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# Essays on the Stock Market's Reaction to Macroeconomic News

A dissertation submitted in partial satisfaction of the
requirements for the degree
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in

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by

Tolga Cenesizoglu

Committee in charge:

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2006

The dissertation of Tolga Cenesizoglu is approved, and it is acceptable in quality and form for publication on microfilm:

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2006

To my wonderful parents Erol and Belgin.

“*For a long time it had seemed to me that life was about to begin - real life. But there was always some obstacle in the way. Something to be got through first, some unfinished business, time still to be served, a debt to be paid. Then life would begin. At last it dawned on me that these obstacles were my life.* ”

– Alfred D’Souza

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ACKNOWLEDGEMENTS

Over my years as a graduate student, it also dawned on me that the obstacles were my life. Without the love, support and guidance of many people, it would not have been possible for me to succeed and enjoy those obstacles that are my life.

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ABSTRACT OF THE DISSERTATION

**Essays on the Stock Market's Reaction to Macroeconomic News**

by

Tolga Cenesizoglu
Doctor of Philosophy in Economics

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Professor Allan Timmermann, Chair

There are probably only few other questions as central to economics as the question "How do market prices react to news?". The reaction of prices to new information has interested and puzzled economists since the early years of the field. This thesis addresses several dimensions of this basic question for the specific case of the stock market. This thesis develops new theoretical models about the reaction of stock prices to macroeconomic news using new mathematical tools and techniques and tests the implications of these and other models using new data sets on macroeconomic news.

In the first chapter of my thesis, *A Rational Model of Underreaction: The Effect of Macroeconomic News*, I analyze the long-term effects of macroeconomic news on the return dynamics. I develop a dynamic general equilibrium asset pricing model where macroeconomic news is an additional state variable. In this framework, I show that the underreaction of stock prices to news is consistent with a rational expectations model rather than a behavioral specification as suggested by recent literature. Furthermore, I show that the reaction of the stock market to news depends on the state of the economy. The empirical results suggest that the stock market underreacts to news about the nominal U.S. Gross Domestic Product.

In the second chapter of my thesis, *Risk and Return Reaction of the Stock Market to Public Announcements about Fundamentals: Theory and Evidence*, I analyze the short-term effects of public macroeconomic announcements about fundamentals on daily returns. This chapter presents new theoretical and empirical results on the effect of public announcements on the stock market. I develop a dynamic general equilibrium asset pricing model where investors learn about the unobserved state of the economy through dividend realizations and periodic public announcements. The main implications of my model can be summarized as follows: 1. If

investors are more risk averse than log utility, returns react negatively to a positive unanticipated news in the announcement. 2. Returns react asymmetrically to the unanticipated news on announcement days. 3. The effect of the unanticipated news depends on the state of the economy which is revealed by the announcement. 4. On announcement days, the conditional volatility of returns is a decreasing function of the investors uncertainty about the announcement. In other words, the higher the degree of uncertainty resolved on announcement days, the smaller the conditional volatility will be. Using real-time data and survey expectations, I develop measures of unanticipated news and uncertainty to test the implications of my theoretical model. I find that the implications of my model hold for the aggregate stock market returns on the U.S. Gross Domestic Product announcement days.

In the last chapter of my thesis, I analyze the asymmetries in the reaction of returns on portfolios with different characteristics to the same macroeconomic news. The first empirical question addressed in this chapter is "Do the effects of macroeconomic news on stock returns differ across assets?". More specifically, I analyze whether stock returns on a portfolio of firms with high market capitalization and/or high book equity-to-market equity ratio react differently than stock returns on a portfolio of firms with low market capitalization and/or low book equity-to-market equity. I find that returns on a portfolio of firms with high market capitalization (large firms) and book-to-market ratio (value firms) react stronger (in magnitude) to macroeconomic news than returns on a portfolio of firms with low market capitalization (small firms) and book-to-market ratio (growth firms). I also find that firms with high market capitalization and low book-to-market ratio are sensitive to fewer macroeconomic variables than firms with low market capitalization and high book-to-market ratio. Having documented these asymmetries in the reaction of firms with different characteristics, I analyze the possible sources of these asymmetries by decomposing the effect of news into three parts, its effect through the market's discount rate component, its effect through the market's cash flow component and its direct effect. First of all, I find that the news does not have any direct effect on stock returns when one controls for the market's discount rate and cash flow components suggesting that the reaction is generally captured by the two market components. Furthermore, I find that the differential reaction across firms with different characteristics is generally due to the differential sensitivity to the market's cash flow component.

# Chapter 1

# A Rational Model of Underreaction: The Effect of Macroeconomic News

## 1.1 Introduction

In its weakest form, the efficient market hypothesis states that no excess returns can be earned by using investment strategies based on historical prices or other financial data. Recent empirical research in asset pricing has revealed several challenges to this hypothesis. The evidence of large excess returns to simple momentum strategies appears to be one of the few affronts to the idea of rational efficient markets. Jegadeesh and Titman (1993) report the original findings of momentum profits and suggest that these profits are due to systematic underreaction of asset prices to the available news in the market. In the early literature, the rational models fail to account for these abnormal profits resulting from simple momentum strategies. Fama and French (1996) acknowledge that their three-factor model fails to account for the profitability of momentum strategies. Recently, few rational models have been developed to account for underreaction of stock prices. On the other hand, several behavioral models, based on different sorts of investor irrationality, have been proposed to account for underreaction in the market. However, these studies have been mostly theoretical and the models have not been thoroughly empirically tested. Cochrane (2001) notes that a convincing story for momentum profits has not been proposed and momentum profits remain a puzzling empirical fact.

This article suggests that a rational model for underreaction and hence for momentum profits is also possible in a nonlinear model for consumption growth. The momentum evidence is closely related to underreaction, since the positive autocorrelations of returns over short horizons may be due to the slow incorporation of news into stock prices. Our main goal in this paper is not to analyze the momentum profits but to develop a rational model for underreaction to account for momentum profits.

It is well known that the basic CAPM is not capable of mimicking the empirical features of asset prices, and thus asset returns. In this paper, we develop a parsimonious extension of the capital asset pricing model (hereafter, CAPM) in which the consumption growth is modeled as a Markov regime switching stochastic process. The model is simplified and cannot possibly account for all empirical features observed, nevertheless it suggests a way to solve this puzzling fact from a rational standpoint. We propose a two state exponential random walk model for consumption growth where the state process follows a Markov chain with time varying conditional transition probability matrix. The probability of staying in each state in every period is a simple function of the observed news variable. Hence, returns are affected by the news variable in a highly nonlinear way that cannot be captured by simple linear models. The dynamics of the model under certain restrictions on model parameters result in the underreaction of asset prices. The intuition of the model is simply that the good state for the consumption growth becomes more persistent following good news about the asset, which simulates a positive shock effect on the returns. However, this is just a model. It has its own shortcomings and simplifications like any other model. In this model, we neither analyze general equilibrium effects nor the multi-firm economy. Furthermore, the model is a representative agent model. The main aim of this paper is to propose a parsimonious model to explain the underreaction of asset prices from a rational point of view.

The rest of the paper is organized as follows. Section 1.2 reviews the relevant empirical literature and discusses both the rational and the behavioral models of underreaction. Section 1.3 introduces the model used in this study and Section 1.4 solves for the asset price and expected returns. Section 1.5 describes what we mean by underreaction. Section 1.6 discusses the data sets employed to analyze the empirical features of the model. Section 1.7 estimates the model parameters from the data. Section 1.8 calculates the price-dividend ratio and the expected returns from the estimated model parameters. Section 1.9 discusses the sensitivity and the robustness of our results to different choices of model parameters. Section 1.10 summarizes our findings and suggests direction for future research.

## 1.2 Literature Review

In this section, we review relevant empirical and theoretical literature on underreaction and the profitability of momentum strategies. We present both behavioral and rational models that attempt to account for the underreaction of asset prices to news.

### 1.2.1 Empirical Evidence

The original empirical findings of momentum strategies are in Jegadeesh (1990), Lehmann (1990) and Jegadeesh and Titman (1993). Every month from January 1963 to December 1989, Jegadeesh and Titman (1993) group all stocks traded on the NYSE into deciles based on their prior six month return and compute average returns of each decile over the six months after portfolio formation. They find that the decile of biggest prior winners outperforms the decile of biggest prior losers by an average of 10% on an annual basis. Jegadeesh (1990) finds that the difference between abnormal returns on the extreme decile portfolios is 2.49% per month over the period 1934-1987. In a shorter time interval, Lehmann (1990) finds return reversals in individual stocks. He reports that the portfolio of assets that had positive returns in one week typically had negative returns ranging from -0.35% to -0.55% per week on average in the next week. On the other hand, those with negative returns in one week typically had positive returns ranging from 0.86% to 1.24% per week on average in the next week.

Several articles including Jegadeesh and Titman (2001), Grundy and Martin (2001) and Rouwenhorst (1998) found that the momentum effects are robust across different markets and subperiods. Jegadeesh and Titman (2001) show that the momentum profits have continued in the 1990s, suggesting that the original results were not a product of data snooping bias. They also examine the predictions of recent behavioral models that propose that momentum profits are due to delayed overreactions that are eventually reversed. Grundy and Martin (2001) show that, after accounting for potential risk factor exposures, momentum exists from the 1920's to the present. In order to account for possible data snooping problems in momentum strategies using the same U.S. market data, Rouwenhorst (1998) analyzes the profitability of these strategies in international markets. He finds that an internationally diversified momentum portfolio earns an excess return of approximately 1% per month.

### 1.2.2 Explanations

The literature has suggested several theoretical explanations to account for underreaction both from rational and behavioral standpoints. Although rational models have been mostly successful accounting for other financial anomalies observed in US markets, the evidence of momentum profits and underreaction has been challenging for such models. On the other hand, behavioral models seem to account for underreaction, at least theoretically. However, there is no consensus among behavioral models on which psychological factors cause underreaction. Furthermore, only recently there have been few attempts to test these behavioral model. The empirical implications of these models are not yet well understood.

#### Rational Explanations

Rational explanations include different approaches ranging from factor models to time varying risk premium and dividend growth. Lo and MacKinlay (1990) suggest that short-term momentum profits may be also due to lead-lag effects between stocks. However, Jegadeesh and Titman (1993) reject that lead-lag effects cannot account for momentum strategies. Fama and French (1996) find that the three factor model developed in Fama and French (1993) explains the strong patterns in returns observed when portfolios are formed on earnings/price, cash flow/price, and sales growth, variables recommended by Lakonishok, Shleifer, and Vishny (1994) and others. However, they find that their model cannot explain momentum profits. Conrad and Kaul (1998) empirically decompose the profits of these strategies and fail to reject that in-sample cross-sectional variation in mean returns can explain profitability of momentum strategies. Lewellen (2002) studies momentum in stock returns, focusing on the role of industry, size, and book-to-market (B/M) factors. The evidence in his paper suggests that stocks covary too strongly with each other. He suggests that excess covariance explains momentum profits. Chordia and Shivakumar (2002) show that profits to momentum strategies can be explained by a set of lagged macroeconomic variables and payoffs to momentum strategies disappear once stock returns are adjusted for their predictability based on these macroeconomic variables. Their results provide a possible role for time-varying expected returns as an explanation for momentum payoffs. Moskowitz and Grinblatt (1999) identify industry momentum as the source of much of the momentum trading profits at 6-12 month horizons. They suggest that once the returns are adjusted for industry effects, momentum profits from individual equities are significantly weaker and mostly statistically insignificant. Berk, Green, and Naik (1999) develop a rational partial equilibrium model of individual firms' investment decisions. The valuation of the cash flows that result from investment decisions, along with the firm's options to grow in the future leads to dynamics for conditional expected returns which helps explain momentum profits. Johnson (2002) develops a continuous time partial equilibrium model where expected dividends growth rates vary over time. This model with a standard pricing kernel produces the momentum profits. He further shows that an enhanced model under which persistent growth rate shocks occur episodically can match many features of the data. He presents theoretical and simulation results. However, he doesn't analyze how his model performs when applied to US market data.

**Behavioral Explanations**

Behavioral models suggest different types of psychological factors of investor irrationality that result in underreaction in the market. The underreaction of stock prices in turn generates excess returns on momentum strategies. Chan, Jegadeesh, and Lakonishok (1997) show that the intermediate-horizon return continuation can be partially explained by the underreaction to earnings news. They present strong evidence of correction of prices when large, positive prior returns are not validated by good news about earnings. For an alternative explanation to the Fama and French three factor model, they suggest that the market might be responding gradually to new information. They claim that if the market is surprised by good or bad earnings news, then on average the market continues to be surprised in the same direction over the next two subsequent announcements. Barberis, Shleifer, and Vishny (1998) develop a parsimonious model of investor sentiment, or of how investors form beliefs, which is consistent with the empirical findings. They employ two psychological phenomena namely representativeness heuristic and conservatism. They solve this model and show that, for a plausible range of parameter values, it generates the empirical predictions observed in the data. However, they don't provide any empirical tests of their model. Daniel, Hirshleifer, and Subrahmanyam (1998) propose a theory of securities market underreactions and overreactions based on two other psychological biases: investor overconfidence about the precision of private information; and biased self-attribution, which causes asymmetric shifts in investors' confidence as a function of their investment outcomes. They show that biased self-attribution adds positive short-lag autocorrelations ("momentum"), short-run earnings drift, but negative correlation between future returns and long-term past stock market and accounting performance. Hong and Stein (1999) proposes a model of a market populated by two groups of boundedly rational agents: "news-watchers" and "momentum traders". They show when only news watchers are active in the market prices adjust to new information slowly, there is underreaction but no overreaction. When they add the momentum traders into the population then the returns exhibit both underreaction and overreaction. The initial reaction of prices in the direction of fundamentals is accelerated, but this comes at the expense of creating eventual overreaction to any news.

