securities are constant over time. Having no restriction of constant correlation implies that increased comovements in the stock index and bond series may be due to changes in both the covariance structure of returns as well as the correlation structure.

We estimate two unrestricted bivariate GARCH models, that differ according to whether or not the various macroeconomic announcements are pooled in the conditional mean return equations or are allowed to have separate effects. The restricted model benchmark assumes no announcement effects on the conditional mean return in the Bivariate GARCH estimation. Each model pairs the S&P 500 excess return with a (one of the three) bondexcess return series. Similar to Bekaert and Harvey (1995) and Doukas and Switzer (2000), we include in the unrestricted models indicator variables that allow us to directly test the effects of specific events on risk premia. We use macroeconomic news release dates (the employment report, PPI, and industrial production releases) as indicator variables to capture possible changes in the risk premia to variance and covariance risk on specific macroeconomic release dates.

The first model includes separately three indicator variables: the PPI releases, the employment report releases and the industrial production releases.

Model 1:

$$R_{Stocks,t} = \alpha_{10} - (\beta_1 + \beta_{11}*Emp_t + \beta_{12}*PPI_t + \beta_{13}*Ind_t)w_{Stocks,t}h_{Stocks,t} - (\delta_1 + \delta_{11}*Emp_t + \delta_{12}*PPI_t + \delta_{13}*Ind_t)*(1-w_{Stocks,t})h_{Stocks\text{-}Bonds,t} + \varepsilon_{Stocks,\, t} \quad (1)$$

$$R_{Bonds,t} = \alpha_{20} - (\beta_2 + \beta_{21}*Emp_t + \beta_{22}*PPI_t + \beta_{23}*Ind_t)w_{Bonds,t}h_{Bonds,t} - (\delta_2 + \delta_{21}*Emp_t + \delta_{22}*PPI_t + \delta_{23}*Ind_t)*(1-w_{Bonds,t})h_{Stocks\text{-}Bonds,t} + \varepsilon_{Bonds,\, t} \quad (2)$$

In this model, Emp, PPI, and Ind are indicator variables that are set to 1 on the employment report, PPI, and Industrial Production release dates respectively, and equal 0 otherwise; w_is are market capitalization weights.

In model 2, we pool the employment report, PPI releases and industrial production releases into a unique dummy, Dum.

Model 2:

$$R_{Stocks,t} = \alpha_{10} - (\beta_1 + \beta_{11}*Dum_t)w_{Stocks,t}h_{Stocks,t} - (\delta_1 + \delta_{11}*Dum_t)(1-w_{Stocks,t})h_{Stocks\text{-}Bonds,t} + \varepsilon_{Stocks,t} \quad (3)$$

$$R_{Bonds,t} = \alpha_{20} - (\beta_2 + \beta_{21}*Dum_t)w_{Bonds,t}h_{Bonds,t} - (\delta_2 + \delta_{21}*Dum_t)(1-w_{Bonds,t})h_{Stocks\text{-}Bonds,t} + \varepsilon_{Bonds,\, t} \quad (4)$$

In (3) and (4), Dum is an indicator variable that is set to 1 on either the employment report, the PPI, or the industrial production release dates. Finally, the restricted model 3 does not include any indicator variable.

Model 3:

$$R_{Stocks,t} = \alpha_{10} - (\beta_1)w_{Stocks,t}h_{Stocks,t} - (\delta_1)(1-w_{Stocks,t})h_{Stocks\text{-}Bonds,t} + \varepsilon_{Stocks,t} \quad (5)$$

$$R_{Bonds,t} = \alpha_{20} - (\beta_2)w_{Bonds,t}h_{Bonds,t} - (\delta_2)(1-w_{Bonds,t})h_{Stocks\text{-}Bonds,t} + \varepsilon_{Bonds,\,t} \quad (6)$$

III. Multivariate GARCH-M Results

Parameter estimates are obtained by maximizing the log-likelihood function. Conditional log-likelihood functions are computed as:

$L_t(\theta) = -\log 2\Pi - ½ \log |H_t| - ½\, e_t'(\theta)H_{t-1}(\theta)e_t(\theta)$

where θ is the vector of all parameters β_{ij} for i = S&P 500, 5-, 10-, 30-year bond and j = 1 or 2 whether it is variance or covariance respectively. To maximize this log-likelihood function, we use the simplex and Berndt, Hall, Hall, and Hausman (1974) algorithms. The BHHH algorithm provides the final parameter estimates, associated standard errors, and p-values.

To test the null hypothesis that the estimated coefficients are equal to 0, we use the likelihood ratio test. For large sample sizes,

$-2[L(\beta_R) - L(\beta_{UR})] \sim \chi^2_m$,

where m is the number of restrictions. If the statistic is greater than the critical value, we reject the null hypothesis that the restriction applies, we conclude that the indicator variable coefficient estimate is significantly different from 0. In most situations involving linear models, especially those with large sample sizes, the more traditional F test and the likelihood ratio test should generate very similar results. However, the likelihood is more appealing when large samples are used in part because it requires no assumption of normality. Remember that we rejected previously the null hypothesis of normality for the four return series.

If both assets (stock and bond) are sensitive to the same information, then we should expect the variance and covariance terms to be statistically significant. The reason is that the macro economic announcements simultaneously affect expectations in both the markets and thus affecting volatility in both markets. On the other hand, if only one market is risk sensitive to the information contained in one particular macroeconomic release, then we should find unusually high changes in its risk premium to variance risk on release dates to compensate for the specific risk exposure.

Statistically significant β_{ik} where k = 1, 2, or 3 indicate that security i's return is significantly influenced by security i's own return volatility on macroeconomic variable k's announcement date. In other words, statistically significant β_{ik} indicate that security i's risk premium to variance risk is significantly different from 0 on macroeconomic variable k's announcement date. Statistically significant δ_{ik} where k = 1, 2, or 3 indicates that security i's return is influenced by security i's return covariance with security j's on announcement k's date. Many possibilities could explain that. As Fleming, Kirby and Ostdiek (1998) suggested it could be due to common information affecting the expectations across markets or it could be due to information spill over caused as a result of portfolio rebalancing. Finally, to a certain extent, we can say that employment report, PPI, and Industrial production release dates will be considered as a source of temporary increase (decrease) in integration if the estimated coefficients δ_{1k} is found to be significantly positive (negative).

The estimated coefficients, their t-statistics and as well as the likelihood ratio statistics of the multivariate GARCH models are reported in tables 7, 8 & 9.

Non-Pooled Macroeconomic Variables Models

Let us first analyse the results for model 1 in Table 7, i.e., the non-pooled macroeconomic variable model. We find that the likelihood ratio statistics (2*(restricted-unrestricted model log-likelihood values)), calculated on the basis of Tables 9 and 7, are greater than the critical value at 5% for S&P500/5-year notes and S&P500/10-year models. This indicates that employment report, PPI releases and industrial production announcements create a regime shift.

