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How Much do Investors Care about Macroeconomic Risk?
Evidence from Scheduled Economic Announcements

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Abstract

Stock market returns are significantly higher on days when important macroeconomic news, such as that about inflation, unemployment, or interest rates, is scheduled for announcement. The average announcement day excess return from 1958 to 2008 is 10.6 basis points versus 1.0 basis points for all the other days, suggesting that over 60% of the cumulative annual equity risk premium is earned on announcement days. In contrast, the risk-free rate is detectably lower on announcement days, consistent with a precautionary saving motive. Our results demonstrate the required trade-off between macroeconomic risk and asset returns, and provide an estimate of the premium investors demand to bear this risk.

JEL Classification: G12

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Introduction

The link between macroeconomic risk and security returns is central to financial economics. While a lot of relevant information about the economy arrives randomly over time, certain important macroeconomic news is released in the form of prescheduled announcements, whose dates are known months in advance. Investors don't know what the news will be, but they do know that there will be news. If asset prices respond to this news, the risk associated with holding securities will be higher around announcements. Risk-averse investors who know that they will be exposed to higher risk should then demand, and in equilibrium receive, a higher expected excess return during those times.

Consistent with this general idea, we find that average U.S. stock market returns are significantly higher on days when important macroeconomic news is scheduled to be announced. On days when the Consumer Price Index (CPI), Producer Price Index (PPI), employment figures or Federal Open Market Committee (FOMC) decisions are released, excess market returns average 10.6 basis points (bps) versus only 1.0 bps for all the other days. These figures imply that compensation for bearing macroeconomic announcement risk accounts for a large portion of the equity risk premium, as more than 60% of the cumulative annual excess return is earned on just 13% of the trading days, whose timing is known to investors well in advance. Conversely, the risk premium for holding stocks at other times is very low, with the average excess return on those days not being statistically distinguishable from zero.

Higher risk on announcement days can also affect the risk-free rate. For example, increased risk can raise desired saving by risk-averse investors to insure against adverse states of the world. In equilibrium, increased precautionary saving demand should reduce returns on the risk-free asset, and we find strong support for this prediction. The holding period return on 30-day U.S. Treasury bills (our proxy for the daily risk-free rate) is 0.2 bps lower on announcement days with a t-statistic of 4.43. For longer-term Treasury securities, which are not riskless assets on a daily horizon, the difference between announcement and non-announcement day returns increases monotonically with a bond's maturity, as we would predict if investors expect higher returns on riskier assets on announcement days.

Our results hold over the full 1958-2008 sample (1961-2008 for Treasuries), are almost unchanged in various subsamples, are robust to exclusion of outliers, and hold separately for each type of announcement. They are also not explained by the day-of-the-week effect documented by French (1980) and Gibbons and Hess (1981).

Our findings suggest that macroeconomic risks are important priced factors for stock and bond returns and for risk-free rates. An extensive prior literature, which we discuss below, presents evidence consistent with a higher conditional risk of holding risky financial assets ahead of macroeconomic announcements. In a rational-expectations equilibrium, such higher risk should also be reflected in higher risk premia and, possibly, lower risk-free rates. If so, anticipated macroeconomic events should be periods of high average returns for risky assets and low risk-free rates. For example, if risk-averse investors prefer to avoid inflation risk, then times of inflation announcements must be times of higher average excess returns over a sufficiently long time period (one in which the average surprise equals zero). The contribution of this paper is to show that stock, bond, and risk-free asset returns behave in a manner consistent with announcement risk being priced. The extra return investors demand for bearing this risk is economically large, with our estimates suggesting it accounts for over 60% of the equity risk premium.

A number of papers investigate the sensitivity of realized returns to the news component of scheduled macroeconomic announcements. For instance, a positive inflation shock (an announcement of an inflation number higher than the consensus forecast) may induce a negative contemporaneous stock market return. In the language of factor models, these papers investigate factor betas as opposed to factor risk premia. Formally, given an announcement day surprise z_{t+1}, defined as the difference between the announced number and its forecast, a test asset return r_{t+1} is decomposed into its conditional expectation and its residual:

$$r_{t+1} = E_t[r_{t+1}] + \beta z_{t+1} + \varepsilon_{t+1}. \tag{1}$$

Starting with Schwert (1981), Pearce and Roley (1983), Pearce and Roley (1985), Hardouvelis (1987), Cutler, Poterba, and Summers (1989), Orphanides (1992), McQueen and Roley (1993), Krueger (1996), and Fleming and Remolona (1997) study the responsiveness β of stock or bond returns to various macroeconomic surprises z_{t+1}. More recently, Boyd, Hu, and Jagannathan (2005) explore the sensitivity of security returns to unemployment surprises and find a positive stock market response to news of rising unemployment during economic expansions (a positive β) and a negative response during contractions (a negative β). Andersen, Bollerslev, Diebold, and Vega (2007) use a high-frequency futures data set and get a similar result that the stock market response to macroeconomic news depends on general economic conditions. Bernanke and Kuttner (2005) analyze the impact of FOMC interest rate announcement surprises on stock market returns.

Flannery and Protopapadakis (2002) estimate a direct announcement effect on contemporaneous returns through the sensitivity to announcement news β together with an indirect effect through higher conditional volatility of shocks ε_{t+1} (even if β equals zero) on announcement days. They employ a GARCH model to identify which macroeconomic surprises (out of 17 candidates) influence realized equity returns or their conditional volatility. They come up with three variables (CPI, PPI, and the monetary aggregate) for which there exists a relation between surprises and returns, and only one of those (the monetary aggregate) affects returns both directly and indirectly.[1][2]

By contrast, this study focuses on the effect of prescheduled announcements on expected returns $E_t[r_{t+1}]$. Expected returns are different economic quantities from betas, and we need an equilibrium theory to relate them to each other. We identify the magnitude of the difference between expected returns on announcement days versus expected returns on

[1] The finding that unexpected inflation and money growth negatively affect stock prices is not new. See Bodie (1976), Nelson (1976), Fama and Schwert (1977), Jaffe and Mandelker (1979), Fama (1987), Schwert (1981), Geske and Roll (1983), Pearce and Roley (1983), and Pearce and Roley (1985) for previous studies establishing this relation.

[2] Brenner, Pasquariello, and Subrahmanyam (2009) estimate a similar GARCH framework for stock, Treasury, and corporate bond markets that allows for an announcement day effect on the mean through a variance-in-mean channel, but find no evidence of a positive statistically significant effect on average excess returns.

other days for the stock market, long-term bonds, T-bills, and book-to-market-sorted stock portfolios. As a consequence, we are not directly interested in the announcement surprise z_{t+1} but rather in the average realized return over a long sample. This means we do not need to make assumptions about market expectations for a given variable or even about what exactly constitutes good or bad news at any particular point in time.[3] We also do not need to know the size or sign of β, as long as we accept the results of the earlier studies that find that β is different from zero, and therefore announcement days are periods of higher systematic risk. Jones, Lamont, and Lumsdaine (1998) adopt a methodology similar to ours and find that both the mean excess returns for long-term Treasury bonds and their volatilities are higher on PPI and employment announcement days.[4]

Our results could be related to the well-known phenomenon of high average stock returns for firms announcing earnings. This earnings announcement premium was first discovered by Beaver (1968) and was subsequently confirmed by Chari, Jagannathan, and Ofer (1988), Ball and Kothari (1991), Cohen, Dey, Lys, and Sunder (2007), and Lamont and Frazzini (2007), who all find that the above-average returns around earnings announcement days do not appear to be explained by increases in risk. Kalay and Loewenstein (1985) obtain the same finding for firms announcing dividends. While potentially similar, our results are easier to interpret in the framework of a rational choice equilibrium, since we do not need to distinguish between the idiosyncratic component of announcement day risk and the systematic component. It is not immediately clear to what extent firm-level announcement risk can be diversified, but macroeconomic announcement risk surely cannot be diversified to any significant extent.

Despite our evidence of a significant announcement day risk premium, we find that realized stock market return volatility is only moderately higher (about 5-8%) on announcement days.

[3] It is not always obvious how the market will interpret a particular macroeconomic shock. For example, if the stock market response to news of rising unemployment depends on current economic conditions, a lower than anticipated number would represent bad news. Similarly, lower than expected inflation in Japan in recent years was not necessarily good news for investors.

[4] We document a similar result in our sample.

The effect on implied volatility is larger than for realized volatility, but the magnitudes are still much lower than those for the difference in returns. We therefore propose an explanation for our results that emphasizes the positive dependence of stock market and long-term bond returns on state variables such as expected long-run economic growth and expected inflation. Intuitively, stocks tend to do particularly badly when news about the state of the economy is very negative, making them much riskier than just their volatility would suggest. A novel prediction here is that long-term bond and stock market returns should move together more on announcement days, which we show to be the case. Our explanation can reconcile the large announcement effect on risk premia with the small effect on observed volatility of stock market returns.

The rest of the paper is organized as follows: Section 1 lists our main predictions and reports our principal results; Section 2 presents additional supporting evidence; and Section 3 concludes. Our model of announcement day risk in an equilibrium endowment economy is given and its predictions are derived in the Appendix.

1. Evidence on Announcement Day Returns

Our intuition is that times around scheduled macroeconomic news announcements are periods of foreseeably higher systematic risk, and that consequently expected excess returns on risky assets should be higher during those periods. In equilibrium, this intuition can also imply that risk-free rates should be lower during the same periods.