In this paper, we propose a rational model for underreaction where the news variable affects the consumption growth process. Our approach is closest to that of Johnson (2002) where he suggests that the nonlinear dynamics of the dividend process generates momentum profits. Our approach differs from his in several ways including the model and the data employed to generate underreaction. We analyze the effect of several macroeconomic news on the price-dividend ratio and the stock returns. We adopt an extension of the CAPM analyzed by Cecchetti, Lam, and Mark (2000). In their paper, they specify investors' beliefs about the consumption process as a regime switching model where the investor has distorted beliefs about the transition probabilities. In their model, they assume that the transition probabilities are linear functions of other unobserved state variables. They employ this model to explain financial anomalies such as equity premium and volatility puzzle. Instead we assume that the transition probabilities are functions of the publicly available news variable. The main contribution of our paper to the existing literature is that our model calibrated to the US data is capable of generating underreaction in aggregate stock prices. To our best knowledge, this study is the first one to attempt this.

## 1.3 The Model

In this section, we develop an extension of the CAPM that can account for the underreaction observed in the data. Before proceeding to the formal description of our model, we discuss the intuition behind this model. In our model, every period the representative investor observes a publicly available news variable and the true state of the consumption growth process. The main idea is that the pricing kernel is a nonlinear function of the observed news variable. Before observing the news variable, the single asset in the economy can be thought of as two separate contingent assets depending on the state of the news variable. In the case of good news, the return of the asset covaries "more positively" (or "less negatively") with consumption than the case of bad news. This makes consumption more volatile. Therefore, the asset must promise higher expected returns to induce the representative investor to hold it. Conversely, in the case of bad news, the return of the asset covaries "less positively" (or "more negatively") with consumption, hence lower expected returns. The natural consequence of underreaction is the predictability of stock returns over short horizons. Our model generates only short horizon predictability and more importantly, it is a rational model since the representative agent knows the true data generating process and makes his/her decisions rationally by estimating the parameters of the true data generating process. We neither claim that this model can explain every empirical feature of the data nor analyze the implications of a multi-firm economy.

The main purpose of our paper is to show that rational underreaction is possible. To provide a benchmark for our investigation, we consider a variant of Lucas (1978)'s representative agent endowment economy, that has served as the workhorse in aggregate asset pricing studies. Consider an economy with a large number of infinitely lived, identical agents, a single perfectly divisible asset producing non-storeable consumption good. One perfectly divisible share of the asset trades in a competitive market. The preferences of the representative investor are represented by a constant relative risk aversion (CRRA) utility function

$$U(C_t) = \frac{C_t^{1+\gamma}}{1+\gamma}, \quad -\infty < \gamma < 0 \tag{1.1}$$

where $C_t$ denotes the representative investor's consumption in period $t$ and $\gamma$ is the coefficient of relative risk aversion. In every period, the investor solves the portfolio allocation problem. If the investor behaves optimally, the Euler equation for the maximization problem is

$$P_t = \beta E_t \left[ \frac{U'(C_{t+1})}{U'(C_t)} (P_{t+1} + D_{t+1}) \right] \tag{1.2}$$

where $P_t$ and $D_t$ denote the price of the asset and the dividends paid in period $t$, respectively. $\beta$ is the investor's time impatience parameter and $E_t[\cdot]$ denotes expectation conditional on the available information at period $t$. In order to solve for the asset price analytically, we follow the literature on modeling regimes in consumption (Cecchetti, Lam, and Mark (1990), Cecchetti, Lam, and Mark (1993), Cecchetti, Lam, and Mark (2000), Whitelaw (2000)) and assume that the log-consumption ($c_t = \log C_t$) follows a random walk with a drift that follows a two-state Markov chain, i.e.

$$\Delta c_t = \mu_{S_t} + \sigma_{S_t} \varepsilon_t, \quad \varepsilon_t \sim iiN(0,1) \tag{1.3}$$

where $\Delta$ denotes the first difference operator, i.e. $\Delta c_t = c_t - c_{t-1}$, $\mu_i$ and $\sigma_i$ for $i = 0, 1$ are the mean and the standard deviation in different states $S_t$, respectively, and $\varepsilon_t$ is the iid standard normal disturbance of the random walk. The state variable $S_t$ follows a two-state Markov chain with time-varying conditional transition probabilities that are simple logit functions of the single news variable observed in the economy, i.e.

$$\begin{aligned}
\Pr(S_{t+1}=1|S_t=1,z_t) = &\quad \pi_1(z_t) &= \frac{\exp(\alpha_1+\beta_1 z_t)}{1+\exp(\alpha_1+\beta_1 z_t)} \\
\Pr(S_{t+1}=0|S_t=1,z_t) = &\quad 1-\pi_1(z_t) &= 1-\frac{\exp(\alpha_1+\beta_1 z_t)}{1+\exp(\alpha_1+\beta_1 z_t)} \\
\Pr(S_{t+1}=0|S_t=0,z_t) = &\quad \pi_0(z_t) &= \frac{\exp(\alpha_0+\beta_0 z_t)}{1+\exp(\alpha_0+\beta_0 z_t)} \\
\Pr(S_{t+1}=1|S_t=0,z_t) = &\quad 1-\pi_0(z_t) &= 1-\frac{\exp(\alpha_0+\beta_0 z_t)}{1+\exp(\alpha_0+\beta_0 z_t)}
\end{aligned} \tag{1.4}$$

where $\{\alpha_1, \beta_1, \alpha_0, \beta_0\}$ are the parameters of the logit specification and $z_t$ is the news (or information) variable observed at the beginning of each period $t$. Thus, the investor first observes the relevant news and depending on the news observed makes her optimal portfolio allocation decision which determines the current price of the asset in period $t$. On the other hand, the investor does not observe the true transition probabilities and needs to estimate the parameters of the logit specification from the consumption data.

The two-state Markov regime switching specification is a reasonable model for consumption. Firstly, it has been reported in the literature that this specification is able to identify the expansionary and contractionary states of business cycles. Secondly, this model with constant transition probabilities is able to match several empirical features of the data.

Although, the fixed transition probability model has been frequently employed in the literature for modeling consumption, the time varying transition probability model is less established. In this paper, we follow Filardo (1994)'s approach by modeling the transition probabilities as logit functions of exogenous variables. In his paper, Filardo models log growth rate of monthly industrial production as a time varying transition probability Markov regime switching process. He concludes that the time varying transition probability model performs better than the fixed probability model in explaining the business cycle turning points. Furthermore, Perez-Quiros and Timmermann (2000) and Perez-Quiros and Timmermann (2001) find that reaction of stock returns to state variables such as interest rate and dividend yield follows a Markov regime switching process with time-varying transition probabilities. In an equilibrium setting, it is customary in the literature to assume the aggregate stock as the claim on the aggregate dividend. Furthermore, these quantities are also equal to output. Therefore, we employ the model of Filardo (1994) for consumption with different explanatory variables. Whitelaw (2000) employs a similar version of our model to analyze risk and return relationship.

For analytical tractability, we further assume that the news variable follows a two state

Markov chain with constant transition probabilities, i.e. $z_t$ takes on two values $z_t = 1$ (Good News) and $z_t = -1$ (Bad News). The transition probabilities of the news variable process are independent of the past, current and future states of the log dividend process ($S_t$), i.e. for all $s$,

$$\begin{aligned} \Pr(z_{t+1} = 1 | z_t = 1, S_s) = & \quad \Pr(z_{t+1} = 1 | z_t = 1) & = k_1 \\ \Pr(z_{t+1} = -1 | z_t = -1, S_s) = & \quad \Pr(z_{t+1} = -1 | z_t = -1) & = k_0 \end{aligned} \tag{1.5}$$

This assumption is also necessary to derive the concentrated likelihood for maximum likelihood estimation as discussed in Filardo (1998). Furthermore, we assume that the investor observes both the true state of the consumption process, i.e. $z_t$, $S_t \in \mathcal{F}_t$ where $\mathcal{F}_t$ denotes the investor's information set at time $t$. However, the econometrician only observes the news variable not the true state of the consumption process. Additionally, the error term in the consumption process ($\varepsilon_t$) is independent of both $S_t$ and $z_t$ at every lag.

## 1.4 Solving the Model

Using the price equation and the data generating process for consumption, it is possible to calculate the price-consumption ratio and expected returns in closed form. This is possible since the news (or information) variable is assumed to follow a discrete Markov process. For continuous news variables, the closed form solutions are no longer available, a discretization methodology is required to obtain approximate numerical solutions. It is also possible to solve this model when the news variable is vector valued discrete Markov process. However, it will be difficult to classify different states as good or bad news when the news variable is a vector-valued. In this case, the number of parameters to be estimated increases dramatically.

In order to solve this model analytically, we expand the state space by defining the news variable $z_t$ as an additional state variable. Since $z_t$ follows a Markov chain with constant transition probabilities, the expanded state space itself is also a Markov chain with 4 possible states and constant transition probabilities. Furthermore, since both $S_t$ and $z_t$ are observable by the investor, the new state vector is also observable. We define expanded state space as $\tilde{S}_t = (S_t, z_t) = \{(1, 1), (1, -1), (0, 1), (0, -1)\}$. Let $\mathbf{\Pi}$ be the $(4 \times 4)$ matrix of transition probabilities of the expanded state space $\tilde{S}_t$. The elements of $\mathbf{\Pi}$ can be written as a function of the transition probabilities of $S_t$ and $z_t$[1], i.e.

$$\Pr(\tilde{S}_{t+1}|\tilde{S}_t) = \Pr(S_{t+1}, z_{t+1}|S_t, z_t) = \Pr(S_{t+1}|S_t, z_t) \cdot \Pr(z_{t+1}|z_t) \tag{1.6}$$

where the last equality follows from the conditional independence of transition probabilities of $z_t$ and $S_s$ as described in Equations (1.5).

The following proposition solves for the current asset price as a function of the current consumption level, the state of the economy and the observed news variable. Since the current state of the economy and the news variables are observable by the investor, the investor can calculate the current asset price from the estimated parameters of the consumption process.

**Proposition 1.1.** *Let $\rho(S_t, z_t)$ denote the price-consumption ratio as a function of the current state variable $S_t$ and the observed news variable, $z_t$ and the $(4 \times 1)$ vector $\rho$ of 4 possible values of $\rho(S_t, z_t)$, i.e. $\rho = [\rho(1,1), \rho(1,-1), \rho(0,1), \rho(0,-1)]'$. Furthermore, let the $(4 \times 1)$ vector $\mathbf{P}_t = [P_t(1,1,C_t)$, $P_t(1,-1,C_t)$, $P_t(0,1,C_t)$, $P_t(0,-1,C_t)]'$ denote the vector of current asset price as a function of $S_t$, $z_t$ and the current consumption level. Then, the current equilibrium prices of the asset is given by*

$$P_t(S_t, z_t, C_t) = \rho(S_t, z_t) C_t \tag{1.7}$$

*and the price-consumption ratio is*

$$\rho = (\mathbf{I}_4 - \mathbf{M})^{-1} \mathbf{M} \iota \tag{1.8}$$

*where $\mathbf{M}$ is a $(4 \times 4)$ matrix of constants, described in the appendix and $\mathbf{I}_4$ and $\iota$ are an identity matrix and a vector of ones, respectively.*
*Therefore, the current price can be written compactly as follows*

$$\mathbf{P}_t = \rho C_t = (\mathbf{I}_4 - \mathbf{M})^{-1} \mathbf{M} \iota C_t \tag{1.9}$$

*Proof.* All proofs are in the appendix. □

In this model, the current asset price is proportional to the current consumption level and the price-consumption ratio can take on only one of four values depending on the current state of the world and the currently observed news variable. This follows directly from

[1] A full description of the transition matrix $\mathbf{\Pi}$ is given in the appendix.

the assumption that investors observe the true state of the consumption process. In the more realistic case where the current state is not observable and must be inferred from the data, the price-consumption ratio would be a continuous variable fluctuating between the bounds of $\max[\rho(1,1),\rho(1,-1),\rho(0,1),\rho(0,-1)]$ and $\min[\rho(1,1),\rho(1,-1),\rho(0,1),\rho(0,-1)]$.

The following corollary calculates the next period's return as a function of next period's state and the news variable. The return is defined to be the ratio of the increase in the asset price to the current price.[2]

**Corollary 1.1.** *Let $r_{t+1}$ and $r_{t+1|t}(S_t,z_t)$ denote the asset return at time $t+1$ and the expected asset return at time $t+1$ conditional on the investor's information set at time $t$, respectively. Furthermore, let the $(4\times 1)$ vector $\mathbf{r_{t+1|t}}$ denote the four possible values of expected return, $r_{t+1|t}(S_t,z_t)$, i.e. $\mathbf{r_{t+1|t}} = [r_{t+1|t}(1,1),\ r_{t+1|t}(1,-1),\ r_{t+1|t}(0,1),\ r_{t+1|t}(0,-1)]'$. Then, the asset return at $t+1$ can be written as*

$$r_{t+1} = \frac{\rho(S_{t+1},z_{t+1})}{\rho(S_t,z_t)}\exp[\mu_{S_{t+1}} + \sigma_{S_{t+1}}\varepsilon_{t+1}] - 1 \tag{1.10}$$

*Furthermore, the vector of expected asset returns at time $t+1$ conditional on the investor's information set at time $t$, $\mathbf{r_{t+1|t}}$ can be written compactly as*

$$\mathbf{r_{t+1|t}} = E_t[\frac{\mathbf{P}_{t+1}-\mathbf{P}_t}{\mathbf{P}_t}] = \frac{\tilde{\mathbf{M}}\rho}{\rho} - \iota = \frac{\tilde{\mathbf{M}}(\mathbf{I}_4-\mathbf{M})^{-1}\mathbf{M}\iota}{(\mathbf{I}_4-\mathbf{M})^{-1}\mathbf{M}\iota} - \iota \tag{1.11}$$

*where $\tilde{\mathbf{M}}$ is another $(4\times 4)$ matrix of constants, described in the appendix and the fractions in the expectation and on the right hand side of equation (1.11) are element by element division.*

Although, the expected return can take on 4 possible values, the return process itself is a continuous variable since it depends on $\varepsilon$.