As general conclusions, we find for model 1 that a stock-specific component of risk is rewarded on PPI release days. The β_{12} coefficient is significantly positive and varies from 0.16% to 0.22%. We also find that stock risk premium to covariance risk is significantly negative on PPI announcement days. δ_{12} ranges from –2% to –3.2% (Model B and C of Table 7). Thus, stocks are compensated for a specific and common component of risk on PPI announcement days. Note that neither stock risk premium to variance risk (β_1) or stock risk premium to covariance risk (δ_1) are significantly different from 0 on regular trading days. On the other hand, bond risk premium to covariance risk (δ_{22}) is significantly positive on PPI announcement days in both models. In fact, on PPI announcement days, a change of 1% in covariance results in a change of about 0.65% to 0.67% to any of the bond returns. Note that bond risk premium to covariance risk is usually significantly negative (δ_2 is about –0.21%).

This suggests that on regular trading days, excess returns decrease (increase) for a positive (negative) change in covariance.

Finally, most of the remaining significant relations involve the S&P 500/30-year bonds. We see that β_{11} is significantly positive in the two bivariate GARCH models involving the S&P 500/30-year bond returns which imply that there is significantly positive shift in the stock risk premium to stock specific risk on employment report announcement days.

Pooled Macroeconomic Variables Models

Finally, we also pool the employment report, PPI and industrial production announcements together and report the results for model 2. First, with the exception of model 2-C, the likelihood ratio statistics indicate (from tables 9 and 8) that we can reject the null hypothesis that the restrictions apply at the 5% level or less. This means that the macroeconomic announcements are a source of temporary regime shifts for the period starting from October 1979 through July 2000.

Furthermore, there is a significantly positive change in the stock risk premium to volatility risk on announcement days (β_{11} ranges from .116 to .138). This suggests that stocks exhibit a specific component of risk to the macroeconomic variables, which is rewarded by market participants.

Also, it seems that the risk premium on covariance risk for bonds increases on macroeconomic release days as δ_{21} is usually significantly positive. This is even more true for models that include the S&P 500 and the 10-year notes. Note that there is a significant relationship between bond excess returns and bond returns covariance with stock returns on regular trading days.

While some macroeconomic variables are more important than others, the release date in the month is also important. In fact, the employment report, which is generally considered to be the most important macroeconomic variable in the literature and in the financial community, is normally the first government news about the health of the economy to be released in a given month. It is usually followed by the PPI, which is released before industrial production. Thus, we might hypothesize that earlier releases can be used to predict later releases, which would explain why later releases, and more specifically industrial production, seem to be less important. However, this does not explain why PPI releases induce a larger change in the risk premium to variance and covariance risks than employment report releases.

IV. Modeling Conditional Variance and Conditional Covariance

Earlier we examined the association between macroeconomic news announcments and **unconditional volatility** for equities and bonds. In this section, we investigate whether or not macroeconomic news announcements induce changes in time-varying **conditional variance and/or conditional covariances**. Our dependent variables in the analyses are the derived estimates of logs of the conditional variance and covariances from the Bivariate GARCH-M models estimated above (models 1 to 3).[8] Our independent variables include the

[8] Since some of the fitted conditional covariances are negative, we added a constant (11) to each estimate, to ensure that their logs could be defined (the lowest conditional covariance estimate was –10.4).

indicator variables for the employment report, PPI, and industrial production. To capture the autocorrelated component of the conditional variance (as well as covariance), we also include the first lag of the dependent variable, in the respective equation. Finally, we use the NYSE trading volume as independent variable consistent with Crouch (1970), Karpoff,(1987), Smirlock et al.(1988) and Lamoureux and Lastrapes (1990), to capture possible volatility changes caused by trading per se, independent of information effects.[9] Since both volume and volatility may be jointly endogenous, we have also conducted the analyses using an instrumental variable approach. In particular, the trading volume estimates are orthogonalized with the volatility estimates by including three lag values of the trading volume and the dummy variable for the announcments as instrumental variables.

Plots of conditional variances and conditional covariances of models 1A, 1B, and 1C are shown in Figures 1 to 3 respectively. The conditional variance of the 5-year notes returns is the least volatile series of the four securities, while the conditional variance of the S&P 500 returns is the most volatile series. The conditional covariance of stock and 5-year notes (10 -year notes) returns and the conditional variance of 5-year notes (10-year note) returns are of the same order of magnitude. The period from the end of 1991 to the end of 1997 experienced relatively low volatility for each series. Finally, there is no specific trend in the three graphs.

Since each multivariate GARCH model generates two conditional variance series and one conditional covariance series, we have nine linear regressions to estimate for each Bivariate

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[9] We set October 1, 1979 as our base period (i.e., the NYSE volume is set to 1 on October 1, 1979); trading volume is subsequent days is set as a fraction of this basis.

GARCH model. The results are very similar, irrespective of the Bivariate GARCH specification adopted. For the sake of parsimony, we present the results for the conditional variances/covariances derived from Model 1 in Table 10 which separates the macro announcement indicator variables in the GARCH mean equations.

The estimated equation is:

$$H_{ij,t} = \rho_0 + \rho_1 X_{t-1} + \rho_2 DEMP_t + \rho_3 DPPI_t + \rho_4 DIND_t + \rho_5 Volume_t + e_t \qquad (7)$$

where, Hij,t is the conditional variance and covariance series, X_{t-1} is lagged value of the dependent variable, $DEMP_t$ is the employment indicator , $DPPI_t$ is the Producer Price Index indicator, $DIND_t$ is the Industrial Production Indicator, and e_t is a random error term . The The indicator variables are equal to one on the announcement days, and zero otherwise.

We reported earlier that employment report and PPI releases have a greater impact relative to industrial production releases on the **unconditional volatility** of bond and stock returns We also found that the **unconditional covariances** double on employment report release dates. Conditional variances and covariances follow a similar pattern. First, we note that we can reject the null hypothesis that all coefficient estimates are not significantly different from zero as the F statistics are higher than the critical value at the 1% significant level. The goodness of fit (measured by adjusted R^2) are generally quite high for the models, particularly for the models pairing the S&P 500 with five-year and ten-year notes.

It is evident from Table 10 that the employment report is a meaningful explanatory variable for both stock and bond conditional variances. The estimated coefficients are significantly positive at the 5% level or less and range from 0.013 to 0.053. The estimated coefficients for the PPI dummy are significantly positive in most of the stock and bond conditional variance equations at the 10% level or less. However, the PPI is not a significant determinant of time-varying conditional covariance. In addition, we observe that industrial production releases are not a significant source of time-varying conditional volatility. Such releases are also not a significant source of time-varying conditional covariance. Finally, NYSE volume has a positive and significant (at the 1% level) effect on the conditional variance of stock and 30-year bond returns as well as the covariance of stock with each of the 5-, 10-, and 30-year bonds return series.