In the Appendix, we analyze this idea in a formal model of scheduled announcements in an endowment economy with a single Lucas tree and a single representative investor with recursive preferences, in which inflation and real interest rates are stochastic. The central idea of our model is that investors learn more about the state of the economy on announcement days than on other days. Thus, in the spirit of the Intertemporal Capital Asset Pricing Model of Merton (1973), investors receive a reward not just for bearing market risk but also intertemporal risk, which is correspondingly higher on announcement days.

Risky assets whose returns have high covariance with the state variable therefore earn much higher risk premia around announcements, even if the volatility of their returns is not very different. Such assets include the overall stock market, long-term nominal bonds, and growth stocks (relative to value stocks). Since these assets' returns have a larger common component on announcement days, they should comove more around announcements.

The model in the Appendix shows how this idea can be made consistent with equilibrium by equating Merton's state variable with long-term expected consumption growth in an endowment economy, in the spirit of Bansal and Yaron (2004). Readers who are not concerned with the theoretical issues of how expected returns can vary in equilibrium in general and between announcement and non-announcement days in particular can skip the model and focus on the intuition and results.

1.1. Pre-scheduled Macroeconomic Announcements

We obtain dates of pre-scheduled monthly macroeconomic news announcements from the Bureau of Labor Statistics from 1958 to 2008 and from the Federal Reserve from 1978 to 2008. We have 157 pre-scheduled CPI announcements from January 1958 to January 1971 and 454 for the PPI from February 1971 to December 2008. We drop the CPI after PPI announcements become available in February 1971, since PPI numbers for a given month are always released a few days earlier, thereby diminishing the news content of CPI numbers.[5] We have 609 employment announcements from January 1958 to December 2008. FOMC interest rate announcements start in January 1978 and end in December 2008. We exclude any unscheduled announcements, leaving us with 269 FOMC observations. 51 of the announcement days in our sample had more than one announcement, while a further 23 were non-trading days. The remaining sample contains 1,415 announcement days versus 11,424 non-announcement days. Interestingly, only 29 of the pre-scheduled announcements in our sample were made on a Monday, representing about 2% of overall announcements. In the second half of our sample, there is only one Monday announcement.

[5] Our results are robust to the inclusion of CPI announcements after January 1971.

Our choice of announcement types is primarily dictated by the availability of data. Employment is the first macroeconomic variable whose date is systematically tracked by the Bureau of Labor Statistics (according to data available on its website), followed five years later by the CPI. We need a long sample for our analysis to ensure the average surprise is close to zero, so that announcement day returns do not reflect a period of particularly good or bad news.[6] Moreover, both employment and inflation clearly constitute important macroeconomic news, as do FOMC announcements. See Jones, Lamont, and Lumsdaine (1998), Bernanke and Kuttner (2005), and Boyd, Hu, and Jagannathan (2005) for further evidence of the variables' relevance.

Our measure of stock market return is the daily return on the Center for Research in Security Prices (CRSP) value-weighted NYSE/Nasdaq/Amex all share index, including dividends. To calculate excess returns, we infer a daily risk-free rate from the monthly risk-free rate (obtained from Kenneth French's website), assuming it to be constant over the month. This biases downwards our estimate of the difference in average excess returns between announcement and non-announcement days, since we also find evidence consistent with a lower daily risk-free rate on announcement days.

We obtain daily Treasury bill (T-bill) returns from the CRSP daily Treasuries file starting in June 1961 (the first date available) and ending in December 2008. Our proxy for the overnight risk-free rate is the daily return on the T-bill in the CRSP file with maturity closest to 30 days.[7] Our results do not depend on the exact choice of the number of days until maturity. Between Friday and Monday there is a weekend effect for T-bills, since three days pass between the Friday T-bill price observation and the Monday observation, whereas only one day passes between all other consecutive price observations (excluding holidays). Consequently, the observed log returns should on average be three times higher on Mondays than on any other trading day, as they reflect three days of earned interest rather than just

[6] A long sample should also address potential critiques based on the peso problem hypothesis.

[7] The CRSP file contains very few observations for bonds with initial maturities of less than 6 months. As a result, hardly any of the bills in our sample are on-the-run 30-day T-bills.

one. We therefore raise the gross Monday return to the power of one third to compare Monday returns with those of other days. (This adjustment is not necessary in the case of stock market returns, as the random component dominates the deterministic component due to the passing of time in the case of stocks.) Since Monday is almost never an announcement day, our procedure must distinguish between an announcement day effect on daily T-bill returns and a mere weekend effect.[8]

For Treasury securities with longer maturities, we use returns provided by CRSP's Daily Treasury Fixed Term Indexes File. These returns are meant to reflect the performance of a hypothetical Treasury bond with fixed maturity, and are calculated using a procedure similar to the one we employ for calculating our daily risk-free rate.

We obtain constant-maturity 30-day implied volatility from the CBOE S&P 100 Vix index, available daily beginning in 1986. These volatilities are then squared to convert them into variances, and the daily difference from market close to market close is calculated. Estimates of the change in stock market risk based on prices at a point in time such as implied volatilities could be more accurate than estimates based on realized volatility. It is quite likely that the window of high risk around an announcement is considerably shorter than one whole day. Even so, our estimates of the difference in risk based on daily data (either implied or realized volatilities) are consistent and unbiased, provided that intraday stock market price increments are independent.

1.2. Stock Market Excess Returns

Table 1 presents our main result: the average excess return on the stock market is 10.6 bps on announcement days versus 1.0 bps on other days. The difference between the returns on the two kinds of days averages 9.6 bps and a t-test for a difference in means (allowing for different variances) gives a t-statistic of 3.53. The non-announcement day returns are not only

[8] Unsurpisingly, our findings are even stronger if we make no corrections to account for the weekend effect in observed daily T-bill returns. This happens because Monday returns are then higher, and Mondays are also very rarely announcement days. Our results are also stronger if we assume a payment lag of one day in the T-bill market, and consequently adjust the Friday return instead of the Monday return.

much lower but are actually not even statistically significant (t-statistic=1.18). Excluding outliers (observations outside the 1st and 99th percentiles of each sample), the average excess returns are 10.9 and 1.2 bps, respectively, with a t-statistic for different means of 4.31, and the non-announcement day returns are still not significant (t-statistic=1.74). This evidence suggests that macroeconomic risks represent important priced factors for stock returns, as the observed equity risk premium is much higher on announcement days.

[**TABLE 1 ABOUT HERE**]

Our hypothesis is that announcement days are fundamentally riskier than other days. The standard deviation of announcement day returns is 96.9 bps versus 92.2 bps for other days (79.5 versus 73.7 excluding outliers), and we can reject the hypothesis of equal variances at the 1% significance level. However, the dispersion of announcement day returns is only 5-8% higher. Furthermore, announcement day returns exhibit about equal skewness as those on other days, and the distribution of announcement day returns has a thinner left tail than the non-announcement day distribution (even excluding the October 1987 market crash, although there is obviously no good reason to exclude such events when evaluating tail risk). It appears that announcement days are not fundamentally riskier simply because the distribution of announcement day returns is less attractive to a myopic investor. Consequently, if announcement day risk premia are higher because of higher fundamental risk, this must be because of higher exposure to intertemporal risk on announcement days.[9]

Table 2 shows evidence from regressions of returns on an announcement day dummy together with controls. The regression coefficients are estimated using ordinary least squares (OLS), and t-statistics are computed using Newey-West standard errors (with 5 lags, but our results do not change with different specifications).[10] Panel A is for the full sample of 12,839 days and panel B excludes outliers using the same cut-offs as above. The first column of each panel reproduces the difference-in-means result of Table 1: the announcement day

[9] For a formal example of this idea, see the Appendix, equation (22).

[10] Our findings remain unaltered if we instead jointly estimate announcement day effects on both the mean and conditional volatility (using a GARCH(1,1) model similar to the one used in Jones, Lamont, and Lumsdaine (1998)). These results are available on request.

dummy has a significantly positive coefficient. We then control for market return lagged one day and squared lagged market return. The coefficient on the lagged market return is positive and significant. Finally, we include day of the week dummies for Monday through Thursday. The presence of these dummies should absorb any impact on returns by different days of the week, which may stem from payment lags, higher or lower trading activity on particular days, or behavioral biases. We confirm that returns are significantly lower on Mondays (even excluding outliers) and otherwise find no significant day-of-the-week effects. The announcement day effect remains positive and highly significant in all specifications, although slightly lower once day-of-the-week effects are included.

[**TABLE 2 ABOUT HERE**]

1.3. Risk-free Rate

Table 3 presents findings on the distributions of announcement day and non-announcement day returns on 30-day T-bills. Our sample starts slightly later (1961, rather than 1958), but is otherwise identical to the stock market sample of announcements.

[**TABLE 3 ABOUT HERE**]

Panel A shows that the average announcement day return for 30-day T-bills is 1.5 bps versus 1.7 bps for non-announcement days. The difference of 0.2 bps is statistically significant with a t-statistic of 4.43. The respective standard deviations are 1.5 and 1.8 bps. 30-day T-bill returns are actually less volatile on announcement days, but the main point is that both of these volatilities are extremely small. The distribution of announcement day returns on 30-day T-bills lies everywhere below that of non-announcement day returns.