## 1.5 Underreaction

In this section, before we give the formal definition, we describe what we mean by underreaction. Underreaction suggests that the expected return in the period following good news should be higher than the expected return following bad news. This is a violation of the efficient market hypothesis since the efficient market hypothesis asserts that the expected returns

[2] In the appendix, we derive the equation for gross return defined as the ratio of next period's asset price plus next period's consumption to the current asset price. The interpretation remains the same.

following either good news or bad news should be equal. In other words, in the semi-strong form of the hypothesis, all the publicly available information should be incorporated into prices so that the returns cannot be predicted with any publicly available information. One direct implication of underreaction is that the returns are predictable by using the news variable. The intuition behind underreaction is that the information is incorporated into prices slower than the efficient market hypothesis would predict. In other words, stock prices underreact to news, a mistake which is corrected in the following period, giving a higher return at that time. The momentum evidence described in Section 1.2 is closely related to underreaction. If the news is good, prices trend up after an initial positive reaction and on the other hand when the news is bad, the prices trend down after an initial negative relation.

Mathematically, if the next period's expected return conditional on current good news is higher than the next period's expected return conditional on bad news, then it is said that the stock prices underreact to news in the economy. The following definition of the hypothesis of underreaction following Barberis, Shleifer, and Vishny (1998) formalizes these ideas.

**Definition 1.1.** *Let $z_t$ be the news observed in the economy at the beginning of period $t$ that can be either good ($z_t = 1$) or bad ($z_t = -1$). Furthermore, let $r_t$ denote the return at time $t$, i.e. $r_t = \frac{P_t - P_{t-1}}{P_{t-1}}$. Then, the stock price underreacts to news in the economy if the following inequality holds:*

$$E[r_{t+1}|z_t = 1, \mathcal{F}_t] > E[r_{t+1}|z_t = -1, \mathcal{F}_t] \tag{1.12}$$

*where $\mathcal{F}_t$ denotes investor's information set at time $t$.*

In this paper, we analyze the possible underreaction of the aggregate stock market to one main type of news, namely the macroeconomic news observed in the economy. In the following section, we describe how the news variable is quantified. The previous empirical work on the aggregate stock market has revealed some evidence of underreaction. Cutler, Poterba, and Summers (1991) generally, though not uniformly, find positive autocorrelation in excess index returns over horizons between one month and one year. They find that the average one month autocorrelation in excess returns in the United States is around 10%. This autocorrelation evidence is consistent with the underreaction hypothesis, which states that stock prices incorporate information slowly, leading to trends in returns over short horizons. Although the more convincing evidence comes from the cross-section of stocks, in this paper we pay little attention to individual stock underreaction.

The following proposition summarizes the necessary conditions for our model to generate underreaction in the stock prices.

**Proposition 1.2.** *The model described in Section 1.3 is capable of generating underreaction in the stock price if the following inequalities hold simultaneously*

$$(\mathbf{r_{t+1|t}})_{11} > (\mathbf{r_{t+1|t}})_{21} \tag{1.13}$$

$$(\mathbf{r_{t+1|t}})_{31} > (\mathbf{r_{t+1|t}})_{41} \tag{1.14}$$

*where* $(\mathbf{r_{t+1|t}})_{ij}$ *denotes the* $ij^{th}$ *element of the expected return vector* $\mathbf{r_{t+1|t}}$.

*Proof.* All proofs are in the appendix. □

Furthermore, there exists a range of model parameters that guarantee that the inequalities (1.13) and (1.14) hold. Since the expressions are not simple and easy to interpret, we restrain ourselves from presenting those conditions here. On the other hand, the intuition of this result is simple. The underreaction of stock prices may not be due to the irrationalities of the investor as suggested frequently in the literature, but due to the nonlinear pricing kernel that depends on the news variable in a nonlinear fashion.

## 1.6 Data

In this section, we describe the data used to analyze empirical features of our model. The data used in this study are threefold. The first data set is the total U.S. consumption. The other two are the forecast and realization of several macroeconomic variables used to quantify the news variable.

The dependent variable modeled in this paper is total U.S. consumption growth. Therefore, we need to proxy for total U.S. consumption. For each quarter, we aggregate quarterly seasonally adjusted annual rate (SAAR) real personal consumption expenditures of nondurable goods and services to obtain total U.S. consumption between 1969:II and 2004:I yielding a total of 140 observations.[3] There are several issues with the quality of data including time aggregation and poor quality of measurement which are beyond the scope of this paper.

[3]The data is publicly available from Federal Reserve Bank of St. Louis (Series PCNDGC96 and PCESVC96 from http://research.stlouisfed.org/fred2/categories/110). More details about the data are available from “A Guide to the National Income and Product Accounts of the United States (NIPA)”.
( http://www.bea.doc.gov/bea/an/nipaguid.pdf).

The following graph presents quarterly U.S. consumption and its growth[4] between 1969:II and 2004:I.

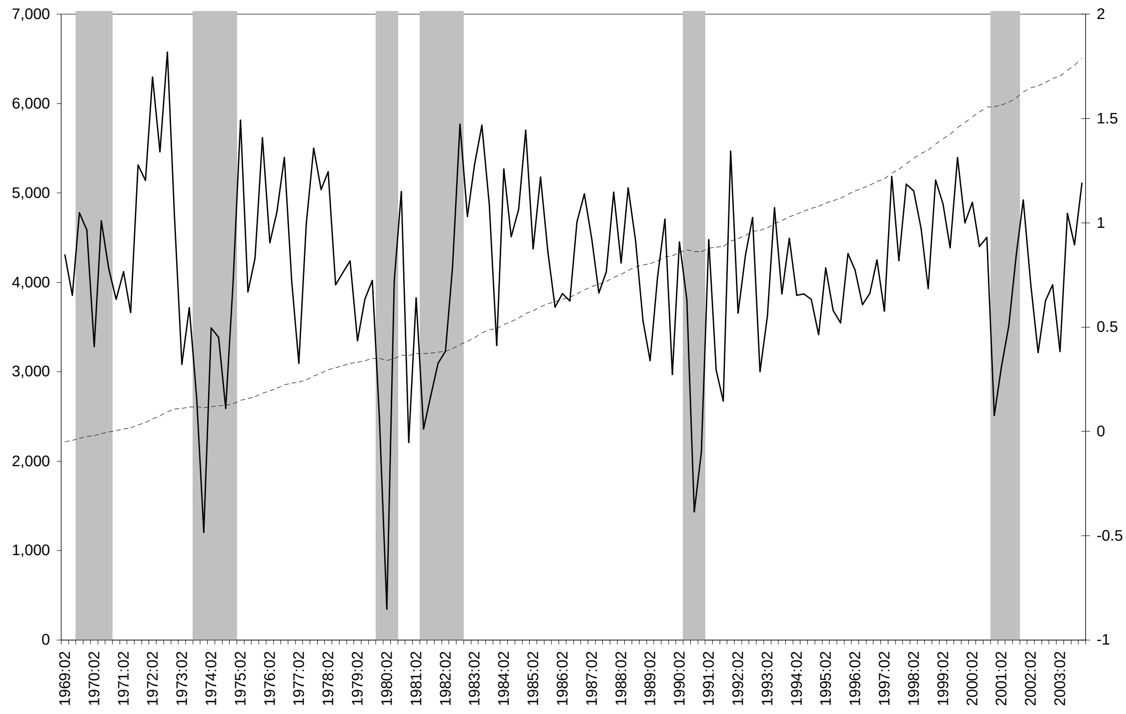



Figure 1.1: Quarterly U.S. Consumption and Consumption Growth

Notes: The dotted line represents U.S. consumption ($C_t$) measured on the left axis of billions of Chained 2000 Dollars. The solid line represents the consumption growth ($\Delta \log(C_t) \times 100$) measured on the right axis. Shaded areas are the NBER recessions.

The consumption growth drops dramatically in recession periods and is generally negative except the recession in 1970. The following table summarizes some descriptive statistics about the quarterly log consumption growth (in percent).

Quarterly consumption growth changes between a maximum of 1.81% and a minimum of -0.85% with a mean of 0.77% and a standard deviation of 0.42. The results are consistent with Whitelaw (2000) and other studies that study aggregate consumption. Using a different data set, Whitelaw (2000) finds that the U.S. consumption grows monthly with an average of 0.260% which corresponds to 0.7820% quarterly growth rate.

[4]The consumption growth is defined to be the log difference between consecutive consumption levels. The consumption growth is percentage growth.

Table 1.1: Descriptive Statistics for log Consumption Growth

| | $\Delta log(C_t)$ |
|---|---|
| Mean | 0.7749 |
| Median | 0.7858 |
| Maximum | 1.8169 |
| Minimum | $-0.8508$ |
| Std. Deviation | 0.4170 |
| Skewness | $-0.6521$ |
| Kurtosis | 4.4401 |

In Figure (1.6), NBER recession quarters correspond to big negative spikes in the consumption growth process. Therefore, we present estimation results from Hamilton (1989)'s fixed transition probability Markov regime switching process for the consumption growth as a part of the descriptive statistics. The following table presents estimation results from a constant variance two state Markov regime switching process with normally distributed error terms.

Table 1.2: A Constant Variance Fixed Transition Probability Markov Regime Switching Model for $\Delta \log(C_t) \times 1000$ ($\Delta log(C_t) = \mu_{S_t} + \sigma\varepsilon_t, \varepsilon_t \sim iiN(0,1)$)

| LL = $-386.1704$ | $\mu$ | $\sigma$ | $Prob$ |
|---|---|---|---|
| Contraction (State 0) | 2.4657 | 3.4098 | 0.7626 |
| | (2.2319) | (0.2564) | (0.1926) |
| Expansion (State 1) | 8.8355 | | 0.9513 |
| | (0.3534) | | (0.0208) |

Notes: The asymptotic standard errors are in parenthesis. For maximum likelihood estimation to work properly, we fit the Markov regime switching process to 10 times percent consumption growth. In other words, the variable modeled is $\Delta \log(C_t) \times 1000$. $Prob$ is the probability of staying in the same state, i.e. $Prob = \Pr(S_{t+1} = i|S_t = i)$ for $i = 0, 1$.

These results are broadly consistent with the results of Cecchetti, Lam, and Mark (1990). They fit the same model to the growth rates of consumption, dividends and GNP. All the parameters except the mean in contraction state are estimated accurately. The states are highly persistent, i.e. the probability of staying in the same state is high. The probability of staying in the same state next period is 0.9513 and 0.7626 for expansion and contraction, respectively. We also calculate the unconditional probability of being in a contraction state[5] to be 0.1702. We

[5] The unconditional probability of being in contraction is calculated as $\Pr(S_t = 0) = (1 - \Pr(S_{t+1} = 1|S_t = 1))/(2 - \Pr(S_{t+1} = 1|S_t = 1) - \Pr(S_{t+1} = 0|S_t = 0))$.

discuss the ability of this model to account for the NBER business cycles in the model calibration section.

The other two data sets employed in this study are the real-time values and forecasts of several different macroeconomic variables. The Real-Time Data Set available from the Federal Reserve Bank of Philadelphia consists of vintages, or snapshots, of time series of major macroeconomic variables as observed by the agents in that period. The forecast variables are available from the Survey of Professional Forecasters at the Federal Reserve Bank of Philadelphia. The Survey of Professional Forecasters is a quarterly survey of macroeconomic forecasts in the United States. We use the median forecasts of individual one-quarter ahead forecast to be the expectation about the future value of the macroeconomic variable. In this study, we analyze the effect of macroeconomics news about Nominal GDP, GDP Price Index, Corporate Profits after Tax, Civilian Unemployment Rate.

We employ the forecast error of macroeconomic variables to quantify the news variable in the economy. Therefore, our focus is on the forecast error rather than realization and forecast. There are also significant data revisions to the real-time data. In this paper, we only use the first announcement of the macroeconomic variable. Table 1.3 summarizes descriptive statistics about the forecast errors of macroeconomic variables.[6]

The forecasters tend to underestimate the true real-time GDP with a mean error of $ 9.34 billion. Although the forecast error seems to be quite large, the mean forecast error is only 0.166 %. The professional forecasters also tend to underestimate the corporate profits after tax with a mean forecast error of 1.132 %. On the other hand, they tend to overestimate civilian unemployment rate and GDP Price Index with mean forecast error of -0.736 % and -1.352 %. Furthermore, the first order autocorrelation of corporate profit after tax forecast error is quite large and significant suggesting that the forecasters might not be using all the available information available for forecasting. One would make a better forecast by simply exploiting the autocorrelation in the forecast errors. We also find that each forecast except GDP Price Index forecast is efficient using Mincer and Zarnowitz (1969) efficiency regression.