In summary, employment report and PPI releases do seem to be sources of time-varying conditional volatility for both stock and bond returns, whereas industrial production releases are not found to be a source of unusually high volatility. On the other hand, **none of the announcements (employment report, PPI, or industrial production releases) elicit significant changes in any of the conditional covariances between stock and bond returns. This result is not consistent with the conjecture of JLL (1998) that the conditional covariance between stock and bond returns should fall on macroeconomic announcment days.**

V. Conclusion

The first and second moments of daily returns of both stocks and bonds have been the subject of numerous studies. In this paper, we study the effect of macroeconomic news releases on stock and bond risk premium to variance and covariance risks. We use the employment report, the PPI, and the industrial production announcements as indicator variables.

From our preliminary results, we observe that bonds like stocks earn higher returns when exposed to macroeconomic risks. However, from the multivariate GARCH analysis, we demonstrate that stocks exhibit a change in the risk premium to variance risk on macroeconomic announcement days. From the non-pooled announcement models, we show that most of this effect is due to PPI announcements. Bonds exhibit a significant positive change to their risk premium to covariance risks. These findings suggest that both assets are not rewarded for the same risk factor. In fact, stocks are rewarded for their specific component of risk while bonds are rewarded for the common component of risk they share with stocks. This is in opposition to regular trading days when bonds earn a significantly negative risk premium to covariance risk.

As anticipated, industrial production releases do not appear to have a significant impact on any of the assets examined. More surprisingly, however, is the fact that employment report releases do not seem to have a significant impact on any of the security risk premia. However, employment report and PPI releases do seem to be sources of time-varying conditional volatility for both stock and bond returns. On the other hand, none of the releases (employment, PPI, or industrial production releases) seem to generate significant changes in the conditional covariance of stock and any of the 5-, 10-, and 30-year bond returns. This is in contrast to the JLL (1998) conjecture that the conditional covariance should fall on announcement days.

Of course, we must be cautious in interpreting these results. The analyses herein focused on large aggregative market indices. Specific industry and/or group of stocks (small vs large stocks, defensive vs. aggressive, etc.) may exhibit different patterns. More disaggregative analyses for alternative asset classes remains a topic for future work.

Bibliography

Baillie, R. T., and T. Bollerslev, 1990. A Multivariate Generalized ARCH Approach to modelling Risk Premia in Forward Foreign Exchange Rate Markets. Journal of International Money and Finance 9, 309-2415 pgs.

Bekaert, G., Harvey, C.R., 1995. Time-varying world market integration. Journal of Finance 5, 403-445.

Berndt, E.K., Hall, B.H., Hall, R.E., and Hausman, R.A., 1974. Estimation and inference in non-linear structural models,. Annals of Economic and Social Measurement 3, 653-66.

Bollerslev, T., 1986. Generalized Autoregressive Conditional Heteroskedasticity, Journal of Econometrics 31 307-328.

Bollerslev, T., Cai, J., Song, F. M., 2002. Intraday periodicity, long memory volatility, and macroeconomic announcement effects in the US Treasury bond market, Journal of Empirical Finance 7, 37-55.

Brown, M.B. and Forsythe, A.B., 1974. Robust Tests for the Equality of Variances, Journal of the American Statistical Association 69, 364-368.

Chan, K.C., Karolyi, G.A., Stulz, R., 1992. Global financial markets and the risk premium on US equity. Journal of Financial Economics 32, 137-168.

Connolly, R. A., 1989. An Examination of the Robustness of the Weekend Effect, Journal of Financial and Quantitative Analysis 24, 133-170.

Connolly, R. A., Stivers, C. T., 2000. Evidence on the Economics of Equity Return Volatitility Clustering, Working Paper University of Carolina, Chapel Hill.

Crouch, R.L.,1970. The volume of transactions and price changes on the New York Stock Exchange, Financial Analyst Journal 26, 104-110.

Donders, M., Vorst, T., 1996. The impact of firm specific news on implied volatilities. Journal of Banking & Finance 20, 1447-62.

Doukas, J., Switzer, L. N., 2000. Common stock returns and international listing announcements: Conditional tests of the mild segmentation hypothesis. Journal of Banking & Finance 24, 471-503.

Ederington, L. H, Lee, J. H., 1993. How markets process information: New releases and volatility. Journal of Finance 48, 1161-92.

______________________, 1995. The short-run dynamics of the price adjustment to new information. Journal of Financial and Quantitative Analysis 30, 117-34.

_______________________, 1996. The creation and resolution of market uncertainty: The impact of information releases on implied volatility. Journal of Financial and Quantitative Analysis 31, 513-540.

Engle, R., Lilien, D., Robins, R., 1987. Estimating time-varying risk premia in the tem structure: The ARCH-M model. Econometrica 55, 391-408.

Engle, R.F., Kroner, K. F., Multivariate Simultaneous Generalized ARCH, Econometric Theory, 1995, Vol. 11, pg. 122, 29 pgs.

Fleming, J., Kirby, C., Ostdiek, B., 1998. Information and volatility linkages in the stock, bond, and money markets. Journal of Financial Economics 49, 111-139.

Hardouvelis, G. A., 1988. Economic News, Exchange Rates and Interest Rates. Journal of International Money and Finance7, 23-36.

________________,1987. Macroeconomic information and stock prices. Journal of Economics and Business 39, 131-141.

Ibbotson and Associates, Stocks, bonds, bills, and inflation yearbook, Ibbotson Associates, Chicago, 1994.

Jain, P. G., 1988. Response of hourly stock prices and trading volume to economic news. Journal of Business 61,219-42.

Jones, C., M. Lamont, O., and R.L. Lumsdaine, 1998. Macroeconomic news and bond market volatility. Journal of Financial Economics 47, 315-337.

Karpoff, J. M., 1987. The Relation between Price Changes and Trading Volume: A Survey,. Journal of Financial and Quantitative Analysis 22, 109-137.

Lamoureux, C. G., Lastrapes, W. D., 1990. Heteroskedasticity in stock return data: Volume versus GARCH effects. Journal of Finance 45, 221-230.

Longin, F., Solnik, B., 1995. Is correlation in international equity returns constant: 1960-1990? Journal of International Money and Finance 14, 3- 27.

McQueen G. and V.V. Roley, 1993. Stock Prices, News, and Business Conditions. Review of Financial Studies 6, 683-707.

Racine, M. D., Ackert, L. F., 2000. Time-Varying Volatility in Canadian and U.S. Stock Index and Index Futures Markets: A Multivariate Analysis. Journal of Financial Research. 23, 129-144.

Ross, Stephen, 1989. Information and Volatility: The Non-Arbitrage Martingale Approach to Timing and Resolution Irrelevancy, Journal of Finance 44, 11-17.

Sheskin, David J., 1997. Parametric and Nonparametric Statistical Procedures. CRC Press: Boca Raton, Florida.