The statistical significance of the result that 30-day T-bill returns are lower on announcement days is stronger if outliers are excluded, with the t-statistic for the difference increasing to 6.79. The exclusion of outliers is more important in this case because of the greater possibility of data error, since bond prices are not reported to an exchange.

Table 4 gives our regression results. As before, column 1 of Panel A reproduces the difference-in-means result. Column 2 controls for lagged return and lagged squared return. Not surprisingly, T-bill returns are highly autocorrelated, but the announcement day effect is still highly significant. Column 3 controls for day-of-the-week effects. Returns on T-bills appear to depend on the day of the week, but, even with the inclusion of dummies for different days, the announcement day effect is still very significant (although somewhat smaller). We conclude that the evidence is consistent with increased announcement day risk reducing the risk-free rate. The model in the Appendix shows how this is predicted through a precautionary saving channel when the coefficient of relative risk aversion is greater than one.

[**TABLE 4 ABOUT HERE**]

1.4. Treasury Bond Excess Returns

In contrast to T-bills, government securities with longer maturities represent risky assets on a daily horizon. If held to maturity, long-term Treasury bonds will provide a guaranteed (nominal) rate of return, but in the meantime their daily price changes will not be fully predictable and will reflect factors such as changes in interest rates. The possibility of such changes can result in longer-term bonds displaying greater differences between announcement and non-announcement day returns.[11] Our model predicts that at long maturities government bonds should have higher excess returns on announcement days and that the difference should be increasing with maturity, provided that inflation risk premia are positive and shocks to expected inflation are more persistent than shocks to expected economic growth. At the short end of the term structure, it is possible for real interest rate risk premia to dominate inflation risk premia, and thus short-tem bond average excess returns can be lower on announcement days.[12]

This hypothesis is confirmed by the data. Fig. 1 shows how the difference between announcement and non-announcement day excess returns varies with a bond's maturity. As

[11] E.g., simple up or down shifts in the yield curve will have the greatest impact on the Treasury bonds with the longest maturities.

[12] See the Appendix, equation (32).

predicted, the performance differential uniformly increases as we increase a bond's time-to-maturity. For a 1-year bond, the average announcement day excess return is actually 0.5 bps lower than the average on other days, with a t-statistic of 2.08. This suggests 1-year bonds are relatively riskless assets (on a daily horizon). However, as we increase a bond's maturity, its announcement day returns become higher than non-announcement day returns. For 5-year bonds, the return differential is 3.0 bps (t-statistic=2.94), and it then grows to 3.9 bps (t-statistic=2.56), 4.9 bps (t-statistic=2.52), and 5.7 bps (t-statistic=2.63) for 10-, 20-, and 30-year bonds respectively. These findings for longer-dated Treasury securities are similar to those reported in Jones, Lamont, and Lumsdaine (1998) for the 1979-1995 period, and are consistent with the hypothesis that investors expect higher returns on riskier assets on days when macroeconomic news is scheduled to be released.

[**FIG. 1 ABOUT HERE**]

1.5. Subsamples and Other Robustness Tests

Our main results for stock market excess returns and T-bill returns hold in both halves of the sample. Table 5 shows that from 1958 to 1983, average stock market excess returns on announcement days were 9.8 bps versus 1.0 bps for non-announcement days, with a t-statistic for the difference of 2.86. From 1984 to 2008, the corresponding figures were 11.3 bps and 1.0 bps, with a t-statistic of 2.40 for the difference. Both announcement day and non-announcement day returns are remarkably similar across the two subsamples, further strengthening the case that the announcement day premium is not a temporary phenomenon or a chance occurrence.

[**TABLE 5 ABOUT HERE**]

Table 6 examines announcement day and non-announcement day risk-free rates in two sub-periods. From 1961 to 1984, the daily T-bill return was 1.8 bps on announcement days and 2.0 bps on non-announcement days, and the t-statistic for the difference was 2.71. Since 1985, the corresponding estimates are 1.3, 1.5, and 2.67. In both sub-periods, the return volatilities are very low and lower on announcement days. As with stock market returns, the difference between announcement and non-announcement days is almost unchanged across the two subsamples.

[TABLE 6 ABOUT HERE]

Our findings also hold separately for each type of announcement. When we divide the sample into 5-year periods, the stock market excess return is higher on announcement days in 9 out of 10 periods, and the T-bill returns are lower in 8 out of 10 periods. The announcement day returns are higher for all 10 Fama-French industry portfolios, with the difference being statistically significant for every industry except for Durables and Telephone and Television Transmission. Finally, neither the turn-of-the-month effect (high equity returns over a four-day interval beginning with the last trading day of the month), first discovered by Ariel (1987) and Lakonishok and Smidt (1988), nor the January effect explain any of our results.[13]

2. Additional Tests and Other Supporting Evidence

In this section we present additional results on announcement day effects.[14] We present evidence that stock market implied variance is higher immediately before announcements; that average excess returns of growth stocks, normally much lower than those of value stocks, are actually higher on announcement days; that the stock market betas of government bonds are much higher on announcement days and the difference in betas is increasing with maturity; and that the daily average correlation between individual stock returns is higher on announcement days.

2.1. Implied Variance

Our model predicts a drop in Vix, or other Black-Scholes implied volatility measures, from before to after announcements.[15] Intuitively, one can think of 30-day ahead Vix as a 'portfolio' of 1-day conditional volatilities. When a high-volatility day, such as an announcement day,

[13] All these results are available on request.
[14] All of these results are consistent with our model, but we do not formally derive every prediction.
[15] We show exactly how in the Appendix.

drops out and is replaced by a low-volatility one, the 'portfolio' volatility drops. We present results on squared implied volatility (implied variance) as these are slightly easier to interpret.

Panel A of Table 7 gives summary statistics for the percentage change in implied variance from previous day market close to following day market close, and compares the changes on announcement days to those on non-announcement days. The average announcement day change is -1.4% whereas for other days the average change is an increase of 1.4%. Both estimates are statistically significant and the difference is large and highly statistically significant (t-statistic=4.13). The median change in implied variance around non-announcement days is precisely zero. The median change around announcement days is -2.8%, and the distribution of announcement day changes lies almost everywhere below the distribution of announcement day changes. When we exclude outliers in Panel B, our findings remain the same and become even more significant.

[**TABLE 7 ABOUT HERE**]

The regression analysis in panel A of Table 8 controls for lagged changes in implied variance and the square of such lagged changes. Neither coefficient is significant nor affects the announcement day effect. Including day of the week dummies also does not impact the significance of the announcement day dummy, which becomes even higher when we exclude outliers in Panel B. In sum, our evidence strongly suggests that the implied variance falls after macroeconomic news is released. Ederington and Lee (1996) obtain a similar result for interest rate options.[16]

[**TABLE 8 ABOUT HERE**]

2.2. Value versus Growth

Our model can be used to price zero-coupon equity or dividend strips (claims on a single future aggregate dividend): the risk premia on such claims will increase (decrease) with maturity

[16]Dubinsky and Johannes (2005) document a decline in implied volatility for individual stock options after earnings announcements. Beber and Brandt (2009) use prices of economic derivatives to measure macroeconomic uncertainty, and show that implied volatilities of stock and bond options decline more after news releases when uncertainty is high.

provided the elasticity of intertemporal substitution is greater than (less than) unity. Longer-term strips will also be more sensitive to news about expected economic growth. Growth stocks, the bulk of whose present value is attributed to cash flows far in the future, can be conceived of as portfolios of dividend strips with high weights on long-term strips and therefore high durations. Value stocks, conversely, have high weights on short-term strips and have more exposure to shocks to realized economic growth. Duration-based explanations of the value premium have been proposed by Brennan, Wang, and Xia (2004), Campbell and Vuolteenaho (2004), and Lettau and Wachter (2007).

Applying similar logic as we did for Treasury bonds of different maturities, we then expect that growth stocks will outperform value stocks on announcement days. We explore the relative performance of value and growth stocks by studying the returns of the Fama-French book-to-market factor (HML), which is the return of a portfolio of high book-to-market stocks minus the return of a portfolio of low book-to-market stocks (Fama and French (1993)).[17] On non-announcement days, the mean HML return equals 2.5 bps (t-statistic=5.30), confirming the well-known result that value stocks outperform growth stocks. However, on announcement days, the mean HML return is actually negative and equals -1.5 bps (t-statistic=-1.22). The difference between HML performance on announcement and non-announcement days is economically (10% on an annualized basis) and statistically (t-statistic=2.98) significant.

2.3. Bond Betas

Table 9 shows betas of government bonds with the stock market return. We regress the excess return of Treasury bonds with different maturities on the stock market excess return, the announcement day dummy, and the interaction term between the two. The coefficient on the announcement day dummy corresponds to the chart in Fig.1: it is negative for the shortest horizon (t-statistic=-2.51) and then becomes positive for a 5-year horizon (t-statistic=2.83) and continues increasing monotonically with bond maturity. While 1-year bonds underperform on announcement days, those with longer maturities outperform, and

[17] The HML portfolio returns become available in July 1963.

this outperformance increases as maturity goes up.

We observe a similar pattern for bond betas. The interaction term, which measures the difference between bond betas on announcement and non-announcement days, is always positive and significant, and it increases with the maturity of the bond. The difference is 0.010 (t-statistic=4.27) for 1-year bonds, and it then monotonically rises to 0.116 (t-statistic=5.99) for 30-year bonds. Bond betas are always at least twice as high on announcement days.