Following the literature on earnings surprise, we define the news variable to be good if the real-time value of the macroeconomic variable exceeds the expectations and bad otherwise. We employ the median forecast to be a proxy for summarizing overall expectation about the macroeconomic variable in the economy. In other words, if the real-time value is higher (lower for unemployment and GDP Price Index) than the median forecast, then the news is assumed to

[6]Forecast error is calculated as the difference between the real-time value of the macroeconomic variable and its median forecast.

Table 1.3: Descriptive Statistics about Forecast Errors of Macroeconomic Variables

| | GDP | Corp. Profits | Unemployment | GDP Price Index |
|---|---|---|---|---|
| Mean | 9.3393 | 4.2347 | -0.0404 | -1.5850 |
| Median | 4.3000 | 1.6000 | -0.0667 | -0.0720 |
| Maximum | 276.7000 | 190.5000 | 0.5333 | 1.9516 |
| Minimum | -172.3000 | -118.6000 | -0.4333 | -120.9598 |
| Std. Deviation | 43.3944 | 29.1748 | 0.1589 | 11.5300 |
| Skewness | 1.3988 | 1.7583 | 0.4164 | -8.9820 |
| Kurtosis | 14.8306 | 19.1459 | 3.6394 | 88.0889 |
| $1^{st}$ order AC | 0.044 | 0.524 | 0.139 | -0.012 |
| p-value | (0.598) | (0.000) | (0.094) | (0.883) |

Notes: GDP denotes quarterly SAAR nominal Gross Domestic Product in $ billion. Corp. Profits denotes quarterly SAAR Corporate Profits after Tax excluding inventory valuation and capital consumption adjustments in $ billion. Unemployment is the seasonally adjusted Civilian Unemployment Rate excluding armed services in percentages. GDP Price Index is the seasonally adjusted GDP Chain-Weighted Price Index with an index level of 100 in the base year 2000. $1^{st}$ order AC is the first order autocorrelation of the corresponding variable where the p-value is the p-value of the corresponding Q statistics for the first order autocorrelation.

be good, otherwise bad. Let $z_t$ denote the news variable observed in the economy as in Section 1.3, then $z_t$ can be written

$$z_t = \text{signum}(Realization_t - Forecast_t) = \text{signum}(ForecastError_t) \tag{1.15}$$

where $Realization_t$ and $Forecast_t$ are real-time value and the one-quarter ahead median forecast of the macroeconomic variable at time $t$, respectively and $ForecastError_t$ is the forecast error as defined above.

The intuition behind this definition of the news is simple. If the investors observe better than expected macroeconomic variables, then they believe that this is a good signal about the economy, i.e. good news ($z_t = 1$). This definition of macroeconomic news is equivalent to the definition of earnings surprise. However, we believe that using macroeconomic variables rather than individual earnings surprises to quantify the news is more reasonable since the individual companies may manipulate their earnings to meet expectations. On the other hand, manipulation of macro variables to meet expectations is almost impossible. Furthermore, the news variable defined as in Equation (1.15) is observable both by the agents in the economy and the econometrician, since both the real-time value and the median forecast are publicly available.

This definition of the news variable can easily be extended to vector-valued news variable by stacking several different news in the economy as a vector. However, for the purposes of this paper, the vector-valued news variable is troublesome, since to our best knowledge, there is no easy way to classify the news as good or bad. The news variable can also be continuous to account for the size of the news by defining the news variable as the forecast error. In this paper, we only focus on the effect of individual binary news on the price and expected returns.

Before we present descriptive statistics about the news variable $z_t$, we discuss the time line of events such as the announcement of the macroeconomic variables, the release of forecasts from the Survey of Professional Forecasters and the release of the news variable. The time line of events determine the release date of the news.

The real-time value of macroeconomic variables for a particular quarter are released in the last month of next quarter. On the other hand, the forecast from the Survey of Professional Forecasters for a particular quarter is released in the middle month of the same quarter. Therefore, the news variable is observable when the latest of the two is released. The following graph presents the time line of events for the second quarter of 1996.

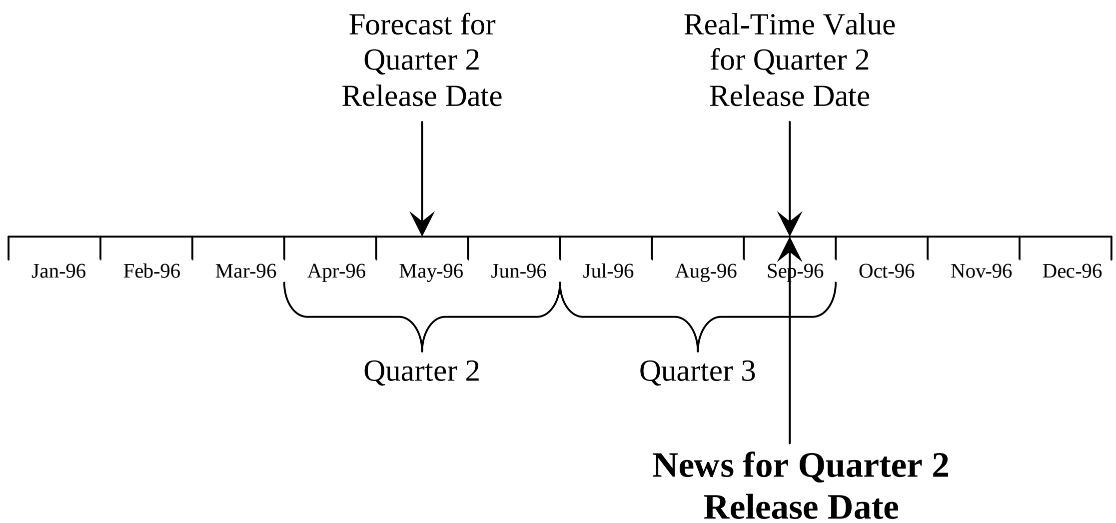



Figure 1.2: Time Line of Release Dates for Forecasts and Announcements

The forecast for the $2^{nd}$ quarter of 1996 from The Survey of Professional Forecasters was released on May 24, 1996 and the real-time values of macroeconomic variables for the same quarter was released on September 12, 1996 from The Federal Reserve Statistical Release. The agents don't observe the real-time value of the macroeconomic variables till the end of the following quarter. Hence, the news variable for $2^{nd}$ quarter of 1996 is observable when the real-time values are released on September 12, 1996. Furthermore, we assume that the news variable for $2^{nd}$ quarter doesn't affect the consumption growth in the $3^{rd}$ quarter but in $4^{th}$ quarter.

The following table summarizes descriptive statistics about the different news variable ($z_t$) as defined in Equation (1.15).

Table 1.4: Descriptive Statistics about Macroeconomic News Variables

| | GDP | Corp. Profits | Unemp. | GDP PI |
|---|---|---|---|---|
| Mean | 0.2766 | 0.1206 | 0.1773 | 0.1773 |
| Std. Deviation | 0.9644 | 0.9962 | 0.9877 | 0.9877 |
| Skewness | -0.5756 | -0.2429 | -0.3603 | -0.3603 |
| Kurtosis | 1.3314 | 1.0590 | 1.1298 | 1.1298 |
| $\Pr(z_{t+1} = 1 \vert z_t = 1)$ | 0.6180 | 0.7308 | 0.6707 | 0.6585 |
| | (0.0519) | (0.0508) | (0.0524) | (0.0524) |
| $\Pr(z_{t+1} = -1 \vert z_t = -1)$ | 0.3333 | 0.6613 | 0.5345 | 0.5000 |
| | (0.0660) | (0.0601) | (0.0655) | (0.0662) |
| $\Pr(z_t = 1)$ | 0.6357 | 0.5572 | 0.5857 | 0.5942 |
| | (0.0353) | (0.0636) | (0.0512) | (0.0495) |

Notes: The asymptotic errors are in parenthesis. The standard errors in the last row are calculated via delta method using asymptotic normality of maximum likelihood estimates of $\Pr(z_{t+1} = 1|z_t = 1)$ and $\Pr(z_{t+1} = -1|z_t = -1)$. Unemp. and GDP PI denote Unemployment and Gross Domestic Product Price Index, respectively.

On average, there are more good news in the economy than bad ones. Good news variable is more persistent than bad news in the sense that the probability of observing a good news following good news is bigger than that of bad news. Moreover, the unconditional probability of observing good news is higher than that of bad news following bad news. One surprising fact is that although, on average, both Civilian Unemployment Rate and GDP Price Index are overestimated by the forecasters, there are more good news than bad news about these macroeconomic variables. Although, these two macroeconomic news have the same first 4 moments, which is most likely a coincidence, they have different statistical properties in terms of the time path of the binary variable.

## 1.7 Calibrating the Model

In order to analyze whether our model is capable of generating underreaction to different macroeconomic news, we need to calibrate the consumption growth process to the aggregate U.S. consumption. In this section, we estimate the model parameters in Equations (1.3), (1.4) in Section 1.3 for different macroeconomic news separately.

We employ a variant of the Hamilton (1989)'s filter for time varying transition probabilities discussed in Gray (1996) and Whitelaw (2000) to estimate model parameters. In this maximum likelihood approach, both the conditional probability of a state and the likelihood function can be written recursively using Bayes' Theorem. The assumption in Equations (1.5) satisfies the assumptions discussed in Filardo (1998) necessary to derive the concentrated likelihood and estimate the nuisance parameters[7] and the model parameters separately. Following Filardo (1994), we model the variance across regimes to be the same to account for the possibility of unbounded likelihood. The details of the filter are discussed in the appendix.

Table 1.5 summarizes the estimation results of the model parameters. Before we proceed to the implications of the estimated model parameters, we analyze the estimation results more closely. The mean for different states and the variance are estimated precisely. The means and the variance are not highly sensitive to the specification of transition probabilities. In other words, the means and the variance remain almost identical whether transition probabilities are fixed or time-varying conditional on different macroeconomic news. Moreover, the mean of consumption growth is higher in expansion for each specification.

There are two main questions about the estimation. First of all, does there exist more than one regime in the data? Secondly, does the data suggest time-varying transition probabilities rather than fixed probabilities? Following, Filardo (1994), we use both econometric and graphical methods to analyze the degree to which of these models fit the data and characterize business cycle fluctuations. Although, it is possible to construct a test statistic for testing two-regime model versus a single regime model using the framework discussed in Hansen (1992), it is computationally intensive. On the other hand, the likelihood ratio test of two-regime versus single regime model doesn't have standard chi-square distribution because of the nuisance parameter problem.[8] Hence, we analyze the degree to which the model fits the data by examining its ability to identify NBER business cycles.

Figure 1.3 presents the ex-post smoothed probabilities of a recession for different model specifications. The probability of a recession should be close to 1 during a recession and 0 during an expansion.

First of all, all specifications fail to account for the first recession in 1970. Whitelaw (2000) suggests the explanation that underlying consumption growth data around 1970 shows

[7]Nuisance parameters are the parameters of the news (information) variable process, i.e. parameters of the $z_t$ process in 1.5.

[8]Under the null hypothesis of a single regime, the nuisance parameters, i.e. regime shift parameters are not identified.

Table 1.5: Estimation Results

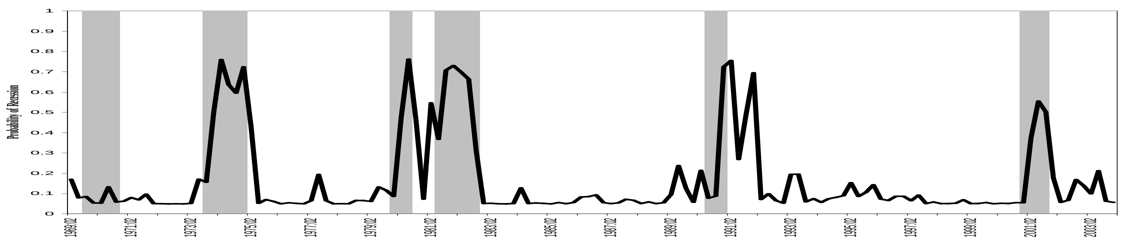
| | FTP | GDP | Corp. Prof. | Unemp. | GDP PI |
|---|---|---|---|---|---|
| LL | -386.1704 | -385.7462 | -384.7746 | -385.4536 | -382.7656 |
| Expansion | | | | | |
| $\mu_1$ | 8.8355 | 8.8800 | 8.8246 | 8.7923 | 8.8288 |
| | (0.4275) | (0.3450) | (0.3764) | (0.3296) | (0.3120) |
| $\sigma$ | 3.4098 | 3.3736 | 3.4715 | 3.5402 | 3.3383 |
| | (0.2963) | (0.2423) | (0.3420) | (0.2210) | (0.2082) |
| $\alpha_1$ | 2.9723 | 2.9584 | 3.7316 | 6.0213 | 6.9608 |
| | (0.4501) | (0.4727) | (8.2996) | (23.6782) | (0.3304) |
| $\beta_1$ | - | 0.0285 | -1.3376 | -3.0581 | 5.0878 |
| | (-) | (1.2320) | (9.2632) | (23.6914) | (0.2690) |
| Contraction | | | | | |
| $\mu_0$ | 2.4657 | 2.4618 | 2.8070 | 3.1130 | 1.9871 |
| | (2.2320) | (1.5670) | (2.0914) | (1.0696) | (1.4480) |
| $\sigma$ | - | - | - | - | - |
| | (-) | (-) | (-) | (-) | (-) |
| $\alpha_0$ | 1.1670 | 4.0890 | 0.9239 | 2.0061 | 0.9921 |
| | (1.0582) | (3.6693) | (1.4005) | (0.9496) | (0.9738) |
| $\beta_0$ | - | -3.3706 | 1.0036 | 1.0625 | 0.6399 |
| | (-) | (3.9019) | (0.7949) | (1.0937) | (0.8547) |
| LR Statistic | - | 0.8484 | 2.7916 | 1.4336 | 6.8096 |
| p-value | (-) | (0.6543) | (0.2476) | (0.4883) | (0.0332) |
| QPS | 0.2071 | 0.2256 | 0.2357 | 0.2357 | 0.1998 |
| LPS | 0.3526 | 0.4188 | 0.4245 | 0.4637 | 0.3102 |
| GSB | 0.0016 | 0.0005 | 0.0006 | 0.0014 | 0.0022 |

Notes: The asymptotic standard errors are in parenthesis. LL denotes the likelihood of the data calculated at the maximum likelihood estimates. $\mu_1, \mu_2$ and $\sigma$ are mean and standard deviation respectively and $\alpha_1, \alpha_0, \beta_1$ and $\beta_0$ are the parameters of the logit specification. LR statistics is the likelihood ratio statistic of the test of fixed versus time-varying transition probabilities ($H_0 : \beta_1 = \beta_0 = 0$ vs. $H_A : \beta_1, \beta_0 \neq 0$). p-value is the corresponding p-value of the LR statistic which is $\chi^2_2$ distributed. QPS, LPS denotes Quadratic Probability Score and Logarithmic Probability Score, respectively. These measures are used to evaluate forecast accuracy of binary prediction of NBER recessions. GSB denotes Global Squared Bias, a measure of forecast calibration. Unemp. and GDP PI denote Unemployment and Gross Domestic Product Price Index, respectively. The measures are discussed in detail in the appendix.