Smirlock, M., and Starks, L., 1988. An Empirical Analysis of the Stock Price-Volume Relationship,. Journal of Banking & Finance 12, 31-42.

Table 1: Macroeconomic release dates distribution across days of the week

	Monday	Tuesday	Wednesday	Thursday	Friday	Total
Employment Report	2	0	2	7	238	249
PPI	3	18	18	44	166	249
Industrial Production	21	52	51	28	97	249
Total	26	70	71	79	501	747

Table 2
Panel A: Basic statistics for the period from October 1, 1979 through July 5, 2000

	S&P 500	5-Yr T-Note	10-Yr T-Note	30-Yr T-Bond
Mean excess return (in %)	0.022	0.008	0.011	0.015
Standard deviation	1.037	0.365	0.545	0.761
Covariance with S&P 500		0.095	0.160	0.242
Sharpe Measure	0.022	0.023	0.020	0.020
Minimum	-22.957	-2.484	-3.671	-3.943
Maximum	8.693	3.014	4.692	7.252
Skewness	-2.323	0.233	0.167	0.140
Kurtosis	51.481	6.768	4.741	3.712
Jarque Bera Statistic	576587	9965	4891	3000
Number of observations	5197	5197	5197	5197
Mean excess returns on announ. Days (in %)	0.684	0.328	0.473	0.693
Mean excess returns on non-announ. Days (in %)	0.430	0.121	0.114	0.099

Table 2
Panel B: Autocorrelation of Excess Return Series, Squared Excess Returns, and Absolute Excess Returns

	S&P 500			5-yr Note			10-yr Note			30-yr Bond		
	XR	XRSQ	XRABS	XR	XRSQ	XRABS	XR	XRSQ	XRABS	XR	XRSQ	XRABS
ρ1	0.017	0.115**	0.190***	0.104**	0.160***	0.183***	0.077**	0.124**	0.150***	0.048*	0.041*	0.063*
ρ2	-0.023	0.145***	0.167***	0.034*	0.157***	0.207***	0.030*	0.174***	0.194***	0.032*	0.098**	0.108**
ρ3	-0.046*	0.073*	0.158***	-0.009	0.104**	0.172***	-0.011	0.114**	0.163***	-0.003	0.069*	0.114**
ρ4	-0.020	0.018	0.135***	-0.023	0.145***	0.206***	-0.033*	0.133***	0.186***	-0.023	0.097**	0.133***
ρ5	0.018	0.135***	0.186***	0.025	0.136***	0.197***	0.022	0.130***	0.175***	-0.001	0.071*	0.123**
ρ6	-0.005	0.030*	0.136***	0.026*	0.109**	0.161***	0.007	0.124**	0.169***	-0.001	0.084**	0.124**
ρ7	-0.026*	0.009	0.098**	0.043*	0.148***	0.179***	0.033*	0.142***	0.149***	0.024	0.095**	0.110**
ρ8	0.006	0.055*	0.138***	0.023	0.139***	0.173***	0.000	0.114**	0.152***	0.017	0.081**	0.101**

Note:
* Significantly higher (or lower) from variance on average trading days at 10%
** Significantly higher (or lower) from variance on average trading days at 5%
*** Significantly higher (or lower) from variance on average trading days at 1%
XR = Excess Returns: XRSQ = Squared Excess Returns; XRABS = Absolute Excess Returns

Table 2

Panel C: Cross-correlation of Excess Return, Squared Excess Return and Absolute Excess Returns

	S&P 500				5-yr	Note		10-yr	Note		30-yr	Bond
Lag	XR	XRSQ	XRABS	XR	XRSQ	XRABS	XR	XRSQ	XRABS	XR	XRSQ	XRABS
8				0.012	0.003	0.014	0.005	0.005	0.025*	0.000	0.005	0.029*
7				0.022	0.007	0.017	0.013	0.012	0.030*	0.016	0.018	0.037*
6				0.013	0.019	0.044*	0.013	0.021	0.058*	0.007	0.007	0.041*
5				0.014	0.015	0.057*	0.009	0.021	0.070*	0.009	0.024	0.074*
4				-0.028*	0.048*	0.061*	-0.030*	0.062*	0.078**	-0.031*	0.081**	0.085**
3				0.021	0.024	0.031*	0.011	0.033*	0.042*	0.001	0.027*	0.032*
2				0.032*	0.018	0.043*	0.023	0.025*	0.057*	0.020	0.036*	0.068*
1				0.072*	0.041*	0.045*	0.067*	0.052*	0.047*	0.055*	0.069*	0.050*
0				0.251*	0.064*	0.193***	0.283***	0.066*	0.217***	0.306***	0.072*	0.222***
-1				-0.007	0.302***	0.085**	-0.004	0.382***	0.109**	-0.006	0.502***	0.117**
-2				-0.032*	0.023	0.045*	-0.018	0.029*	0.062*	-0.004	0.030*	0.059*
-3				-0.031*	0.042*	0.029*	-0.040*	0.079**	0.048*	-0.033*	0.087**	0.061*
-4				-0.020	0.009	0.041*	-0.025*	0.015	0.055*	-0.029*	0.024	0.072*
-5				-0.016	0.029*	0.049*	-0.013	0.034*	0.070*	-0.014	0.046*	0.088**
-6				0.024	0.003	0.031*	0.019	0.011	0.045*	0.022	0.011	0.048*
-7				-0.009	-0.000	0.021	-0.002	0.006	0.031*	-0.008	0.010	0.037*
-8				-0.015	0.005	0.025*	-0.021	0.011	0.046*	-0.020	0.006	0.047*

Notes:
* Significantly higher (or lower) from variance on average trading days at 10%
** Significantly higher (or lower) from variance on average trading days at 5%
*** Significantly higher (or lower) from variance on average trading days at 1%
XR = Excess Returns: XRSQ = Squared Excess Returns; XRABS = Absolute Excess Returns

Table 3: Basic Statistics on Announcement and Post Announcement Days
Period: October 1, 1979 through July 5, 2000

Panel A: Employment Report Announcements

	S&P 500	5-year note	10-year note	30-year bond
Announcement days				
Daily mean excess return (in%)	0.068	0.049	0.061	0.069
Standard Deviation	1.097[a]	0.529[c]	0.766[c]	1.034[c]
Covariance		0.196	0.313	0.483
Sharpe	0.062	0.092	0.080	0.067
Post-announcement days				
Daily mean excess return (in%)	-0.099	-0.016	-0.022	-0.025
Standard Deviation	1.022	0.417[c]	0.612[c]	0.857[c]
Covariance		0.162	0.245	0.342
Sharpe	-0.097	-0.039	-0.036	-0.030

[a] Significantly higher (or lower) from volatility on average trading days at 10%
[b] Significantly higher (or lower) from volatility on average trading days at 5%
[c] Significantly higher (or lower) from volatility on average trading days at 1%