[**TABLE 9 ABOUT HERE**]

This evidence is consistent with the existence of a priced common factor to stock and bond returns on announcement days that is less present at other times. It is also predicted by our model if the announcement day increase in the variance of news about expected future consumption growth is greater than the announcement day increase in the variance of news about current growth. In other words, provided the information that arrives specifically on announcement days is more relevant to state variables such as expected economic growth or expected inflation, as opposed to realized economic growth or realized inflation, bonds and stocks should comove more around announcements.

This point is perhaps most easily understood by considering an extreme but empirically plausible case. Suppose: (1) the only sources of time-variation in expected returns are expected economic growth and expected inflation; (2) investors learn nothing about current growth through announcements and nothing about expected future growth or inflation (and, by implication, interest rates) other than through announcements; (3) shocks to expected inflation are negatively correlated with shocks to expected economic growth; and (4) shocks to realized inflation and economic growth are independent of everything else. Since bond returns depend only on news about nominal interest rates, bond returns will be deterministic on non-announcement days and their market betas will be zero. On announcement days both the market return and bond returns will respond negatively to news that future inflation will be higher than anticipated, so bond betas will be positive and increasing with maturity.

2.4. Correlation

If the Roll critique is important, the variance of stock market returns may not represent a good proxy for aggregate risk, as is evidenced by the anaemic ability of stock market variance, which is itself highly predictable, to forecast future stock market excess returns.[18] Pollet and Wilson (2008) show that, when the stock market is a poor proxy for the portfolio of aggregate wealth, changes in the average correlation between stock returns can nevertheless reveal changes in aggregate risk. Consistent with this idea, they find that estimates of the average correlation between daily returns have strong ability to forecast future stock market returns at horizons of one month to three years.

At daily frequencies, the same idea can be used to calculate the daily average correlation between 5-minute returns on the 500 largest (by market cap) stocks in the U.S. market.[19] Comparing such estimates of daily average correlation based on intraday returns starting in 1995, we find that the mean announcement day correlation equals 0.245 versus 0.216 on other days (with a t-statistic for the difference of 3.78). Although correlation and aggregate risk are only approximately linearly related, and then only under restrictive assumptions, this result suggests, as do our findings on realized and implied volatility, that aggregate risk is higher on announcement days, but that the increase is not of the same order of magnitude as the increase in risk premia.

3. Conclusion

We show that average excess returns on the U.S. stock market are much higher on days when important macroeconomic news is scheduled to be announced. We also find that returns on 30-day T-bills, our measure of the risk-free rate, are lower on these days. For longer-term Treasury securities, which are not riskless assets on a daily horizon, we find that the difference between announcement and non-announcement day returns uniformly increases with a bond's

[18] See Lettau and Ludvigson (2007) for a comprehensive recent survey of the literature on forecasting returns with variance estimates.

[19] We thank Fabian Garavito and Runquen Chen for the use of their daily correlation estimates.

maturity and is positive for bonds with maturities of five years or more. Bonds comove much more with the stock market on announcement days, and this tendency also monotonically increases with maturity. Our results demonstrate a clear link between macroeconomic risk and financial asset returns. Investors seem to require higher expected returns on risky assets as a compensation for bearing risks associated with macroeconomic news. In addition, the risk premium on non-announcement days appears to be very low, with our numbers implying that over 60% of the cumulative annual excess return for the stock market is earned on announcement days.

Our findings on risk-free rates are consistent with precautionary saving. If aggregate risk is higher on announcement days, then investors who care about daily changes in their wealth will seek to save more out of current wealth on those days relative to other days. Although the effect might appear economically small (a 0.2 basis point reduction in the daily return on the 30-day T-bill), it is highly statistically significant. To our knowledge, this is some of the first evidence of precautionary saving affecting U.S. asset prices.

These results are consistent with a simple equilibrium model of economy-wide risk that varies deterministically over time because of prescheduled announcements. This model can reconcile the large increase in stock market risk premia with the relatively small increase in stock market variance that we estimate. Because investors learn more about future economic conditions around announcements, they should be less willing to hold assets, such as stocks, that covary positively with these news, even if the variance of stock returns is itself not much higher. If such shocks are persistent, even a small increase in their volatility (the news arrival rate) around announcements can result in large increases in the market risk premium. A reasonable calibration of our model produces risk premia and volatilities that match our empirical results.

The above explanation for the documented announcement day premia focuses on a risk-return trade-off that compensates investors for higher announcement day risk. An interesting alternative possibility is that some investors effectively become more risk-averse ahead of announcements, resulting in a higher price of announcement day risk (i.e. a higher risk premium for the same exposure).

Why should pre-scheduled announcements make investors more risk-averse? One possibility is that investors are averse to uncertainty in the sense proposed by Knight (1921). With an announcement approaching, their utility functions become more concave as the worse possible distributions of outcomes receive higher weights. Recent research has proposed a rich set of preferences for ambiguity-averse investors, building on the early work of Gilboa and Schmeidler (1989). However, Skiadas (2008) shows that for small risks (a large probability of a small change or a small probability of a large change) many of the preferences in the current literature are, to a first-order approximation, equivalent to expected utility or Kreps-Porteous recursive preferences, so that ambiguity aversion need have no first-order effects on asset prices when risks are small (of the same order as the time horizon under consideration). Pre-scheduled announcements, however, are the quintessential large risk: they are events involving the near certainty of a non-negligible change (even if zero-mean). Thus, even standard ambiguity aversion can deliver higher risk prices ahead of announcements. Other potential explanations include the changing composition of investors participating in stocks and T-bills ahead of announcements, which would alter the risk aversion of the representative investor, or an irrationally excessive investor aversion to announcement risk.

Appendix

We use recursive Epstein-Zin utility, rather than the simpler power utility, because in our equilibrium model power utility has some empirically unattractive properties (when risk aversion is greater than one). Specifically, as noted by Bansal and Yaron (2004), increases in aggregate risk induce an increase in desired precautionary saving, which in equilibrium reduces expected returns on all assets (the wealth effect) and reduces desired portfolio weights on riskier assets (the substitution effect). Assuming investors have power utility preferences requires the wealth effect to dominate the substitution effect, implying that valuations of even risky assets should be increasing in aggregate risk (holding expected cash flows constant). Furthermore, under power utility, changes in expected consumption growth do not affect risk premia. The more general Epstein-Zin framework avoids these unappealing implications. (See Bansal, Khatacharian, and Yaron (2005) for evidence that both higher aggregate uncertainty and lower expected consumption growth decrease risky asset valuations.)

A.1. Real Economy

We assume that log real aggregate dividends (which equal the endowment) $d_t = \ln D_t$ follow

$$\Delta d_{t+1} = \mu_t + \nu_{d,t+1} \tag{2}$$

The expected growth of the endowment (the drift), μ_t, varies randomly over time, following an AR(1) process:

$$\mu_{t+1} = (1-\phi)\overline{\mu} + \phi\mu_t + \nu_{\mu,t+1} \tag{3}$$

The conditional variances of both news terms are assumed to be higher on announcement days:

$$Var_t[\nu_{x,t+1}] = \sigma^2_{x,L} + (\sigma^2_{x,H} - \sigma^2_{x,L})A_{t+1}, \tag{4}$$

for $x = d, \mu$, where A_{t+1} is a deterministic indicator variable that equals one if there is a pre-scheduled announcement between dates t and $t+1$ and zero otherwise, and $\sigma_{x,H} > \sigma_{x,L}$. The exposition is considerably simplified if we assume that news about current and expected future endowment growth are uncorrelated.

This model is essentially that of Bansal and Yaron (2004) with the addition of deterministic changes in variances due to announcement effects, and we use a similar approximation to solve the model in closed form. Note that the announcement effects on variances are assumed and the model is used to derive the resulting announcement effects on prices and expected returns.

A.2. Preferences

A representative investor chooses an optimal consumption path and invests in a claim to the aggregate endowment and a risk-free asset. The investor is assumed to have recursive Epstein-Zin preferences

$$U_t = \left((1-\beta)C_t^{1-\frac{1}{\psi}} + \beta(E_t[U_{t+1}^{1-\gamma}])^{\frac{1-\frac{1}{\psi}}{1-\gamma}}\right)^{\frac{1}{1-\frac{1}{\psi}}}, \tag{5}$$

where β is the time discount rate, γ is the coefficient of relative risk aversion, and ψ is the elasticity of intertemporal substitution (EIS). When $\gamma = 1/\psi$, these preferences nest the special case of power utility. See the discussion at the beginning of this Appendix of why we choose to work with Epstein-Zin rather than power utility preferences. Market clearing requires $C_t = D_t$.