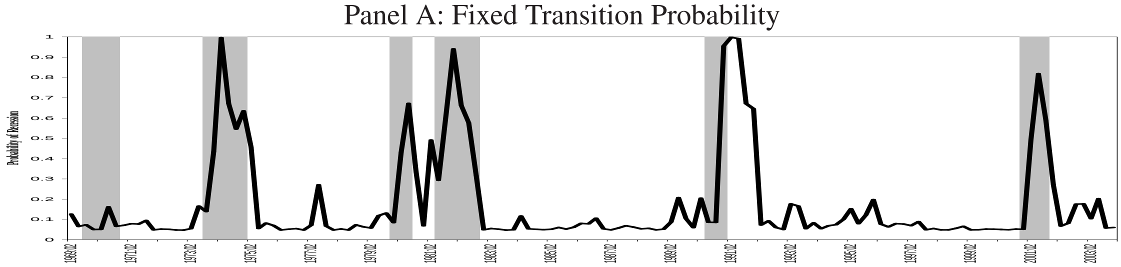
no contraction-like behavior. Secondly, the specifications with Corporate Profits after Tax and Unemployment Rate fail to identify the 2001 recession. Overall, the specification with the Nominal GDP news performs better than any other specification considered in this paper. It identifies 3 out of 6 post-1969 recessions with probability one and identifies the other recessions better than the fixed transition probability specification. From the probability plots, it is clear that the regime switching with time-varying probabilities conditional on GDP news performs excellently in fitting the data.

Table 1.5 also reports likelihood ratio (LR) statistic for likelihood ratio test of fixed versus time-varying transition probabilities assuming a two-regime model for consumption growth. The restricted model, i.e. the fixed transition probability model corresponds to the restriction that $\beta_1 = \beta_0 = 0$. Since our model satisfies restrictions discussed in Filardo (1994), the LR statistic is $\chi^2$ distributed with 2 degrees of freedom. We fail to reject fixed transition probability at 5% confidence level in all specifications except when the transition probabilities depend on GDP Price Index news. This specification also has the most significant estimated parameters. In terms of forecast accuracy of the NBER business cycles measure by QPS (Quadratic Probability Score) and LPS (Logarithmic Probability Score), only the GDP Price Index outperforms the fixed transition probability specification. However, in terms of forecast calibration measured by GSB (Global Squared Bias), the GDP specification outperforms other specifications.

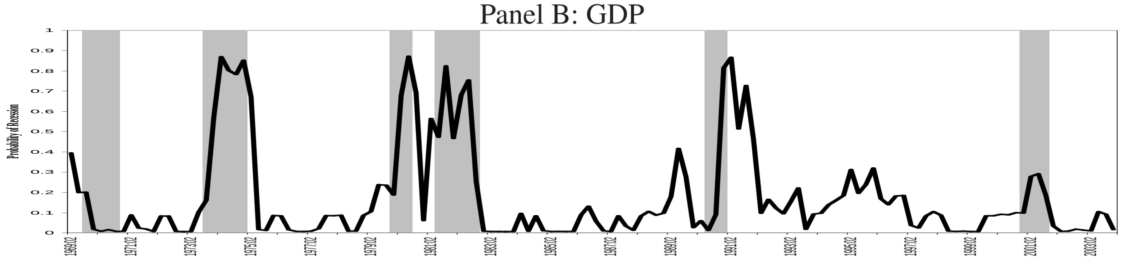
The issue of time-varying transition probabilities is less clear than existence of multiple regimes. However, the two time-varying transition probability specifications outperforms the fixed transition probability specification as suggested both econometrically and graphically.



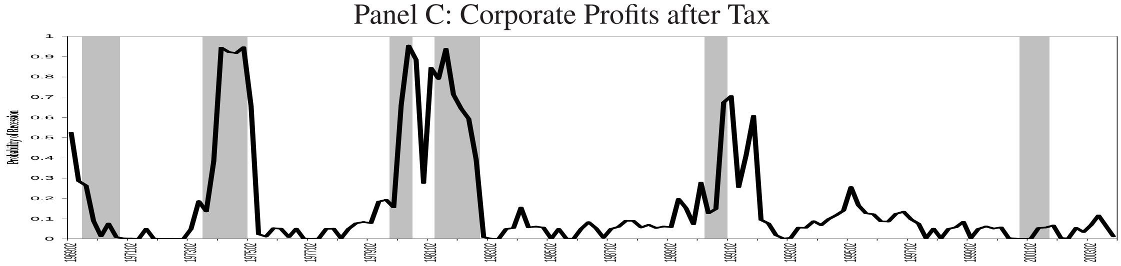
Panel A: Fixed Transition Probability



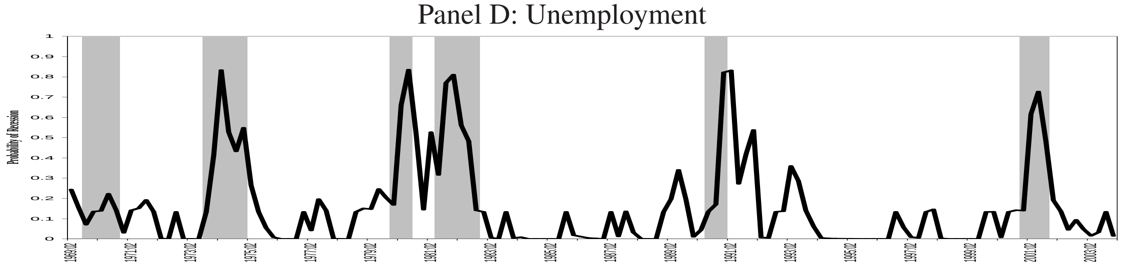
Panel B: GDP



Panel C: Corporate Profits after Tax



Panel D: Unemployment



Panel E: GDP Price Index

Figure 1.3: Ex-Post Smoothed Probability of Recession of Model Specifications with Different News Variables

Notes: The shaded regions are the NBER recessions. The vertical axis is the probability of a recession.

The parameters of greatest interest to the current investigation are the parameters of the time varying transition probabilities, i.e. $\alpha_1, \alpha_0, \beta_1, \beta_0$. These parameters are estimated accurately for the fixed transition probability specification and time-varying transition probability conditional on GDP Price Index news. The specification conditional on GDP news is marginally significant. However, the specifications conditional on Corporate Profits and Unemployment fail to be accurate at any conventional significance level.

The effect of news on the consumption growth can be inferred from the movements in $\pi_1(z_t)$ and $\pi_0(z_t)$. Filardo (1994) defines the content of news to be "good" if $\pi_1(z_t)$ increases and $\pi_0(z_t)$ decreases when $z_t$ increases. In other words, in that case, both the probability of switching from expansion to expansion and contraction to expansion increases, hence the probability of being in expansion next quarter increases. According to this definition of the content of news, the news about GDP is the only news with "good" content. The content of Corporate Profits after Tax and Unemployment is "bad" and the GDP Price Index is ambiguous. Hence, following good news about GDP, the expansion state for consumption growth becomes more likely. The following table summarizes the time-varying transition probabilities calculated from the estimated model parameters.

Table 1.6: Time-Varying Transition Probabilities

| | GDP | Corp. Profits | Unemp. | GDP PI |
|---|---|---|---|---|
| $\pi_1(1)$ | 0.9518 | 0.9164 | 0.9509 | 1.0000 |
| $\pi_1(-1)$ | 0.9493 | 0.9938 | 0.9999 | 0.8668 |
| $\pi_0(1)$ | 0.6723 | 0.8730 | 0.9556 | 0.8364 |
| $\pi_0(-1)$ | 0.9994 | 0.4801 | 0.7198 | 0.5872 |

Notes: $\pi_1(1), \pi_1(-1), \pi_1(1), \pi_0(-1)$ are the transition probabilities conditional on the current news variable as defined in Equation (1.4). Unemp. and GDP PI denote Unemployment and Gross Domestic Product Price Index, respectively.

## 1.8 Price-Dividend Ratio and Expected Returns

Using Equations (1.8) and (1.11) and the estimated model parameters of consumption growth and the news process, it is possible to calculate the price-consumption ratio and expected returns. Since, in our model, the consumption is equal aggregate dividend, one can think of the price-consumption as the price-dividend ratio. In order to calculate the price-dividend ratio and expected returns, we also need to specify the investor's time impatience parameter $\beta$ and risk aversion parameter $\gamma$. Following Whitelaw (2000)[9], we use $\beta = 0.9910$ and $\gamma = -2$ and the sensitivity of our results is discussed later. The following table presents the 4 possible values of price-dividend ratio and expected returns for different model specifications.

Table 1.7: Price-Dividend Ratio and Expected Returns

| | FTP | GDP | Corp. Profits | Unemp. | GDP PI |
|---|---|---|---|---|---|
| P/D Ratio | | | | | |
| $\rho(1,1)$ | 58.9772 | 59.2672 | 58.5532 | 58.7186 | 59.1370 |
| | (8.8569) | (3.3939) | (4.6595) | (6.6228) | (1.1794) |
| $\rho(1,-1)$ | 58.9772 | 59.2698 | 58.4152 | 58.6029 | 59.3300 |
| | (8.8569) | (3.4024) | (4.9495) | (7.0013) | (1.1950) |
| $\rho(0,1)$ | 59.8906 | 60.1657 | 59.4130 | 60.43583 | 60.2241 |
| | (8.4491) | (3.6148) | (4.7004) | (6.4581) | (7.1091) |
| $\rho(0,-1)$ | 59.8906 | 60.6131 | 58.8547 | 59.9072 | 59.8798 |
| | (8.4491) | (3.7499) | (4.7144) | (6.5188) | (7.0261) |
| Exp. Return in % | | | | | |
| $r_{t+1\|t}(1,1)$ | 0.9325 | 0.9501 | 0.8783 | 0.9220 | 0.9998 |
| | (0.2369) | (0.1325) | (0.1752) | (0.1547) | (0.0391) |
| $r_{t+1\|t}(1,-1)$ | 0.9325 | 0.9467 | 0.9701 | 0.9767 | 0.8177 |
| | (0.2369) | (0.1349) | (0.6214) | (0.3926) | (0.0387) |
| $r_{t+1\|t}(0,1)$ | 0.0343 | 0.1590 | -0.0593 | -0.0719 | -0.1315 |
| | (0.1582) | (0.2124) | (0.2926) | (0.2461) | (0.2471) |
| $r_{t+1\|t}(0,-1)$ | 0.0343 | -0.2469 | 0.4010 | 0.1792 | 0.2013 |
| | (0.1582) | (0.4948) | (0.3244) | (0.2640) | (0.2612) |

Notes: The asymptotic standard errors are in parenthesis. The standard errors are calculated as the sample standard deviation of bootstrapped price-dividend ratio and expected returns.[10] Unemp. and GDP PI denote Unemployment and Gross Domestic Product Price Index, respectively.

First of all, both the price-dividend ratio and the expected returns are calculated accurately. The only news variable that generates underreaction in the stock price is the news about Nominal GDP. In other words, the expected returns following good news about GDP is higher than the expected returns following bad news about GDP in either state of the economy. The news about GDP Price Index generates underreaction only in the expansion. On the other hand, both news about Corporate Profits after Tax and Unemployment Rate generates opposite effect in the expected returns.

Furthermore, the underreaction evidence following GDP news is significant yielding a t statistics of 5.2154 in the expansion state and 45.2975 in the contraction state both with 19998

[9]Whitelaw (2000) uses $\beta = 0.997$ for monthly data, the corresponding quarterly time impatience parameter is 0.9910.

degrees of freedom. Although, the effect might seem smaller in the expansion state, one should note that the expected returns are quarterly returns and the effect becomes more pronounced in the annual returns.