Panel B: PPI Announcements

	S&P 500	5-year note	10-year note	30-year bond
Announcement days				
Daily mean excess return (in%)	0.063	0.070	0.099	0.146
Standard Deviation	1.168[c]	0.415[c]	0.644[c]	0.869[c]
Covariance		0.153	0.253	0.337
Sharpe	0.054	0.170	0.154	0.168
Post-announcement days				
Daily mean excess return (in%)	-0.061	0.006	0.021	0.017
Standard Deviation	1.805[c]	0.404[c]	0.572	0.808[a]
Covariance		0.012	0.049	0.169
Sharpe	-0.034	0.015	0.036	0.021

[a] Significantly higher (or lower) from volatility on average trading days at 10%
[b] Significantly higher (or lower) from volatility on average trading days at 5%
[c] Significantly higher (or lower) from volatility on average trading days at 1%

Panel C: Industrial Production Announcements

	S&P 500	5-year note	10-year note	30-year bond
Announcement days				
Daily mean excess return (in%)	0.057	0.037	0.056	0.057
Standard Deviation	1.052	0.360	0.525	0.727
Covariance		0.067	0.128	0.212
Sharpe	0.054	0.102	0.106	0.078
Post-announcement days				
Daily mean excess return (in%)	-0.065	0.000	0.014	0.011
Standard Deviation	1.760[c]	0.406[c]	0.621[c]	0.849[c]
Covariance		0.032	0.086	0.210
Sharpe	-0.037	0.000	0.022	0.012

[a] Significantly higher (or lower) from volatility on average trading days at 10%
[b] Significantly higher (or lower) from volatility on average trading days at 5%
[c] Significantly higher (or lower) from volatility on average trading days at 1%

Table 4: Median equality test for the S&P 500, 5-. 10-, and 30-year bonds returns: Post-, and announcement days vs nonannouncement days

Wilcoxon/Mann-Whitney tie-adj. (one-tailed test)				
Employment Report	**S&P 500**	**5-year note**	**10-year note**	**30-year bond**
Announcement	0.65	0.87	1.05	1.06
Post-Announcement	1.00	1.05	0.58	0.55
PPI	**S&P 500**	**5-year note**	**10-year note**	**30-year bond**
Announcement	1.25	2.37***	2.42***	2.99***
Post-Announcement	1.93**	1.51*	1.44*	0.65
Industrial Production	**S&P 500**	**5-year note**	**10-year note**	**30-year bond**
Announcement	1.40*	1.70**	1.96**	1.58*
Post-Announcement	0.23	0.30	0.80	0.32

*** Significantly higher (or lower) from variance on nonannouncement days at 1%
** Significantly higher (or lower) from variance on nonannouncement days at 5%
* Significantly higher (or lower) from variance on nonannouncement days at 10%

Table 5: Variance equality test for the S&P 500, 5-. 10-, and 30-year bonds returns: announcement, and Post announcement days vs nonannouncement days

Brown-Forsythe (one-tailed test)				
Employment Report	**S&P 500**	**5-year note**	**10-year note**	**30-year bond**
Announcement	2.61**	79.78***	68.20***	65.27***
Post-Announcement	0.73	2.17*	1.72*	1.01
PPI	**S&P 500**	**5-year note**	**10-year note**	**30-year bond**
Announcement	1.50	14.63***	19.24***	17.35***
Post-Announcement	4.64**	1.96*	1.57*	3.93**
Industrial Production	**S&P 500**	**5-year note**	**10-year note**	**30-year bond**
Announcement	0.26	1.44	0.03	0.11
Post-Announcement	3.38**	1.23	1.76*	3.36**

*** Significantly higher (or lower) from variance on nonannouncement days at 1%
** Significantly higher (or lower) from variance on nonannouncement days at 5%
* Significantly higher (or lower) from variance on nonannouncement days at 10%

Table 6 A: Mean daily excess return of the S&P 500, 5-. 10-, and 30-year bonds on announcement days classified by days of the week

	S&P 500	5-year note	10-year note	30-year bond
Monday	0.186	(0.001)	0.033	0.111
Tuesday	0.075	0.091	0.145	0.213
Wednesday	0.200	0.009	0.029	0.022
Thursday	0.189	0.063	0.108	0.168
Friday	0.040	0.039	0.043	0.053

Table 6 B: Mean test for the S&P 500, 5-. 10-, and 30-year bonds returns

	S&P 500	5-year note	10-year note	30-year bond
Monday	1.733	0.072	0.591	1.455
	(0.083)	(0.942)	(0.554)	(0.146)
Tuesday	1.083	3.971	4.242	4.453
	(0.279)	(0.000)	(0.000)	(0.000)
Wednesday	3.029	0.342	0.848	0.430
	(0.003)	(0.737)	(0.397)	(0.667)
Thursday	3.044	2.966	3.417	3.787
	(0.002)	(0.003)	(0.001)	(0.000)
Friday	1.246	3.422	2.682	2.415
	(0.213)	(0.001)	(0.007)	(0.016)

Note: The mean test performed is a T-test. It tests if S&P500, 5-, 10-, and 30-year bond returns on announcement days, classified by weekdays, are significantly different from average returns. We present the test statistics and p-values (in parenthesis).

Table 6 C: Median test for the S&P 500, 5-. 10-, and 30-year bonds returns

	S&P 500	5-year note	10-year note	30-year bond
Monday	1.561	0.254	0.834	1.178
	(0.119)	(0.799)	(0.404)	(0.239)
Tuesday	0.452	2.518	2.843	2.672
	(0.651)	(0.012)	(0.005)	(0.008)
Wednesday	2.151	0.486	1.057	0.897
	(0.032)	(0.627)	(0.291)	(0.370)
Thursday	1.904	2.134	2.241	2.843
	(0.057)	(0.033)	(0.025)	(0.005)
Friday	1.387	1.258	0.971	1.015
	(0.165)	(0.209)	(0.332)	(0.310)

Note: The median test performed is the Wilcoxon/Mann-Whitney test. It tests if the median S&P500, 5-, 10-, and 30-year bond returns on announcement days, classified by weekdays, are significantly different from average returns. We present the test statistics and p-values (in parenthesis).