A.3. Real Risk-free Rate

In equilibrium, the investor consumes the aggregate endowment D_t each period, and the risk-free asset is in zero net supply. The equilibrium log risk-free rate is then given by

$$\begin{aligned} r_{ft+1} &= -\ln\beta + \frac{1}{\psi}\left(\mu_t + \frac{1}{2}Var_t\left[\Delta d_{t+1}\right]\right) - \gamma\left(1+\frac{1}{\psi}\right)\frac{1}{2}Var_t[\Delta d_{t+1}] \\ &\quad -\left(\gamma - \frac{1}{\psi}\right)\left(1-\frac{1}{\psi}\right)Var_t\left[\frac{\rho}{1-\rho\phi}\mu_{t+1}\right] \end{aligned} \tag{6}$$

The log risk-free rate consists of four terms. The first term depends on the rate of time preference. The second depends on the log expected growth rate of consumption, which in equilibrium equals the log expected growth rate of the aggregate endowment. This term is independent of risk aversion γ, but not of risk $Var_t[\Delta d_{t+1}]$ because of Jensen's inequality: for risk-neutral investors, an increase in the variance of log dividend growth increases the log risk-free rate because log expected dividend growth increases, reducing desired saving. As ψ becomes large, this term goes to zero since investors become increasingly willing to postpone consumption in exchange for a higher rate of interest today.

The third term is a precautionary saving term that is zero for risk-neutral investors. For risk-averse investors, an increase in aggregate risk raises desired precautionary saving, reducing the market-clearing risk-free rate. The precautionary saving effect of increased risk dominates the effect through the second term if and only if investors are sufficiently willing to substitute consumption across time (increasing in ψ) relative to their willingness to substitute across states (decreasing in γ). A necessary and sufficient condition for the risk-free rate to be decreasing in aggregate risk is that $\psi \geq \left(\frac{1}{\gamma} - 1\right)$. Since ψ is weakly positive, this condition is always fulfilled for investors with greater than unit risk aversion. Thus, for empirically plausible values of γ (see for example Campbell and Viceira (2002), chapter 2), we expect the risk-free rate to be lower on announcement days.

This precautionary saving effect in daily returns is likely to be small. r_{ft+1} is the marginal rate of transformation of consumption foregone at date t into consumption the immediately following day. Eq. (6) says that when date $t+1$ is an announcement day, the same investor will desire to save more at date t for consumption at date $t+1$ than he or she will when date $t+1$ is not an announcement day. Since investors are long-lived, this additional desired saving cannot be very large, but even long-lived investors put some weight on smoothing consumption from day to day.

The fourth term is an additional precautionary saving term proportional to the variance of the permanent component of shocks to expected endowment growth. This term is zero for both investors with unit elasticities of intertemporal substitution and for investors with power utility. For the case of γ and ψ greater than one, this term reduces the risk-free rate on announcement days. Risk-averse investors who are highly willing to substitute future for current consumption (those with high ψ) are most prone to changing their desired consumption plans in response to permanent changes in consumption growth. Such investors will wish to save more as the variance of such news increases (holding the risk-free rate constant).

A.4. Stock Market Returns

The log return on the risky claim to the aggregate endowment is

$$\begin{aligned} r_{MKT,t+1} &= -\ln\beta + (\gamma-1)(1-\frac{1}{\psi})\frac{1}{2}Var_t\left[\nu_{d,t+1} + \frac{\rho}{1-\rho\phi}\nu_{\mu,t+1}\right] + \frac{1}{\psi}\mu_t \\ &\quad +\nu_{d,t+1} + (1-\frac{1}{\psi})\frac{\rho}{1-\rho\phi}\nu_{\mu,t+1} \end{aligned} \tag{7}$$

Expected market returns are higher on announcement days provided $(\gamma-1)(1-\frac{1}{\psi}) > 0$. For the leading empirical case of $\gamma > 1$, this condition requires that the elasticity of intertemporal substitution ψ is greater than one. Recent work by Bansal and Yaron (2004), Bansal, Tallarini, and Yaron (2008), Vissing-Jorgenson (2002), and others presents evidence and arguments in favor of $\psi > 1$.

A.5. Proof of Equations (6) and (7)

For a representative investor with Epstein-Zin preferences, the stochastic discount factor is given by

$$m_{t+1} = \ln M_{t+1} = \theta\ln\beta - \frac{\theta}{\psi}\Delta d_{t+1} - (1-\theta)r_{MKT,t+1}, \tag{8}$$

where r_{MKT} is the log return on the market portfolio, defined as the claim to aggregate dividends in perpetuity, and $\theta = (1-\gamma)/(1-\frac{1}{\psi})$.

Since everything is log-normal, the log return on any asset $r_{j,t+1}$ is then given by

$$E_t[m_{t+1} + r_{j,t+1}] + \frac{1}{2}Var_t[m_{t+1} + r_{j,t+1}] = 0 \tag{9}$$

In order to solve the model ,we use the Campbell-Shiller approximation for the log return on the market portfolio

$$r_{MKT,t+1} \approx k + \Delta d_{t+1} + \rho(p_{t+1} - d_{t+1}) - (p_t - d_t), \tag{10}$$

where k is an unimportant constant and $\rho = (1 + \exp(\overline{d-p}))^{-1}$ is another constant that is slightly less than one. We assume that announcements are not spaced through our sample in such a way that the mean log dividend-price ratio is badly defined. A sufficient condition is that announcements are regularly spaced, so that in any long period, such as one year, there is a fixed number.

Next we assume that the log aggregate price-dividend ratio is linear in the drift term μ_t and its intercept is a deterministic function of time:

$$p_t - d_t = a_{0,t} + a_1 \mu_t \tag{11}$$

As in Bansal and Yaron (2004), a_1 is positive and the price-dividend ratio is increasing in expected dividend growth if and only if $\psi > 1$, so that the direct effect on wealth through increased growth more than offsets the indirect effect through a higher discount rate due to higher expected growth.

The solution implies that the stochastic discount factor is given by

$$m_{t+1} = -\delta_{t+1} - \frac{1}{\psi}\mu_t - \gamma v_{d,t+1} - (\gamma - \frac{1}{\psi})\frac{\rho}{1-\rho\phi} v_{\mu,t+1}, \tag{12}$$

where

$$\delta_{t+1} = -\ln\beta - (1-\gamma)(\gamma - \frac{1}{\psi})\frac{1}{2} Var_t\left[\nu_{d,t+1} + \frac{\rho}{1-\rho\phi} v_{\mu,t+1}\right] \tag{13}$$

Iterating (11) forward one period gives

$$p_{t+1} - d_{t+1} = a_{0,t+1} + a_1 \mu_{t+1} \tag{14}$$

Plugging these into the approximation (10) for the log market portfolio return, then plugging the derived expression into the pricing equation (9), given the equation for the stochastic discount factor (8), and equating coefficients gives:

$$a_1 = \frac{1 - \frac{1}{\psi}}{1 - \rho\phi} \tag{15}$$

and

$$a_{0,t} = b_0 + b_1 A_{t+1} + \rho a_{0,t+1} \tag{16}$$

confirming our conjecture. Here

$$b_0 = \ln \beta + k + \rho a_1 (1 - \phi)\overline{\mu} - \frac{1}{2}(\gamma - 1)(1 - \frac{1}{\psi}) \left(\sigma_{d,L}^2 + \left(\frac{\rho}{1 - \rho\phi} \right)^2 \sigma_{\mu,L}^2 \right) \tag{17}$$

and

$$b_1 = -\frac{1}{2}(\gamma - 1)(1 - \frac{1}{\psi}) \left((\sigma_{d,H}^2 - \sigma_{d,L}^2) + \left(\frac{\rho}{1 - \rho\phi} \right)^2 (\sigma_{\mu,H}^2 - \sigma_{\mu,L}^2) \right) \tag{18}$$

Assuming no rational bubbles implies

$$\lim_{s \to \infty} \rho^s E_t[p_{t+s} - d_{t+s}] = 0 \tag{19}$$

hence

$$\begin{aligned} \lim_{s \to \infty} \rho^s a_{0,t+s} + \lim_{s \to \infty} \rho^s a_1 E_t[\mu_{t+s}] &= \lim_{s \to \infty} \rho^s a_{0,t+s} + a_1 \overline{\mu} \lim_{s \to \infty} \rho^s \\ &= \lim_{s \to \infty} \rho^s a_{0,t+s} = 0 \end{aligned} \tag{20}$$

hence

$$a_{0,t} = \frac{b_0}{1 - \rho} + b_1 \sum_{j=1}^{\infty} \rho^j A_{t+1+j} \tag{21}$$

Plugging back into the approximation (10) gives equation (7). Equation (6) follows from substituting (7) into (8).

A.6. Stock Market Risk Premium

Subtracting equation (6) from equation (7) shows that the conditional market risk premium is

$$\begin{aligned}
\ln E_t\left[\frac{1+R_{MKT,t+1}}{1+R_{f,t+1}}\right] &= E_t[r_{MKT,t+1}] - r_{f,t+1} + \frac{Var_t[r_{MKT,t+1}]}{2} \qquad (22) \\
&= -Cov_t[m_{t+1}, r_{MKT,t+1}] \\
&= \gamma Var_t[\Delta d_{t+1}] + (\gamma - \frac{1}{\psi})(1 - \frac{1}{\psi})Var_t\left[\frac{\rho}{1-\rho\phi}\mu_{t+1}\right] \\
&= \gamma Var_t[r_{MKT,t+1}] + \frac{\gamma - 1}{\psi}Cov_t\left[r_{MKT,t+1}, \frac{\rho}{1-\rho\phi}\mu_{t+1}\right]
\end{aligned}$$

It will be higher on announcement days provided ψ is not too low. For the special cases of power utility or unit intertemporal elasticity of substitution, the variance of the permanent component of shocks to economic growth does not affect consumption. When both γ and ψ are greater than one, the market risk premium is increasing in the variance of this permanent component. An increase in the drift μ_t raises both expected future consumption growth, through a cash-flow effect, and discount rates, through its increase in desired borrowing and the risk-free rate. The cash-flow effect dominates if and only if $\psi > 1$. Thus, market risk premia can be considerably higher on announcement days if investors expect to receive more news about future economic growth on such days.