The intuition behind our findings is simple. First of all, according to Filardo (1994)'s definition of content of news, GDP is the only news variable with unambiguously "good" content as discussed above. Following good news about GDP, the expansion state in the next period becomes more likely independent of the current state. The higher probability of being in the expansion state next period coincides with higher stock price next period, which in turn implies higher expected return. The evidence that only the news with unambiguously "good" content is similar to the first correlation requirement in Proposition 2 of Johnson (2002).

Our results can be summarized by two implications. Firstly, as expected different news variables have different effects on the expected return. Therefore, the underreaction evidence depends highly on the conditioning news variable. Secondly, the underreaction is highly related to the state of the economy. These implications are inline with the existing literature. The event studies such as post-earnings announcement drift, IPO announcements etc. find differing effects of these news on the stock returns. Moreover, among other studies, Chordia and Shivakumar (2002) find that certain business cycle variables explain systematic variation in momentum profits.

## 1.9 Sensitivity Analysis and Robustness Checks

In this section, we analyze the sensitivity and robustness of our results to different specification of model parameters. We only perform this analysis on the model with the GDP news variable since this model specification is the only one that generates underreaction in the stock prices. Before proceeding to calculating the expected return for different discount factors and risk aversion coefficients, we discuss whether the estimates of price-dividend ratio and expected return match historical figures.

Since, in equilibrium, the aggregate consumption equals aggregate dividend, we analyze whether the price-dividend ratio estimated from our model matches the historical average of S&P 500 price dividend ratio. The price-dividend ratio for S&P 500 at the end of year 2003 was 220 and historically it has ranged from 60 to 250 with an average of 155. The quarterly returns on S&P 500 has ranged from -20.5484% to 26.0421% with an average of 3.7727%. In the following table, we present price-dividend ratios and expected returns calculated from estimated parameters of the model specification with GDP news for time impatience parameter $\beta$ of 0.996 and risk aversion parameter $\gamma$ of -1.3.

Table 1.8: Sensitivity Analysis for Price-Dividend Ratio and Expected Returns

| | GDP |
|---|---|
| P/D Ratio | |
| $\rho(1,1)$ | 157.9675 |
| $\rho(1,-1)$ | 157.9696 |
| $\rho(0,1)$ | 158.6985 |
| $\rho(0,-1)$ | 159.0625 |
| Exp. Return in % | |
| $r_{t+1\|t}(1,1)$ | 0.8886 |
| $r_{t+1\|t}(1,-1)$ | 0.8863 |
| $r_{t+1\|t}(0,1)$ | 0.3662 |
| $r_{t+1\|t}(0,-1)$ | 0.0942 |

Notes: The standard errors are exactly the same as in Table (1.7)

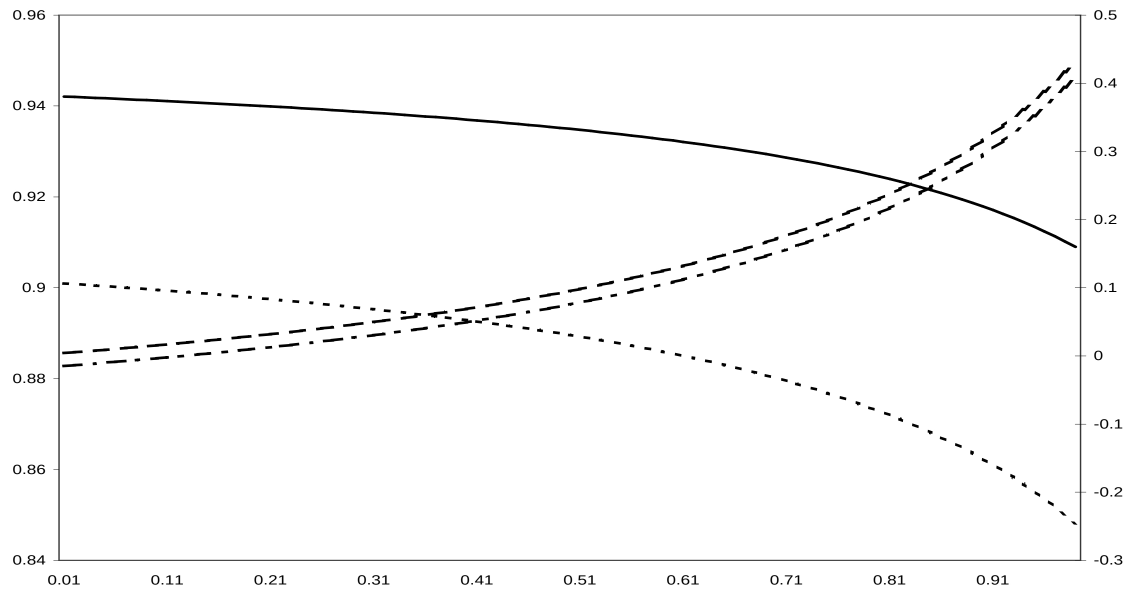
Table 1.8 shows that this framework is flexible enough to match the historical averages of the aggregate stock market. It is also possible to match the range of the historical data with different combinations of risk aversion and time impatience parameters. Although expected quarterly return figures are smaller than the average quarterly return on S&P 500, it is still possible to match the figures with high degree of risk aversion.

Figure 1.4 presents sensitivity of underreaction effect with respect to the time impatience parameter and risk aversion.

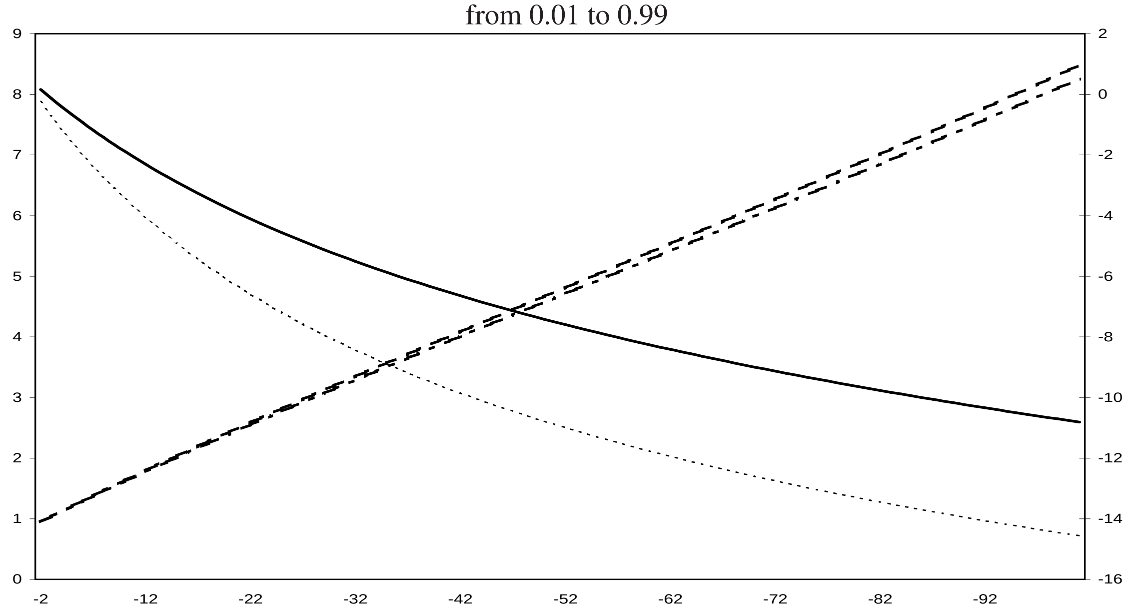
The underreaction evidence generated from the model is robust to different parameter choices. The underreaction is more pronounced in the contraction state. Although the expected returns calculated from the estimated model parameters changes with time impatience parameter, the difference between the expected returns following good news and those following bad news remain almost the same for different values of $\beta$. On the other hand, the underreaction effect becomes more pronounced as the representative investor becomes more risk averse.

## 1.10 Conclusion

In this paper, we develop a parsimonious asset pricing model where the consumption growth is modeled as a Markov regime switching process with a time-varying transition probabilities conditional on observed macroeconomic news. We show that it is possible to generate




Panel A: Plot of expected returns for a $1 \times 100$ grid of time impatience parameter $\beta$ ranging from 0.01 to 0.99




Panel B: Plot of expected returns for a $1 \times 100$ grid of risk aversion parameter $\gamma$ ranging from -2 to -101

Figure 1.4: Sensitivity Analysis of Expected Returns to Parameter Choices

Notes: The solid line and the dotted line represent the expected return following good news and bad news, respectively, in contraction state measured on the right vertical axis. The dashed line and the dotted dashed line represent the expected return following good news and bad news, respectively, in expansion state measured on the left vertical axis. The expected returns are presented in percent terms. The horizontal axis is $1 \times 100$ for model parameters.

underreaction in the aggregate stock price with a rational model under certain parameter restrictions. We argue that a rational model of underreaction is possible by defining the conditioning variable as another state variable of the model.

Furthermore, we find that time-varying transition probability model fits the consumption growth data better than fixed transition probability model. The model specification with GDP and GDP Price Index outperform the other specifications considered in this paper.

We find that the underreaction depends on the current state of the economy and conditioning news variable. The only news variable that the stock prices underreact to in both states is the news about Nominal GDP. The evidence is robust to different model parameter specifications. To our best knowledge, this is the first study to analyze the effect of macroeconomic news on stock prices in this framework.

In this paper, we don't analyze the implications of our model for momentum profits. However, the model can easily be extended to employ past returns or earnings as conditioning variables. In this case, it is still possible to calculate the asset price and expected returns using Tauchen and Hussey (1991)'s quadrature-based approximation. Future research should focus on analyzing momentum profits in this framework.

# Chapter 2

# Risk and Return Reaction of the Stock Market to Public Announcements about Fundamentals: Theory and Evidence

## 2.1 Introduction

Investors are constantly faced with the arrival of new information, such as macroeconomic releases, earnings and dividends announcements, political news etc. Such news lead investors to update their expectations about the fundamentals of the economy. The effect of news on stock returns is central to financial decision making. Investors need to know how return dynamics are affected by news for portfolio allocation, risk management and pricing options. The response of returns to news such as monetary policy decisions (e.g. FOMC meetings) conveys important information for policy makers. Furthermore, the effect of news on the stock market return has important implications for factor models used in security valuation. More importantly, the concept of market efficiency is closely related to the reaction of stock returns to news. Analyzing effects of public announcements on returns might shed some light on market efficiency. It is clear that the change in investors' expectations affect the stock market. This fact that new information affects not only the mean of stock returns but also the conditional volatility is well documented in the finance literature (Boyd, Hu, and Jagannathan (2005), Flannery and Protopapadakis (2002), Bernanke and Kuttner (2003), Bomfim (2003)). In contrast with the remarkable progress made in modeling stock returns to account for the empirical facts, little is known about the theoretical relation between the fundamentals and the reaction of returns to news.

The difficulty in analyzing the effect of news on return dynamics is that we do not directly observe information arrivals. It is difficult to accurately measure the information content and uncertainty about unscheduled news. On the other hand, analysis of public announcement effects provides a good starting point. First of all, the timing of macroeconomic news is exogenously determined and publicly known. Secondly, it is relatively easy to quantify investors' expectations about scheduled macroeconomic announcements by employing model-based or survey-based measures. Scheduled announcements are released on a periodic basis, thus, information arrivals are neither in clusters, nor positively correlated. Analyzing the reaction of stock returns to public macroeconomic announcements might provide intuition about the reaction of returns to other types of scheduled announcements, such as earnings announcements. Furthermore, recent empirical findings suggest that the stock market reacts differently to scheduled and unscheduled announcements. Effects observed for scheduled announcements such as the calm-before-the-storm effect.[1] are not observed for unscheduled announcements. Analyzing the stock market's reaction to macroeconomic announcements might provide intuition about different effects of scheduled and unscheduled news on return dynamics

Although there is strong empirical evidence that public announcements about fundamentals affect both the mean and conditional volatility of returns on announcement days, several questions still remain about the theoretical link between public announcements and the behavior of stock returns. A formal model is crucial not only for analyzing the theoretical link but also for constructing reasonable proxies for investors' expectations and uncertainty about the announcement. Instead of the current practice of using either ad hoc forecasting models or surveys, a formal model provides guidelines on how to construct such proxies for market expectations about announcements.

The finance literature on the effect of news on the mean of stock returns is relatively limited compared to the literature on the effect of news on volatility. In a recent paper, Boyd, Hu, and Jagannathan (2005) find that unemployment news have asymmetric effects on the mean S&P 500 returns depending on the state of the economy. Unanticipated news in unemployment announcements seems to affect stock returns positively in contractions and negatively in expansions. They suggest three different channels through which the information content of un-

[1] Jones, Lamont, and Lumsdaine (1998) find empirical evidence of relatively low conditional volatility of returns before major scheduled macroeconomic announcements. They dubbed this empirical fact the "calm-before-the-storm" effect.

employment news affects stock returns. Unemployment news reveals unanticipated information about future interest rates, the equity risk premium, and corporate earnings or dividends. McQueen and Roley (1993) find a strong relation between stock returns and macroeconomic news surprises, such as inflation, industrial production, and unemployment news. Flannery and Protopapadakis (2002) use a GARCH model of daily equity returns in which both realized returns and their conditional volatility are allowed to vary with 17 macroeconomic series' announcements. Of these 17 macroeconomic announcements, they identify three nominal variables (CPI, PPI, and Money Aggregate-M1 or M2) and three real variables (Employment Report, Balance of Trade, and Housing Starts) as possible candidates for risk factors. They find that the two nominal variables that affect the level of returns are CPI and PPI. Bernanke and Kuttner (2003) analyze the effect of unanticipated changes in the federal funds rate target on value-weighted portfolio of all assets in the Center for Research in Security Prices (CRSP) universe. They find that an unanticipated rate cut of 25 basis points increases the level of stock prices by approximately 1 percent. Employing the decomposition of Campbell (1991), they find that most of the effect of monetary policy on stock prices can be traced to its implications for forecasted equity risk premiums. Among other studies, Balduzzi, Elton, and Green (1999), Fleming and Remolona (1999) and Andersen, Bollerslev, Diebold, and Vega (2003) find important effects of inflation news (CPI and PPI) on other types of assets such as bonds and exchange rates. The stylized fact from this strand of literature is that returns react to the surprise content of news. Stock returns react to the announcement strongly when one controls for the anticipated content of the news. Furthermore, the stock market reacts negatively to positive unanticipated news and this reaction is stronger for positive unanticipated news than negative ones.