Table 7
Multivariate GARCH-M estimates of Model 1

Estimates of a bivariate model of daily excess stock returns and U.S. bond market returns,
Oct. 1, 1979-July 5, 2000

The stock index used is the S&P 500. The bond indices are the 5 and 10 year U.S. Treasury Notes and the 30 year U.S. Treasury Bond. The excess returns $r_{Stocks,t}$, and $r_{Bonds,t}$, are calculated as returns net of the daily three-month U.S.Treasury bill yield. The market weights $w_{Stocks,t}$ and $w_{Bonds,t}$ are market weights computed as daily interpolations from monthly data from Morgan Stanley Capital International and DRI-WEFA and sum to unity in each regression. The indicator variables Emp_t, PPI_t, and Ind_t are equal to one on the employment report, the PPI, and Industrial Production release dates respectively, and zero otherwise.Robust t-statistics computed with quasi-maximum likelihood estimates are shown below the coefficient estimates, along with the p-values parentheses. One (two) asterisk(s) indicates significant at .05 (.10) level. The model parameters are from the following equations:

$$R_{Stocks,t} = \alpha_{10} - (\beta_1 + \beta_{11}*Emp_t + \beta_{12}*PPI_t + \beta_{13}*Ind_t)w_{Stocks,t}h_{Stocks,t} - (\delta_1 + \delta_{11}*Emp_t + \delta_{12}*PPI_t + \delta_{13}*Ind_t)*(1-w_{Stocks,t})h_{Stocks\text{-}Bonds,t} + \varepsilon_{Stocks,t} \quad (1)$$

$$R_{Bonds,t} = \alpha_{20} - (\beta_2 + \beta_{21}*Emp_t + \beta_{22}*PPI_t + \beta_{23}*Ind_t)w_{Bonds,t}h_{Bonds,t} - (\delta_2 + \delta_{21}*Emp_t + \delta_{22}*PPI_t + \delta_{23}*Ind_t)*(1-w_{Bonds,t})h_{Stocks\text{-}Bonds,t} + \varepsilon_{Bonds,t} \quad (2)$$

$$\begin{bmatrix} \varepsilon_{Stocks} \\ \varepsilon_{Bonds} \end{bmatrix} = \varepsilon_t \sim N(0,H_t), H_t = \begin{bmatrix} h_{stocks,t} & h_{Stocks-Bonds,t} \\ h_{Stocks-Bondst} & h_{Bonds,t} \end{bmatrix} = Q'Q + G'H_tG + C'\varepsilon_t\varepsilon_t'C$$

	α_{10}	β_1	δ_1	β_{11}	δ_{11}	β_{12}	δ_{12}	β_{13}	δ_{13}
A - S&P500/5y note	.025	.043	- .870	.051	1.786	0.190*	-2.140	.085	1.632
	1.096	1.445	-1.433	0.545	0.747	2.334	-1.064	1.097	.671
B - S&P500/10y note	0.021	0.040	- .355	0.056	0.690	0.222*	-2.017**	.121	.264
	0.870	1.342	-0.931	0.563	0.439	2.726	-1.695	1 .525	0.176
C - S&P500/30y bond	-0.067	0.101*	.610	.237*	-2.893	0.164*	-3.186*	.005	1.005
	-1.237	2.054	1.167	2.198	-1.496	2.061	-3.033	.058	.649

Table 7 Continued

α_{20}	β_2	δ_2	β_{21}	δ_{21}	β_{22}	δ_{22}	β_{23}	δ_{23}	**Function Value**	**Max log-lik. Ratio**
0.005	0.541**	-0.211*	0.252	0.404**	0.367	0.671*	1.761**	-0.378		
0.770	1.828	-4.544	0.307	1.646	0.359	2.269	1.662	-1.436	1588.471	1254.30
0.012	0.315	-0.201*	0.196	0.245	-0.083	0.658*	0.919	-0.203		
1.032	1.440	-4.278	0.319	0.964	-0.124	2.457	1.238	-0.802	-630.923	24.70
0.106*	-0.404**	-0.384*	0.230	-0.005	0.685	0.651*	-0.066	0.044		
3.298	-1.677	-5.281	0.289	-0.017	1.228	2.246	-0.105	0.136	-2914.389	-138.05

Table 8
Multivariate GARCH-M estimates of Model 2

Estimates of a bivariate model of daily excess stock returns and U.S. bond market returns,
Oct. 1, 1979-July 5, 2000

The stock index used is the S&P 500. The bond indices are the 5 and 10 year U.S. Treasury Notes and the 30 year U.S. Treasury Bond. The excess returns $r_{Stocks,t}$, and $r_{Bonds,t}$, are calculated as returns net of the daily three-month U.S.Treasury bill yield. The market weights $w_{Stocks,t}$ and $w_{Bonds,t}$ are market weights computed as daily interpolations from monthly data from Morgan Stanley Capital International and DRI-WEFA and sum to unity in each regression. The indicator variable Dum_t, is equal to one on the employment report, the PPI, or ndustrial Production release dates, and zero otherwise. Robust t-statistics computed with quasi-maximum likelihood estimates are shown below the coefficient estimates, along with the p-values parentheses. One (two) asterisk(s) indicates significant at .05 level. The model parameters are from the following equations:

$$R_{Stocks,t} = \alpha_{10} - (\beta_1 + \beta_{11}*Dum_t)w_{Stocks,t}h_{Stocks,t} - (\delta_1 + \delta_{11}*Dum_t)(1-w_{Stocks,t})h_{Stocks\text{-}Bonds,t} + \varepsilon_{Stocks,t} \quad (3)$$

$$R_{Bonds,t} = \alpha_{20} - (\beta_2 + \beta_{21}*Dum_t)w_{Bonds,t}h_{Bonds,t} - (\delta_2 + \delta_{21}*Dum_t)(1-w_{Bonds,t})h_{Stocks\text{-}Bonds,t} + \varepsilon_{Bonds,t} \quad (4)$$

$$\begin{bmatrix} \varepsilon_{Stocks} \\ \varepsilon_{Bonds} \end{bmatrix} = \varepsilon_t \sim N(0,H_t), H_t = \begin{bmatrix} h_{stocks,t} & h_{Stocks-Bonds,t} \\ h_{Stocks-Bondst} & h_{Bonds,t} \end{bmatrix} = Q'Q + G'H_tG + C'\varepsilon_t\varepsilon_t'C$$

Model 2: One dummy that is equal to 1 when the employment report and/or the PPI and/or the Industrial Production is/are released.											Function Value	Max log-likelihood Ratio
	α_{10}	β_1	δ_1	β_{11}	δ_{11}	α_{20}	β_2	δ_2	β_{21}	δ_{21}		
A - S&P500 and 5-year note	0.024	0.043	-0.818	0.116*	0.748	0.005	0.587*	-0.214*	0.627	0.308**		
	1.045	1.456	-1.366	2.117	0.514	0.719	2.001	-4.673	1.067	1.868	1581.625	1240.610
B - S&P500 and 10-year note	0.020	0.040	-0.341	0.138*	-0.212	0.012	0.355	-0.206*	0.180	0.309**		
	0.850	1.349	-0.904	2.501	-0.242	0.991	1.633	-4.406	0.431	1.900	-636.782	12.978
C - S&P500 and 30-year bond	-0.089*	0.171*	-0.267	0.118*	0.176	0.007	0.239	-0.068	0.096	-0.020		
	-2.332	4.529	-0.813	2.223	0.313	0.260	1.586	-0.763	0.299	-0.144	-2859.802	-28.877