In this model, the market risk premium is not necessarily proportional to its conditional return variance. If the stock market return has a positive covariance with permanent shocks to expected economic growth, conservative investors (those with $\gamma > 1$) will demand higher risk premia on announcement days even if there are only small increases in stock market variance. Such investors require compensation for the tendency of the market to perform poorly when news about future economic growth is bad.

A.7. Nominal Bonds and Inflation

We now introduce inflation shocks. The log dollar price of an N-period nominal discount bond is $p^{\$}_{n,t}$ and its real holding period return is

$$r_{n,t+1} = p^{\$}_{n-1,t+1} - p^{\$}_{n,t} - \pi_{t+1}, \tag{23}$$

where π is the log rate of inflation. We assume

$$\pi_{t+1} = z_t + \eta_{\pi,t+1} \tag{24}$$

and

$$z_{t+1} = (1-\lambda)\overline{\pi} + \lambda z_t + \eta_{z,t+1} \tag{25}$$

Once again, the conditional variances of realized inflation and expected inflation shocks are assumed to be higher on announcement days. The structural source of inflation and its relation to real variables is beyond the scope of this paper. However, we assume that neither shocks to realized or expected inflation are correlated with shocks to realized endowment growth $\nu_{d,t+1}$. The signs of the correlations between expected inflation and expected real endowment growth and between realized inflation and expected endowment growth are discussed below. Following Campbell and Viceira (2002), chapter 3, it is helpful to write out the dependencies of the inflation shocks on each other and on shocks to the drift:

$$\eta_{z,t+1} = \beta_{z\mu} v_{\mu,t+1} + \varepsilon_{z,t+1} \tag{26}$$

and

$$\eta_{\pi,t+1} = \beta_{\pi\mu} v_{\mu,t+1} + \beta_{\pi z}\varepsilon_{z,t+1} + \varepsilon_{\pi,t+1} \tag{27}$$

The shocks $v_{\mu,t+1}$, $\varepsilon_{z,t+1}$, and $\varepsilon_{\pi,t+1}$ are orthogonal but have higher variances on announcement days. The loadings ($\beta_{z\mu}$, $\beta_{\pi\mu}$, and $\beta_{\pi z}$) are assumed to be the same on all days for simplicity. In order to generate a positive inflation risk premium, we require that $\beta_{z\mu}$ be negative, so that shocks to expected inflation are negatively related to shocks to expected economic growth.

A.8. Nominal Bond Risk Premia

The price of a nominal bond is derived by conjecturing that

$$p^{\$}_{n,t} = c^n_{0,t} + c^n_1 \mu_t + c^n_2 z_t, \tag{28}$$

where $c^n_{0,t}$ is a deterministic function of time and maturity and the other coefficients depend only on maturity. Since the log price of \$1 is zero, all coefficients equal zero at $n = 0$. Since the bond's real return is $p^{\$}_{n-1,t+1} - p^{\$}_{n,t} - \pi_{t+1}$, iterating forward, plugging the conjecture into equation (9) and equating coefficients confirms the conjecture and in particular gives

$$c^n_1 = -\frac{1}{\psi}\frac{1-\phi^n}{1-\phi} \tag{29}$$

$$c^n_2 = -\frac{1-\lambda^n}{1-\lambda} \tag{30}$$

In real terms, consistent with the rest of the Appendix, risk premia on nominal bonds are then given by

$$E_t[r_{n,t+1}] - r_{f,t+1} + \frac{1}{2}Var_t[r_{n,t+1}] = Cov_t[-m_{t+1}, p^{\$n-1}_{t+1} - p^{\$n}_t - \pi_{t+1}] \tag{31}$$
$$= \left(\gamma - \frac{1}{\psi}\right)\frac{\rho}{1-\rho\phi}Var_t\left[\mu_{t+1}\right]\left(-\frac{1}{\psi}\frac{1-\phi^{n-1}}{1-\phi} - \frac{1-\lambda^{n-1}}{1-\lambda}\beta_{z\mu} - \beta_{\pi\mu}\right)$$

The risk premia are proportional to the sum of three terms. The first term is the risk premium on an N-period real bond. When either γ and ψ are both greater or both less than one, this implies that risk premia are lower on announcement days by an amount increasing in magnitude with bond maturity. Intuitively, since the short-term real interest rate depends positively on expected endowment growth, and real long-term bond holding period returns are negatively correlated with the short-term real rate, long-term real bonds offer desirable hedges against the risk of a decline in expected economic growth. Since this risk is higher on announcement days, longer-term real bonds should underperform by more on such days.

The second term depends negatively on the covariance between shocks to expected inflation and shocks to expected real endowment growth. In order to generate a positive inflation risk premium, this covariance must be negative. Although there is evidence that the inflation risk premium may have declined over time, most studies agree that it has always been positive (see, for example, Buraschi and Jiltsov (2007) and Campbell, Sunderam, and Viceira (2009)).

Finally, the third term depends negatively on the covariance between shocks to realized inflation and to expected economic growth. The sign of this covariance is a matter of debate and must also depend on the inflation policy of the central bank, which we do not discuss, but it is likely to be small in magnitude. As emphasized by many authors (see Ang, Dong, and Piazzesi (2007), Ang, Boivin, and Dong (2008) or Gallmeyer, Hollifield, Palomino, and Zin (2007)), there is no particular reason why this covariance should have a constant sign or magnitude. However, this third term is the same for all maturities.

The risk premium on two nominal bonds with maturities $n+1$ and n is increasing in maturity, and higher on announcement days, provided

$$-\beta_{z\mu} > \frac{1}{\psi}\left(\frac{\phi}{\lambda}\right)^{n-1} \tag{32}$$

This is guaranteed for sufficiently long-term bonds provided that (as we assume) shocks to expected inflation are negatively related to long-term economic growth ($\beta_{z\mu} < 0$) and that shocks to expected inflation are more persistent than shocks to economic growth ($\phi < \lambda$). For sufficiently short-term bonds the risk premium can decline with maturity and will be lower on announcement days. The model therefore predicts that for short-term bonds the average excess returns on announcement days can be lower than on non-announcement days, but should always be higher for longer-term bonds.

A.9. Stock Market Implied Volatility

Our model has implications for Black-Scholes implied volatilities, such as the CBOE's (old) Vix index. Under the assumptions of the Black-Scholes model, the square of the implied volatility of a τ-day option (assuming no dividends are paid between dates t and $t+\tau$) is the conditional variance of the log τ-day ahead price $p_{t+\tau}$:

$$\sigma^2_{\tau,BS} = Var_t[\ln P_{t+\tau}] = Var_t\left[p_{t+\tau}\right] \tag{33}$$

Since

$$p_{t+\tau} = (p_{t+\tau} - d_{t+\tau}) + d_{t+\tau} \tag{34}$$

the Black-Scholes implied variance is approximately

$$\sigma^2_{\tau,BS} \approx \left(\frac{1-\frac{1}{\psi}}{1-\rho\phi}\right)^2 Var_t\left[\sum_{j=1}^{\tau}\phi^{\tau-j}\nu_{\mu,t+j}\right] + Var_t\left[\sum_{j=1}^{\tau}\nu_{d,t+j}\right] \tag{35}$$

The model-implied change in the square of constant-maturity Black-Scholes implied volatility from the day prior to an announcement to the end of the following day is therefore

$$\Delta\sigma^{\tau 2}_{BS,t+1} = \left(\sigma^2_{d,H} - \sigma^2_{d,L}\right)\left(A_{t+1+\tau} - A_{t+1}\right) + \left(\sigma^2_{\mu,H} - \sigma^2_{\mu,L}\right)\left(\frac{1-\frac{1}{\psi}}{1-\rho\phi}\right)^2 \sum_{j=1}^{\tau}\left(\phi^{\tau-j}\right)^2\left(A_{t+1+j} - A_t\right), \tag{36}$$

where τ is the number of days until expiration of the options from whose prices the implied volatility is derived. In the case of Vix, τ is standardized to 30 days and is quoted on an annualized basis, so will change by $\frac{365}{30}\Delta\sigma^{\tau 2}_{BS,t+1}$ from the end of date t to the end of date $t+1$.

This change consists of two terms. First, if date $t+1$ is an announcement day and date $t+31$ is not, then squared implied volatility will decline by an amount equal to the increase in variance of dividend growth around announcement days. Intuitively, one can think of Vix as a "portfolio" of 30 individual daily implied volatilities, so when a high volatility day is replaced by a low volatility one, this term of Vix should drop by $\sigma^2_{d,H} - \sigma^2_{d,L}$.

The second term is more complex, since it depends not only on the day added and the day subtracted, but also on the intervening days. Since the persistence of shocks to expected growth is less than one, the impact of announcements today on the conditional variance of $\mu_{t+\tau}$ will be smaller than the impact of an announcement later in the next 30 days. In particular, if A_{t+31} is also an announcement day, this second term in Vix could actually increase by a small amount at date $t+1$. However, $A_{t+31} = 1$ and $A_{t+j} = 0$ for $j = 2...30$ maximizes the increase in this second term for any value of ϕ. Furthermore, the second highest value, if A_{t+31} is zero, is negative for any value of ϕ. Thus, provided we assume $A_{t+31} = 0$ for all dates t, the model predicts a drop in Vix from before to after announcements. This assumption, if false, biases against our finding the results we report in the paper.