There is ample evidence on the effect of news on return volatility. Recently, Flannery and Protopapadakis (2002) and Bomfim (2003) find strong evidence of effects of macroeconomic announcements on the volatility of the stock market returns. Flannery and Protopapadakis (2002) analyze daily conditional volatility of value-weighted NYSE-AMEX-NASDAQ market index from CRSP between January 1980 and December 1996. They find that the conditional volatility reacts to announcements about the money supply, and three real variables (Employment Report, Balance of Trade, and Housing Starts). Bomfim (2003) analyzes the pre-announcement and news effects on the stock market in the context of public disclosure of monetary policy decisions. He finds that the stock market tends to be relatively quiet, conditional volatility is abnormally low, on days preceding regularly scheduled policy announcements. Jones, Lamont, and Lumsdaine (1998) examine the reaction of conditional volatility implied by ARCH models to news releases in the Treasury bond market. They find a risk premium on the release dates and a lack of persistence of announcement-day volatility. Furthermore, they find that the volatility of returns decreases significantly before the announcement day and dub this empirical fact as the "calm-before-the-storm". Li and Engle (1998) examined the heterogeneity in the degree of persistence between scheduled macroeconomic announcement days and non-announcement days in the Treasury futures market. They find that scheduled and unscheduled macroeconomics announcements have different effects on the conditional volatility of returns. Specifically, scheduled announcements have less persistent effects on conditional volatility. Among other studies, Andersen and Bollerslev (1998), Andersen, Bollerslev, Diebold, and Vega (2003) and Faust, Rogers, Wang, and Wright (2003) find strong evidence of effects of macroeconomic announcements on the volatility of several different assets. The stylized facts from this strand of literature are the relatively low persistence of stock volatility after an announcement and the calm-before-the-storm effect. Additionally, the effect of news is relatively different when one distinguishes between scheduled and unscheduled announcements. The literature suggests two possible channels that news affects the conditional volatility of asset returns: clustered news arrival and heterogeneity of information across market participants. In this paper, we suggest that the conditional volatility on scheduled announcement days reacts to the resolution of uncertainty about the growth rate of the economy.

Although there is evidence that asset returns respond to new macroeconomic information, little is known about the link between announcements about fundamentals and the stock market's reaction. Kim and Verrecchia (1991) develop a three-period partial equilibrium model to analyze the market reaction to anticipated announcements. They conclude that a price change reflects the change in investors' expectations due to the arrival of new information, whereas volume arises due to information asymmetries. Veronesi (1999) finds that conditional volatility of returns is a function of investors' uncertainty about the state of the economy. He finds that this effect results in asymmetric reaction of returns to news. However, neither of them test the implications of their models.

The contribution of the paper is twofold. First, we develop a general equilibrium asset pricing model to describe the theoretical link between fundamentals and the stock market's reaction to public news announcements. Specifically, we develop an asset pricing model where investors learn about the future growth rate of the economy through dividend realizations and regularly scheduled public announcements. In the general equilibrium framework, the effect of news about fundamentals on the stochastic discount factor and the growth rate of the economy are closely linked. This fact not only simplifies our analysis and makes it analytically tractable but also allows us to focus on one type of macroeconomic announcements, namely the Gross Domestic Product (GDP) releases. It is relatively straightforward to develop model-based measures of unanticipated news and uncertainty in our model. Furthermore, due to the learning component, our model is capable of generating empirical facts such as time-varying volatility and expected returns. In a simplified version of the model, we analyze the effect of a single announcement that resolves the uncertainty in the economy. In this simplified framework, we derive testable implications of our model.

Analyzing the implied return equation on announcement days, the implications of our model can be summarized as follows: In line with the existing literature, we find that the mean return on announcement days is a function of unanticipated news. That is, it reacts to the surprise content of the announcement.[2] The mean return on announcement days is significantly different from the mean return on non-announcement days if there is a significant surprise that is not already incorporated into investors' beliefs. This reaction to unanticipated news is negative if investors are more risk averse than a log-utility investor. In other words, returns react negatively (positively) to positive (negative) unanticipated news when investors are more risk averse than log utility. The intuition behind this result is straightforward. In a power utility framework, the risk aversion parameter is closely tied to the intertemporal elasticity of substitution[3], which measures how willing investors are to substitute consumption across time.[4] Unanticipated positive news about the state of the economy has two effects on the equilibrium asset price: income and substitution effects. An unanticipated higher growth rate increases future consumption, hence the asset price which is a claim on future consumption. On the other hand, investors are willing to consume more in the current period which decreases the current equilibrium asset price due to the increase in the stochastic discount factor. The reaction of the price to news depends on which effect dominates in equilibrium which in turn depends on the risk aversion parameter. If investors are more risk averse than a log-utility investor, the substitution effect dominates the income effect. Hence, a positive surprise about the growth rate of the economy has a negative effect on the equilibrium return of the risky asset. The magnitude of the reaction depends on the risk aversion of the representative investor and the size of surprise in the announcement. Furthermore, we find that the reaction of equilibrium returns to unanticipated news about the growth

[2] In this paper, we use the terms "unanticipated news" and "surprise" interchangeably.

[3] In a power utility framework, the reciprocal of the risk aversion parameter is the intertemporal elasticity of substitution.

[4] It is the interpretation of this parameter as the intertemporal elasticity of substitution that drives this result, not the interpretation of risk aversion.

rate of the economy is asymmetric. A positive unanticipated news affects the mean stock return more than a negative unanticipated news of the same magnitude. On the other hand, in line with Veronesi (1999), we find that the conditional volatility of returns on both announcement and non-announcement days is a function of investors' uncertainty. Differently, we derive a closed form solution for the conditional volatility of returns on announcement days. Furthermore, we find that the effect of uncertainty on the conditional volatility is sensitive to investors' risk aversion. We claim that it is the resolution of uncertainty on announcement days that causes the conditional volatility to behave differently relative to non-announcement days. The higher the degree of uncertainty resolved on the announcement day, the smaller the conditional volatility will be. The resolution of uncertainty about the state of the economy is the main theoretical link between news about fundamentals and the behavior of conditional volatility on announcement days. Finally, in line with the efficient market hypothesis, we find that the information revealed on announcement days is incorporated into the equilibrium price in one period.

Secondly, we develop model-based and survey-based measures of unanticipated news and uncertainty about the announcement. We test the implications of our model for advance GDP announcements using a simple GARCH framework for daily returns with these constructed measures. The empirical results provide supporting evidence for our model and can be summarized as follows: The effect of unanticipated news on stock returns is negative and robust across different measures. In other words, unanticipated positive (negative) news about GDP decreases (increases) the mean return on advance GDP announcement days. Since advance GDP estimates are released on announcement days before the stock market opens, our results are not only explanatory but also predictive. We find that a one percent positive standardized surprise about the state of the economy in the announcement will decrease the stock market return by $0.057\%$. This result is robust even when we estimate an EGARCH specification or include control variables such as the dividend yield, the risk-free rate and a dummy for announcement days in the mean equation. We also find that the reaction of the stock market to unanticipated news in advance GDP announcements is asymmetric. On the other hand, we find that the uncertainty resolved on announcement days has a significant negative effect on the conditional volatility. Although in the presence of control variables, this effect is less significant, it is robust across different measures. The higher the degree of uncertainty resolved on the announcement day, the smaller the conditional volatility of returns will become on announcement days. This result suggests that the conditional volatility on an announcement day when a higher level of uncertainty is resolved is smaller than the conditional volatility on another announcement day when a relatively lower level of uncertainty is resolved. One should note that the conditional volatility of returns might still be higher than the conditional volatility on non-announcement days. Our simulation results suggest that our model is capable of replicating these empirical results for a range of risk aversion parameters. Furthermore, in line with the existing literature, we find that the effect of unanticipated news lasts less than a day. In other words, the information in the announcement is incorporated quickly into the price. Following Campbell (1991), we decompose returns into three components and find that the change in expectations about future growth due to unanticipated news is the main source of this observed reaction. Finally, we analyze the reaction of the stock market returns to employment situation announcements and find the implications of our model hold for news that are less than perfectly correlated with the growth rate.

The rest of the paper is organized as follows: Section 2.2 introduces the setup and assumptions of the general model and presents analytical solutions for asset prices in this framework. Section 2.3 discusses the intuition behind our model in a simplified framework and presents the implications of our model. Section 2.4 discusses the data employed in our empirical analysis. Section 2.5 summarizes our empirical approach to test the implications of our model. Section 2.6 presents the empirical results on the effect of advance GDP announcement news on the stock market, risk-free rate and excess return dynamics. Section 2.7 analyzes the sources of the stock market's reaction to news. Section 2.8 summarizes the empirical results on the effect of employment news on the stock market returns. Section 2.9 concludes. All proofs are in the appendix.

## 2.2 The Model

In this section, we develop a dynamic general equilibrium asset pricing model where investors learn about the growth rate of the economy by observing dividend realizations between public announcements.

Consider a discrete time standard pure exchange economy (Lucas (1978)) with a representative investor whose preferences can be represented by a constant relative risk aversion utility function,

$$U(C_t) = \begin{cases} \frac{C_t^{1-\gamma}}{1-\gamma} & \text{if } \gamma \neq 1 \\ \log(C_t) & \text{if } \gamma = 1 \end{cases} \tag{2.1}$$

where $C_t$ denotes the investor's consumption in period $t$ and $\gamma$ is the coefficient of relative risk aversion. The investor's opportunity set comprises a risky asset, whose dividend at time $t$ is denoted by $D_t$ and a riskless asset whose risk-free rate of return is $r_t^f$. We assume that the supply of the risky asset is fixed and normalized to 1. Let $d_t$ denote the log-dividend process, i.e. $d_t = \log(D_t)$. We further assume that dividends grow according to the following process:

$$\Delta d_t = \mu_{z_n} + \sigma_{z_n}\varepsilon_t \quad \text{for } T_{n-1} < t \leq T_n \tag{2.2}$$

where $\Delta$ denotes the first difference operator (i.e. $\Delta d_t = d_t - d_{t-1}$), $\varepsilon_t$ is an iid Gaussian random variable (i.e. $\varepsilon_t \sim N(0,1)$) and $T_n$ is the release time of the n$^{\text{th}}$ announcement that reveals what the growth rate of the economy has been since the release of the previous announcement at time $T_{n-1}$. We assume that announcements are regularly scheduled. Let $T$ denote the number of periods between announcements, i.e. $T = T_n - T_{n-1}$ for $n = 1, 2, \ldots$. $z_n$ is the state of the economy between announcement days $T_{n-1}$ and $T_n$. Although $z_n$ is realized on the previous announcement day, $T_{n-1}$, we assume that investors do not observe the current growth rate of the dividend stream until the n$^{\text{th}}$ announcement day, $T_n$. In other words, let $\mathcal{F}_t$ denote the investor's information set at time $t$ which consists of past announcements and past dividend realizations, then $z_n$ is observed on the n$^{\text{th}}$ announcement day (i.e. $z_n \in \mathcal{F}_{T_n}$).

For analytical tractability, we assume that the state variable takes N different values. Specifically, we assume that $z_n \in \{1, 2, \ldots, N\}$ and without loss of generality $\mu_1 > \mu_2 > \ldots > \mu_N$. We assume that the state variable possibly takes a new value only on announcement days, hence we use the time index $n$ to track the state variable rather than the time index $t$ that tracks the dividend process. We do not restrict the variance of the growth rate of different states in the general framework, whereas the variances are set equal in the simplified framework. We further assume that the state variable evolves according to a first-order $N$-state Markov chain where the transition probabilities are given by

$$\{\Pr(z_n = i | z_{n-1} = j)\} = \{q_{ji}\} = \mathbf{Q} \tag{2.3}$$

where **Q** is an $N \times N$ matrix of transition probabilities. The intuition behind this specification is simple. The dividends are paid out every period, whereas the dividend growth possibly switches to a different state every $T$ periods on announcement days.[5] On the announcement day, the news reveals what the true growth rate has been since the previous announcement. The main advantage of this specification is that not only is it analytically tractable but it is also realistic. In the real world, investors do not observe the growth rate of the economy in the current quarter until the

[5] One can think our model as a model with daily dividend realizations and quarterly regimes.

Bureau of Economic Analysis (BEA) releases advance GDP estimates in the following quarter. Although investors do not observe the current growth rate between announcements, they learn about the growth rate by observing dividend realizations in the interim. On the announcement day, investors form their beliefs about the state of the economy until the next announcement depending on the current announcement. In other words, the announcement not only reveals the state of the economy in the last quarter but also affects investors' beliefs about the state of the economy until the next announcement.