Table 9
Multivariate GARCH-M estimates of Model 3 (Restricted Model)
Estimates of a bivariate model of daily excess stock returns and U.S. bond market returns,
Oct. 1, 1979-July 5, 2000

The stock index used is the S&P 500. The bond indices are the 5 and 10 year U.S. Treasury Notes and the 30 year U.S. Treasury Bond. The excess returns $r_{Stocks,t}$, and $r_{Bonds,t}$, are calculated as returns net of the daily three-month U.S.Treasury bill yield. The market weights $w_{Stocks,t}$ and $w_{Bonds,t}$ are market weights computed as daily interpolations from monthly data from Morgan Stanley Capital International and DRI-WEFA and sum to unity in each regression. Robust t-statistics computed with quasi-maximum likelihood estimates are shown below the coefficient estimates, along with the p-values parentheses. An asterisk indicates significant at .05 level. The model parameters are from the following equations:

$$R_{Stocks,t} = \alpha_{10} - (\beta_1)w_{Stocks,t}h_{Stocks,t} - (\delta_1)(1-w_{Stocks,t})h_{Stocks\text{-}Bonds,t} + \varepsilon_{Stocks,t} \quad (5)$$

$$R_{Bonds,t} = \alpha_{20} - (\beta_2)w_{Bonds,t}h_{Bonds,t} - (\delta_2)(1-w_{Bonds,t})h_{Stocks\text{-}Bonds,t} + \varepsilon_{Bonds,t} \quad (6)$$

$$\begin{bmatrix} \varepsilon_{Stocks} \\ \varepsilon_{Bonds} \end{bmatrix} = \varepsilon_t \sim N(0, H_t), H_t = \begin{bmatrix} h_{stocks,t} & h_{Stocks-Bonds,t} \\ h_{Stocks-Bondst} & h_{Bonds,t} \end{bmatrix} = Q'Q + G'H_tG + C'\varepsilon_t\varepsilon_t'C$$

Model 3: Restricted Models							
	α_{10}	β_1	δ_1	α_{20}	β_2	δ_2	Function Value
A - S&P500/5y note	0.074*	-0.077*	0.105	-0.007	0.110	0.167*	
	3.355	-3.167	0.145	-0.707	0.284	2.213	961.320
B - S&P500/10y note	0.020	0.055*	-0.338	0.012	0.388**	-0.175*	
	0.882	1.991	-0.935	1.049	1.870	-4.058	-643.271
C - S&P500/30y bond	0.025	0.032	-0.303	-0.008	0.044	0.074	
	0.772	0.921	-0.980	-0.325	0.216	1.314	-2845.363

Table 10: Conditional Variance /Covariance Regressions with Three Indicator Variables

OLS estimates of $H_{ij,t} = \rho_0 + \rho_1 X_{t-1} + \rho_2 DEMP_t + \rho_3 DPPI_t + \rho_4 DIND_t + \rho_5 Volume_t + e_t$ (7)
where, Hij,t is the estimated conditional variance and covariance series (from model 1), X_{t-1} is lagged value of the dependent variable, $DEMP_t$ is the employment dummy, $DPPI_t$ is the Producer Price Index dummy, $DIND_t$ is the Industrial Production Dummy, and e_t is a random error term ; t statistics and p-values are shown below the coefficient estimates.

	Constant	X(t-1)	DEMP	DPPI	DIND	Volume	R Bar**2	F(5,5188)	p-value
Panel A - Dependent Variables are the conditional variances and covariance of model 1A									
S&P 500 Variance	**-0.018**	**0.969**	**0.017**	**0.019**	-0.001	**0.001**			
	-5.966	292.710	1.967	2.077	-0.102	5.290	0.946	18135.793	0.000
	0.000	0.000	0.049	0.038	0.919	0.000			
5-year note Variance	**-0.016**	**0.995**	**0.055**	**0.011**	0.006	0.000			
	-4.538	620.465	12.458	2.501	1.341	0.695	0.989	92527.049	0.000
	0.000	0.000	0.000	0.012	0.180	0.487			
Covariance	**0.254**	**0.895**	0.000	0.000	0.000	**0.000**			
	17.211	146.338	0.634	0.480	-0.361	-6.530	0.824	0.824	0.000
	0.000	0.000	0.526	0.631	0.718	0.000			
Panel B - Dependent Variables are the conditional variances and covariance of model 1B									
S&P 500 Variance	**-0.017**	**0.971**	**0.017**	**0.020**	-0.001	**0.001**			
	-5.842	305.117	2.025	2.251	-0.134	5.203	0.950	19648.819	0.000
	0.000	0.000	0.043	0.024	0.894	0.000			
10-year note Variance	**-0.015**	**0.992**	**0.048**	**0.015**	0.001	0.000			
	-5.470	534.204	10.525	3.373	0.163	0.823	0.984	62984.517	0.000
	0.000	0.000	0.000	0.001	0.871	0.411			
Covariance	**0.284**	**0.883**	0.001	0.000	0.000	**0.000**			
	18.201	136.799	0.855	0.479	-0.217	-6.602	0.803	4238.603	0.000
	0.000	0.000	0.393	0.632	0.828	0.000			
Panel C - Dependent Variables are the conditional variances and covariance of model 1C									
S&P 500 Variance	**-0.022**	**0.913**	**0.021**	**0.020**	0.004	**0.002**			
	-5.994	164.296	1.936	1.772	0.339	6.187	0.849	5847.092	0.000
	0.000	0.000	0.053	0.076	0.734	0.000			
30-year note Variance	**-0.179**	**0.664**	**0.013**	**0.007**	-0.001	**0.000**			
	-32.353	64.095	4.576	2.406	-0.445	3.637	0.446	836.690	0.000
	0.000	0.000	0.000	0.016	0.656	0.000			
Covariance	**0.937**	**0.613**	0.000	0.000	0.001	**0.000**			
	35.303	55.957	-0.012	-0.116	0.185	-3.153	0.379	636.092	0.000
	0.000	0.000	0.991	0.908	0.853	0.002			