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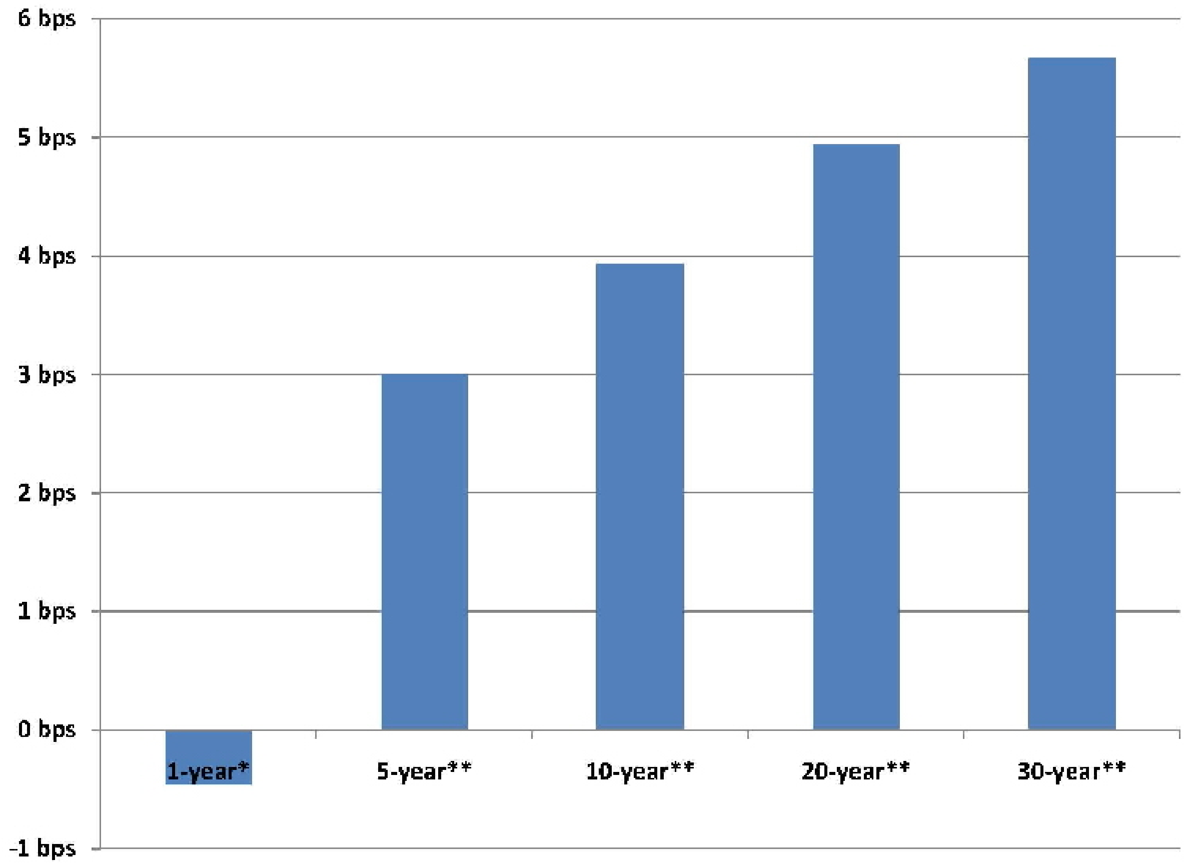

Figure 1. The Difference between Announcement Day and Non-announcement Day Treasury Bond Excess Returns. The chart plots the difference between the mean announcement day excess return and the mean excess return on other days for Treasury bonds of different maturities. Treasury bond returns are obtained from the CRSP Fixed Term Indices File. The difference is expressed in basis points (bps). * and ** indicate statistical significance at the 5% and 1% levels respectively.

Table 1
Summary Statistics for Daily Stock Market Excess Returns

This table shows the distribution of stock market excess returns on announcement days and non-announcement days. Announcement days are those trading days when CPI/PPI (CPI before January 1971 and PPI afterwards) numbers, employment numbers, and FOMC interest rate decisions are scheduled for release. The sample covers the 1958-2008 period. Market excess returns are computed as the difference between the CRSP value-weighted market return and the risk-free rate. The daily risk-free rate is derived from the 1-month risk-free rate provided by CRSP. All numbers are expressed in basis points.

	Panel A: All observations			**Panel B: Excluding outliers (1% and 99%)**		
	Announcement	Non-Announcement	Difference	Announcement	Non-Announcement	Difference
Mean	10.6	1.0	**9.6**	10.9	1.2	**9.7**
t-stat	[4.12]	[1.18]	**[3.53]**	[5.10]	[1.74]	**[4.31]**
1% percentile	-256.2	-244.7	-11.4	-203.3	-197.6	-5.7
25% percentile	-34.5	-40.4	5.9	-33.1	-39.0	5.9
Median	13.1	4.2	8.8	13.1	4.2	8.8
75% percentile	58.0	44.6	13.4	57.1	43.8	13.3
99% percentile	288.9	235.4	53.5	220.5	185.1	35.4
Std. Dev.	96.9	92.2		79.5	73.7	
Skewness	-0.6	-0.6		-0.1	-0.2	
Kurtosis	9.2	21.4				
N	1,415	11,424		1,385	11,194	

Table 2

Regression Analysis - Daily Stock Market Excess Returns

This table presents the results of OLS regressions of daily stock market excess returns on an announcement day dummy variable and various other controls. Ann. day is a dummy variable equaling 1 if day t is an announcement day and equaling 0 otherwise. Market excess returns (Mktrf) are computed as the difference between the CRSP value-weighted market return and the risk-free rate (expressed in basis points). Monday-Thursday are dummy variables for the corresponding days of the week. T-statistics are calculated using Newey-West standard errors (with 5 lags) and are given in brackets.

	Panel A: All observations			**Panel B: Ex. outliers (1% and 99%)**		
	(1)	**(2)**	**(3)**	**(1)**	**(2)**	**(3)**
Intercept	1.016	-0.026	3.938	1.215	0.678	5.184
	[1.13]	[-0.03]	[2.30]	[1.58]	[0.88]	[3.45]
Ann. day	**9.588**	**9.753**	**6.996**	**9.694**	**9.976**	**7.541**
	[3.52]	**[3.56]**	**[2.53]**	**[4.27]**	**[4.38]**	**[3.27]**
$Mktrf_{t-1}$		0.095	0.096		0.103	0.104
		[5.63]	[5.67]		[9.73]	[9.74]
$(Mktrf_{t-1})^2$		0.0001	0.0001		0.0000	0.0000
		[1.59]	[1.57]		[0.56]	[0.54]
Monday			-14.213			-11.778
			[-5.58]			[-5.72]
Tuesday			-2.658			-5.601
			[-1.07]			[-2.66]
Wednesday			1.493			0.473
			[0.62]			[0.24]
Thursday			-3.398			-4.660
			[-1.45]			[-2.34]
N	12,839	12,838	12,838	12,579	12,578	12,578
R^2(%)	0.01	1.1	1.4	0.2	1.6	2.0

Table 3
Summary Statistics for Daily 30-day T-bill Returns

This table shows the distribution of daily 30-day T-bill returns on announcement days and non-announcement days. Announcement days are those trading days when CPI/PPI (CPI before January 1971 and PPI afterwards) numbers, employment numbers, and FOMC interest rate decisions are scheduled for release. The sample covers the 1961-2008 period. 30-day T-bill returns are defined as the return of the T-bill issue whose length of maturity is closest to 30 days (daily T-bill quotes are obtained from CRSP starting in June 1961). All numbers are expressed in basis points.

	Panel A: All observations			**Panel B: Excluding outliers (1% and 99%)**		
	Announcement	Non-Announcement	Difference	Announcement	Non-Announcement	Difference
Mean	1.5	1.7	**-0.2**	1.5	1.7	**-0.2**
t-stat	[35.92]	[98.8]	**[-4.43]**	[55.52]	[139.77]	**[-6.79]**
1% percentile	-0.9	-0.7	-0.3	-0.3	-0.1	-0.2
25% percentile	0.9	0.9	-0.1	0.9	0.9	-0.1
Median	1.3	1.4	-0.1	1.3	1.4	-0.1
75% percentile	1.9	2.1	-0.2	1.9	2.0	-0.2
99% percentile	6.5	8.2	-1.8	5.0	6.3	-1.3
Std. Dev.	1.5	1.8		0.9	1.2	
Skewness	9.9	3.7		1.3	1.9	
Kurtosis	213.8	75.9				
N	1,334	10,496		1,306	10,286	

Table 4
Regression Analysis - Daily 30-day T-bill Returns

This table presents the results of OLS regressions of daily 30-day T-bill returns on an announcement day dummy variable and various other controls. Ann. day is a dummy variable equaling 1 if day t is an announcement day and equaling 0 otherwise. 30-day T-bill returns (Tbill) are defined as the return of the T-bill issue whose length of maturity is closest to 30 days (expressed in basis points). Monday-Thursday are dummy variables for the corresponding days of the week. T-statistics are calculated using Newey-West standard errors (with 5 lags) and are given in brackets.