Figure 1: Conditional variance and conditional covariance of Model 1A

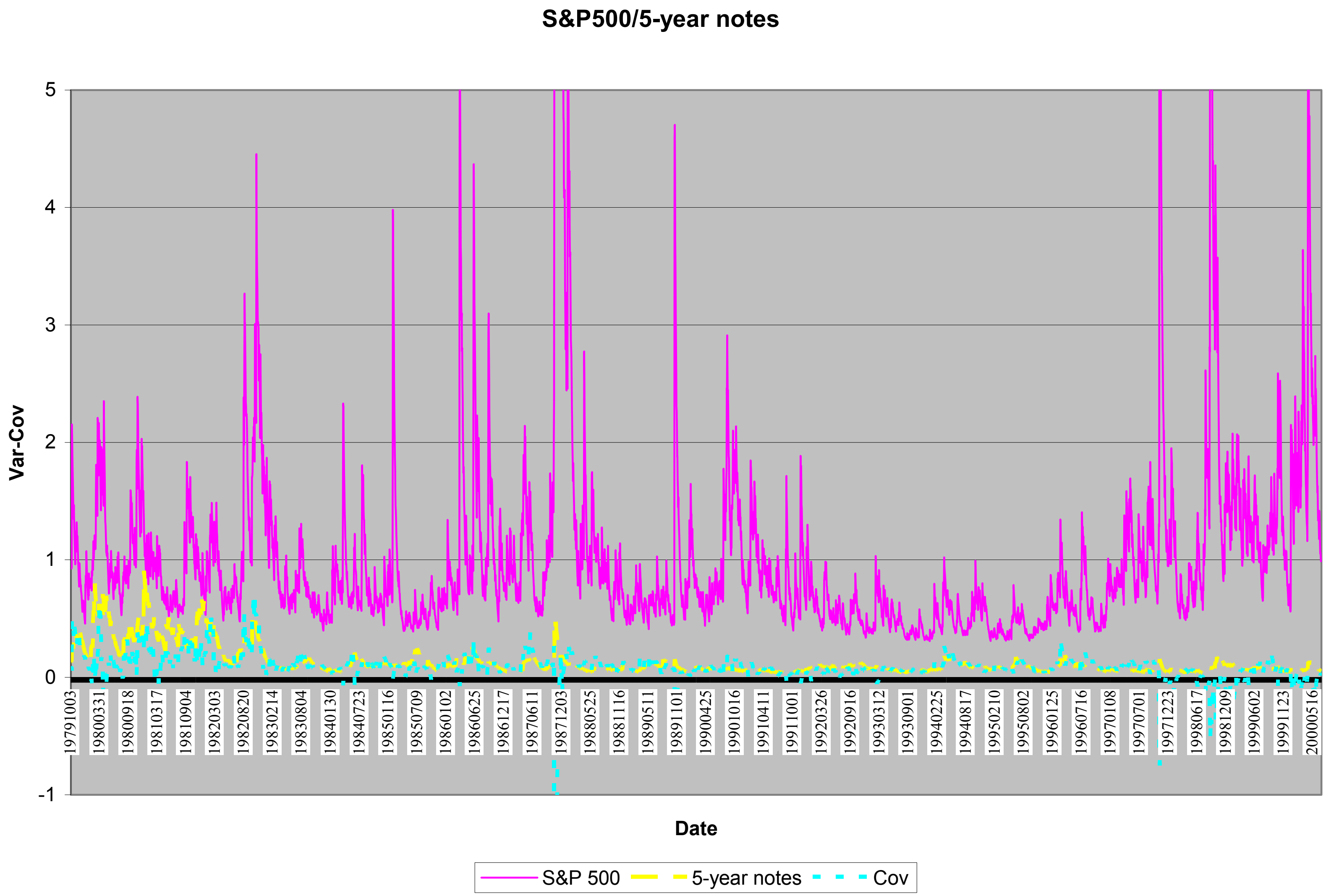

Figure 2: Conditional variance and conditional covariance of Model 1B

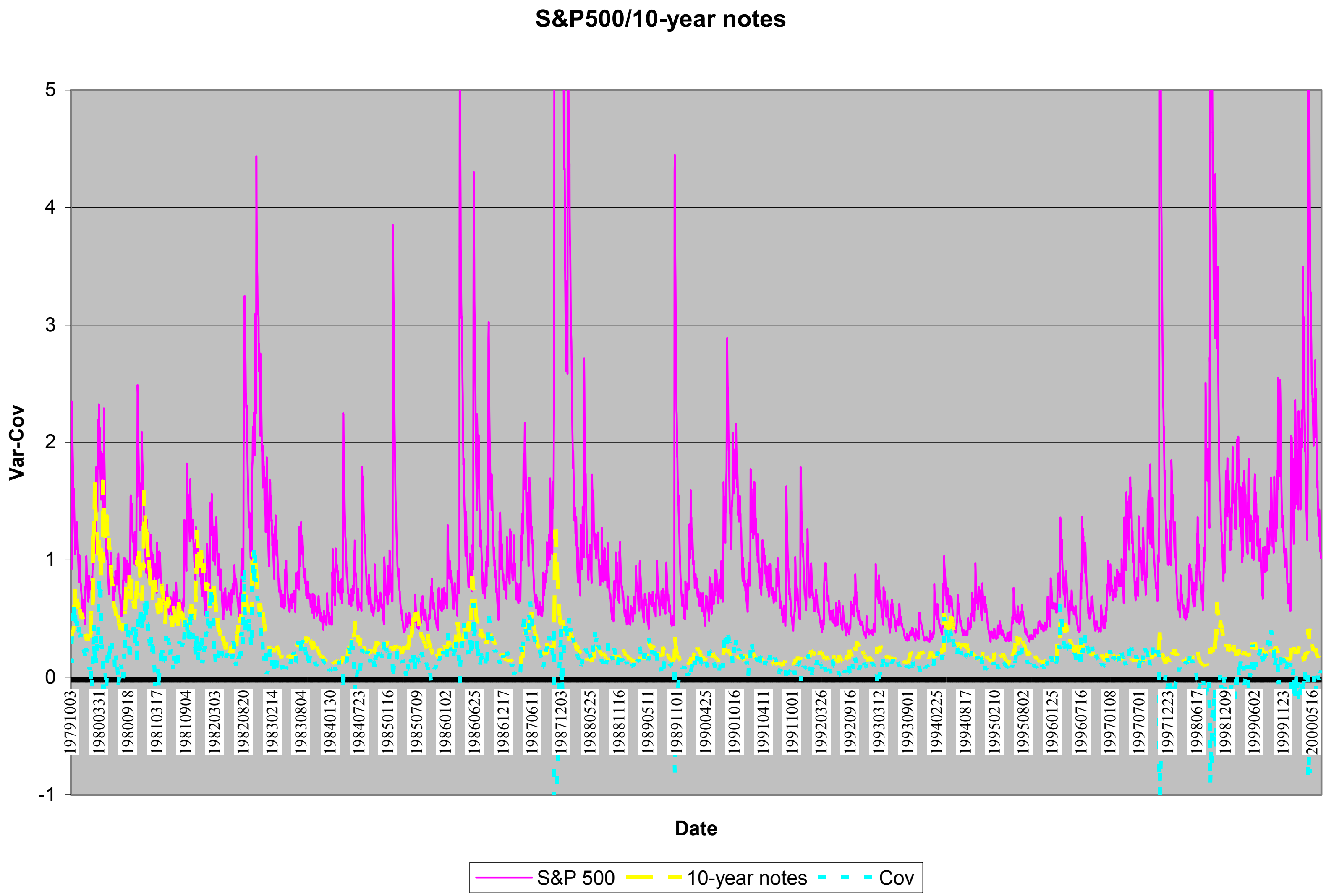

Figure 3: Conditional variance and conditional covariance of Model 1C