	Panel A: All observations			**Panel B: Ex. outliers (1% and 99%)**		
	(1)	**(2)**	**(3)**	**(1)**	**(2)**	**(3)**
Intercept	1.702	1.158	0.921	1.652	1.140	0.959
	[69.19]	[13.96]	[9.88]	[82.03]	[18.84]	[14.59]
Ann. day	**-0.200**	**-0.177**	**-0.112**	**-0.195**	**-0.168**	**-0.117**
	[-4.70]	**[-4.21]**	**[-2.61]**	**[-7.07]**	**[-6.49]**	**[-4.35]**
Tbill_{t-1}		0.331	0.332		0.311	0.312
		[6.44]	[6.43]		[7.21]	[7.19]
$(\text{Tbill}_{t-1})^2$		-0.0093	-0.0093		-0.0048	-0.0047
		[-4.41]	[-4.36]		[-1.53]	[-1.52]
Monday			0.086			0.078
			[1.61]			[2.84]
Tuesday			0.454			0.325
			[8.14]			[9.96]
Wednesday			0.268			0.202
			[5.07]			[7.29]
Thursday			0.318			0.259
			[5.84]			[9.17]
N	11,830	11,693	11,693	11,592	11,485	11,485
R^2 (%)	0.1	8.0	9.0	0.3	16.0	17.1

Table 5
Summary Statistics for Daily Stock Market Excess Returns - Subsamples

This table shows the distribution of stock market excess returns on announcement days and non-announcement days over the first and second halves of our sample. Announcement days are those trading days when CPI/PPI (CPI before January 1971 and PPI afterwards) numbers, employment numbers, and FOMC interest rate decisions are scheduled for release. The sample covers the 1958-2008 period. Market excess returns are computed as the difference between the CRSP value-weighted market return and the risk-free rate. The daily risk-free rate is derived from the 1-month risk-free rate provided by CRSP. All numbers are expressed in basis points.

	Panel A: 1958 - 1983			**Panel B: 1984-2008**		
	Announcement	Non-Announcement	Difference	Announcement	Non-Announcement	Difference
Mean	9.8	1.0	**8.8**	11.3	1.0	**10.3**
t-stat	[3.38]	[1.05]	**[2.86]**	[2.80]	[0.69]	**[2.40]**
1% percentile	-174.9	-204.5	29.7	-286.1	-288.2	2.0
25% percentile	-32.1	-37.3	5.2	-37.2	-44.0	6.8
Median	12.8	3.0	9.7	13.6	5.4	8.2
75% percentile	51.7	41.8	9.9	65.3	48.9	16.4
99% percentile	220.5	201.6	18.9	343.8	271.1	72.6
Std. Dev.	72.9	75.7		112.6	107.0	
Skewness	0.3	0.0		-0.8	-0.8	
Kurtosis	2.8	4.2		8.3	22.8	
N	631	5,901		784	5,523	

Table 6
Summary Statistics for Daily 30-day T-bill Returns - Subsamples

This table shows the distribution of daily 30-day T-bill returns on announcement days and non-announcement days over the first and second halves of our sample. Announcement days are those trading days when CPI/PPI (CPI before January 1971 and PPI afterwards) numbers, employment numbers, and FOMC interest rate decisions are scheduled for release. The sample covers the 1961-2008 period. 30-day T-bill returns are defined as the return of the T-bill issue whose length of maturity is closest to 30 days (daily T-bill quotes are obtained from CRSP starting in June 1961). All numbers are expressed in basis points.

	Panel A: 1961 - 1984			**Panel B: 1985-2008**		
	Announcement	Non-Announcement	Difference	Announcement	Non-Announcement	Difference
Mean	1.8	2.0	**-0.2**	1.3	1.5	**-0.2**
t-stat	[31.56]	[81.08]	**[-2.71]**	[21.87]	[60.08]	**[-2.67]**
1% percentile	-1.3	-0.4	-1.0	-0.7	-0.9	0.1
25% percentile	1.1	1.1	0.0	0.6	0.7	-0.1
Median	1.5	1.5	0.0	1.2	1.3	-0.1
75% percentile	2.3	2.3	0.0	1.6	1.9	-0.2
99% percentile	7.1	9.2	-2.1	4.5	6.6	-2.0
Std. Dev.	1.4	1.7		1.6	1.8	
Skewness	1.3	2.6		14.5	5.1	
Kurtosis	8.3	22.7		312.6	136.1	
N	582	5,256		752	5,240	

Table 7
Summary Statistics for Implied Variance

This table shows the distribution of daily changes in implied variance on announcement days and non-announcement days. Announcement days are those trading days when CPI/PPI (CPI before January 1971 and PPI afterwards) numbers, employment numbers, and FOMC interest rate decisions are scheduled for release. Implied variance is calculated from the CBOE S&P 100 Volatility Index, which is a constant-maturity 30-day measure of the expected volatility for the S&P 100 Index (available starting in 1986). All numbers are expressed in percentage points.

	Panel A: All Observations			**Panel B: Excluding outliers (1% and 99%)**		
	Announcement	Non-Announcement	Difference	Announcement	Non-Announcement	Difference
Mean	-1.4	1.4	**-2.8**	-2.2	0.8	**-3.0**
t-stat	[-2.47]	[3.85]	**[-4.13]**	[-5.28]	[5.57]	**[-6.88]**
1% percentile	-28.3	-26.0	-2.3	-25.8	-21.7	-4.1
25% percentile	-9.3	-6.1	-3.2	-9.1	-6.0	-3.1
Median	-2.8	0.0	-2.8	-2.8	0.0	-2.8
75% percentile	3.2	6.6	-3.4	3.1	6.4	-3.3
99% percentile	53.1	40.8	12.3	31.9	33.3	-1.4
Std. Dev.	15.6	25.9		10.8	10.6	
Skewness	4.1	46.9		0.8	0.6	
Kurtosis	36.1	2884.4				
N	721	5,070		705	4,968	

Table 8
Regression Analysis - Implied Variance

This table presents the results of OLS regressions of daily changes in implied variance on an announcement day dummy variable and various other controls. Ann. day is a dummy variable equaling 1 if day t is an announcement day and equaling 0 otherwise. Daily change in implied variance (ΔImpVar) is calculated from the CBOE S&P 100 Volatility Index, which is a constant-maturity 30-day measure of the expected volatility for the S&P 100 Index (available starting in 1986). Monday-Thursday are dummy variables for the corresponding days of the week. T-statistics are calculated using Newey-West standard errors (with 5 lags) and are given in brackets.

	Panel A: All Observations			**Panel B: Ex. outliers (1% and 99%)**		
	(1)	**(2)**	**(3)**	**(1)**	**(2)**	**(3)**
Intercept	1.401	1.408	0.270	0.840	0.855	-0.325
	[3.96]	[4.44]	[0.57]	[6.21]	[6.08]	[-0.89]
Ann. day	**-2.834**	**-2.873**	**-2.264**	**-2.996**	**-2.897**	**-2.430**
	[-4.33]	**[-3.76]**	**[-3.72]**	**[-6.82]**	**[-6.66]**	**[-5.32]**
$\Delta \text{ImpVar}_{t-1}$		-0.004	-0.002		-0.070	-0.071
		[-0.03]	[-0.02]		[-5.63]	[-5.68]
$(\Delta \text{ImpVar}_{t-1})^2$		0.0000	0.0000		0.0000	0.0000
		[-0.05]	[-0.06]		[4.92]	[4.96]
Monday			1.551			0.381
			[0.86]			[0.79]
Tuesday			1.011			1.309
			[1.69]			[2.81]
Wednesday			0.835			1.669
			[1.54]			[3.64]
Thursday			1.935			2.188
			[3.26]			[4.51]
N	5,791	5,781	5,781	5,673	5,663	5,663
R^2 (%)	0.1	0.2	0.2	0.1	0.2	0.2

Table 9
Bond Betas on Announcement and Non-Announcement Days

This table presents the results of OLS regressions of daily excess returns for Treasury bonds with different maturities on contemporaneous stock market excess returns and an announcement day dummy. Ann. day is a dummy variable equaling 1 if day t is an announcement day and equaling 0 otherwise. The sample covers the 1961-2008 period. Market excess returns (Mktrf) are computed as the difference between the CRSP value-weighted market return and the risk-free rate (expressed in basis points). Treasury bond returns are obtained from the CRSP Fixed Term Indices File (expressed in basis points). T-statistics are given in brackets.

	1-year Bond	**5-year Bond**	**10-year Bond**	**20-year Bond**	**30-year Bond**
Intercept	0.443	0.479	0.210	0.381	0.225
	[6.03]	[1.60]	[0.47]	[0.64]	[0.35]
$Mktrf_t$	-0.001	0.004	0.016	0.034	0.024
	[-0.69]	[1.21]	[3.27]	[5.23]	[3.58]
Ann. day	**-0.551**	**2.526**	**3.013**	**3.639**	**4.277**
	[-2.51]	**[2.83]**	**[2.23]**	**[2.03]**	**[2.25]**
Ann. day * $Mktrf_t$	**0.010**	**0.044**	**0.077**	**0.098**	**0.116**
	[4.27]	**[4.81]**	**[5.61]**	**[5.36]**	**[5.99]**
N	11,830	11,830	11,830	11,830	11,830
R^2(%)	0.2	0.4	0.6	0.8	0.7

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