Our model is a general equilibrium model with a representative investor learning about the dividend process. First of all, we analyze a general equilibrium framework to simplify the analysis and focus on one type of news, namely the cash flow news. One can think of extending this framework to a partial equilibrium. However, it complicates the analysis without a substantial gain in intuition about the question addressed by this paper. Secondly, instead of a market microstructure structure, we develop a model without strategic interaction and trading. Recently, Reny and Perry (2005) show the strategic foundation for rational expectations equilibrium by considering a double auction with large number of buyers and sellers. This large double auction equilibrium is almost efficient, almost fully aggregates investors information sets and is arbitrarily close to the unique fully revealing rational expectations equilibrium. Hence, our model can be considered as a reduced form model of a market microstructure model where the number of buyers and sellers is large. Finally, our model is a learning model rather than a model where investors know the true growth rate of the dividend process. A learning model is a natural choice for the question addressed by this paper. Furthermore, asset pricing models with learning are known to generate dynamics such as time-varying volatility and expected returns that standard Lucas asset pricing models fail to do. Learning is not the only way to generate such dynamics in asset returns, but it is relatively easy to quantify in this framework.

Our model is closest to that of Veronesi (2000). In his paper, he analyzes how information quality affects stock returns. He develops a dynamic general equilibrium Lucas-type asset pricing model where investors learn about the growth rate of the economy through dividend realizations and an external signal. Our model differs from his in terms of the information flow of the external signal. Instead of modeling the external signal as a continuous process, it is modeled as a discrete periodic process since the question we address is different from his. Furthermore, in contrast to Veronesi (2000), we assume that the external signal is not noisy. In other words, the external signal reveals the growth rate of the economy. Our model would nest his if we assume that the announcement is a noisy signal about the growth rate of the economy. Our model is also close to the framework of Cecchetti, Lam, and Mark (1990) where they analyze serial correlation of returns with a Lucas asset pricing model similar to ours. Our model differs from theirs in terms of the signal extraction problem that investors face. In their model, investors know the true state of the economy. That is, there is no learning in their model.[6] However, we assume that investors learn about the state of the economy by observing dividend realizations and public announcements.

### 2.2.1 Investors' Belief

Before proceeding to the analytical derivation of equilibrium asset prices and returns, we need to analyze how investors' beliefs about the growth rate evolve over time. Investors form their beliefs about the growth rate of the economy by observing dividend realizations and announcements.[7] For $T_{n-1} \leq t \leq T_n$ and $n = 1, 2, \ldots$, let $\pi_{it}$ denote investors' posterior beliefs that the current state of the economy is $i$ given their information set at time $t$. Mathematically, $\pi_{it} = \Pr(z_n = i|\mathcal{F}_t) = \Pr((\mu_{z_n}, \sigma_{z_n}) = (\mu_i, \sigma_i)|\mathcal{F}_t)$ for $i = 1, 2, \ldots, N$. Furthermore, let $\pi_{i0}$ denote the initial prior probability at time 0 before observing any announcements or dividend realizations. The following lemma characterizes the law of motion of $\pi_{it}$:

**Lemma 2.1.** *Investors' posterior beliefs about the state of the economy evolves as follows:*

$$\pi_{it} = \begin{cases} \sum_{j=1}^{N} q_{ji} 1_{\{z_{n-1}=j\}} & \text{if } t = T_{n-1} \\ \frac{\phi(\frac{\Delta d_t - \mu_i}{\sigma_i})\pi_{i,t-1}}{\sum_{j=1}^{N} \phi(\frac{\Delta d_t - \mu_j}{\sigma_j})\pi_{j,t-1}} & \text{if } T_{n-1} < t < T_n \\ 1_{\{z_n=i\}} & \text{if } t = T_n \end{cases} \tag{2.4}$$

*for $n = 1, 2, \ldots$ where $\phi(\cdot)$ is the standard normal density function.*

*Proof.* All proofs are in the appendix. □

Before proceeding to the intuition of the signal extraction, one should note that the announcement reveals not only the true growth rate of the economy since the previous announcement but also reveals information about the future growth rate. In other words, there are two different probabilities on announcement days. The first one is the probability of the currently

[6] One can obtain their model by assuming that announcements occur every period in our model, i.e by setting $T = 1$.

[7] Observing equilibrium prices does not reveal any further information about the growth rate, since we assume that investors have common information about the economy derived from past announcements and dividend realizations.

released announcement that is given by the third case in Equation (2.4). The second one is the prior probability about the next announcement that is given by the second case in Equation (2.4).

The intuition of the signal extraction described in the above lemma is simple. Before observing any signals (dividend realizations) about the current growth rate, having observed the last announcement, investors form prior beliefs about the next state according to the law of motion of the state variable. As they start observing signals about the current growth rate, they update their prior beliefs according to the Bayes' law. Therefore, their posterior beliefs about the current growth rate is a function of the last announcement and the dividend realizations since the previous announcement.

$\pi_{it}$ characterizes not only investors' fluctuating expectations but also investors' uncertainty about the growth rate of the economy. As we discuss in the next section, it is the investors' fluctuating expectations that generates dynamics in prices and returns that is not possible with standard models. Fluctuation in beliefs about fundamentals is the main theoretical link between the stock market's reaction and announcements about fundamentals.

### 2.2.2 Equilibrium Asset Prices

We next solve for the equilibrium price and return of the risky asset. Equilibrium prices and interest rates are determined by standard market clearing conditions. Let $P_t$ denote the price of the risky asset, then investors choose the fraction of wealth invested in the risky asset, $\alpha_t$, and consumption, $C_t$, in order to solve the following maximization problem:

$$\max_{C_t,\alpha_t} E_t[\sum_{\tau=0}^{\infty} \beta^{\tau} U(C_{t+\tau})] \tag{2.5}$$

subject to the budget constraint:

$$W_{t+1} = \left(W_t - C_t\right)\left(\alpha_t\left(\frac{P_{t+1} + D_{t+1} - P_t}{P_t}\right) + (1-\alpha_t) r^f_{t+1}\right) \tag{2.6}$$

where $W_t$ denotes investors' wealth at time $t$. $\beta$ is the investor's time impatience parameter and $E_t[\cdot]$ denotes expectation conditional on the available information at time $t$, $\mathcal{F}_t$. The Euler equation for the maximization problem is given by

$$P_t = \beta E_t\left[\frac{U'(C_{t+1})}{U'(C_t)}(P_{t+1} + D_{t+1})\right] \tag{2.7}$$

An equilibrium is defined by a vector process $(C_t, \alpha_t, P_t, r^f_t)$ such that the Euler equation in (2.7) holds and markets clear, i.e. $\alpha_t = 1$ and $C_t = D_t$.

Before proceeding to the derivation of the price of the risky asset on non-announcement days, the following lemma characterizes the price of the risky asset on announcement days. We assume that the transversality condition holds so that there is a unique equilibrium.[8]

**Lemma 2.2.** *The equilibrium price of the risky asset on announcement days is given by*

$$P_{T_n} = \lambda_{z_n} D_{T_n} \quad \textit{for } n = 1, 2, \ldots$$

*$\lambda_{z_n}$ can take $N$ different values depending on the announcement where $\boldsymbol{\lambda} = (\lambda_1, \ldots, \lambda_N)'$ is given by :*

$$\boldsymbol{\lambda} = (\mathbf{I} - \mathbf{HQ})^{-1}\mathbf{QG} \tag{2.8}$$

*where $\mathbf{Q}$ is the transition probability matrix defined in Equation (2.3). $\mathbf{G}$ is a $N \times 1$ vector whose $i^{th}$ element, $g_i$, is given by $g_i = \frac{(\beta e^{a_i})^{T+1}-1}{\beta e^{a_i}-1} - 1$. $\mathbf{H}$ is a $N \times N$ diagonal matrix whose $i^{th}$ diagonal element, $h_i$, is given by $h_i = (\beta e^{a_i})^T$. $a_i$ is a constant that depend on model parameters and is given by $a_i = (1-\gamma)\mu_i + (1-\gamma)^2\sigma_i^2/2$.*

*Proof.* All proofs are in the appendix. □

The price-dividend ratio switches between $N$ possible values on announcement days. The lemma suggests that the price-dividend ratio between announcement days is a weighted average of the $N$ possible values. The price of the risky asset on announcement days is similar to the one derived in Cecchetti, Lam, and Mark (1990). One can obtain their derivation of the price of the risky asset by setting $T = 1$. The following proposition solves for the equilibrium price of the risky asset between announcement days.

**Proposition 2.1.** *The price of the risky asset at time t ($T_{n-1} < t < T_n$) can be expressed as:*

$$P_t = \sum_{i=1}^{N} \left[ \left( \frac{(\beta e^{a_i})^{T_n - t + 1} - 1}{\beta e^{a_i} - 1} - 1 \right) \pi_{it} + (\beta e^{a_i})^{T_n - t} \lambda_i \pi_{it} \right] D_t \tag{2.9}$$

*where $\lambda_i$ and $a_i$ are constants defined in Lemma 2.2.*

*Proof.* All proofs are in the appendix. □

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[8]The transversality condition for our model can be expressed as $\lim_{\tau\to\infty} E_t \, \beta^\tau \left(\frac{D_{t+\tau}}{D_t}\right)^{-\gamma} P_{t+\tau} = 0$. A necessary and sufficient condition for the transversality condition to hold is $\beta e^{a_i} < 1$ for $i = 1, 2, \ldots, N$ where $a^i$ is defined in Lemma 2.2.

The price and the return processes are functions of the horizon to the announcement day and investors' beliefs about the current state of the economy. Furthermore, $\pi_{it}$ not only depends on dividend realizations but also reflects the previous announcement, hence the price is a function of both the previous announcement and the current state of the economy which is revealed on the next announcement day. Although this model is both analytically tractable and realistic, like any other model, it has its shortcomings. The main disadvantage is its implications for the price-dividend ratio. The price-dividend ratio is time-varying between announcement days, but it reverts to one of the $N$ values, $(\lambda_1, \lambda_2 \ldots, \lambda_N)$, on announcement days. However, one should note that any model with regime switching in the fundamentals is subject to the same criticism. The following corollary characterizes the law of motion for the return, the main interest of this paper.

**Corollary 2.1.** *Let $r_t$ denote the return process for the risky asset. Then $r_t$ can be expressed as:*

$$\begin{aligned} r_t =& \frac{P_t + D_t - P_{t-1}}{P_{t-1}} \\ =& \frac{\sum_{i=1}^{N} \left( \frac{(\beta e^{a_i})^{T_n - t + 1} - 1}{\beta e^{a_i} - 1} - 1 \right) \pi_{it} + (\beta e^{a_i})^{T_n - t} \lambda_i \pi_{it}}{\sum_{i=1}^{N} \left( \frac{(\beta e^{a_i})^{T_n - t + 2} - 1}{\beta e^{a_i} - 1} - 1 \right) \pi_{i,t-1} + (\beta e^{a_i})^{T_n - t + 1} \lambda_i \pi_{i,t-1}} \cdot e^{\mu_{z_n} + \sigma_{z_n} \varepsilon_t} - 1 \end{aligned} \tag{2.10}$$

*Proof.* All proofs are in the appendix. □

Notice that the return process depends on investors's beliefs not only in the current period but also in the last period. In our model, one can consider dividend shocks ($\varepsilon_t$) as unscheduled announcements or news. The main difference between announcement day returns and non-announcement day returns is the presence of a covariance term between dividend shocks and investors' beliefs. In other words, by construction, the dividend shock on announcement days is not correlated with the announcement conditional on investors' information set before the announcement day. However, on non-announcement days, the dividend shock has an additional effect on stock returns through the updating process of investors' beliefs. In a simplified version of the model described in the next section, we derive analytical expressions for both mean return and volatility of returns on announcement days and discuss the intuition behind our results.

## 2.3 A Simple Model

In this section, we present a simplified version of the model introduced above. The simplified version of the model is an extreme case of our model where all uncertainty is resolved on the announcement day.

We assume that the dividends grow according to Equation (2.2). There is only one announcement about the growth rate of the dividend process, which reveals the true growth rate. Specifically,

$$\Delta d_t = \mu_{z_{T^*}} + \sigma \varepsilon_t \tag{2.11}$$

where $z_{T^*} \in \{1, 2\}$ is similar to the news variable discussed in the previous section. The state of the economy is realized at time 0. However, it is not observed until the announcement day, $T^*$, i.e. $z_{T^*} \in \mathcal{F}_{T^*}$. Before the announcement day, $T^*$, the investors do not observe the true growth rate, however, they face a signal extraction problem. They learn about the true growth rate by observing dividend realizations. We further assume that there are two states of the economy, high growth ($z_{T^*} = 1$) and low growth ($z_{T^*} = 2$) state. In other words, the growth rate of the economy in state 1 is greater than the growth rate in state 2, i.e. $\mu_1 > \mu_2$.[9] This model can be obtained as a special case of the general model discussed above by setting $N = 2$ and $q_{11} = q_{22} = 1$.[10] That is, once the news variable is announced on the first announcement day, it takes the same value at every future announcement day with probability 1. Hence, it reveals the true future growth rate of the economy.

The learning process and price-dividend ratio are similar to the general model. Let $\pi_0$ denote the prior probability of high growth state before observing any announcements or dividend realizations. Let $\pi_t$ denote $\Pr(z_{T^*} = 1|\mathcal{F}_t)$ (or equivalently, $\Pr(\mu_{z_{T^*}} = \mu_1|\mathcal{F}_t)$), then

$$\pi_t = \begin{cases} \frac{\phi(\frac{\Delta d_t - \mu_1}{\sigma})\pi_{t-1}}{\phi(\frac{\Delta d_t - \mu_1}{\sigma})\pi_{t-1} + \phi(\frac{\Delta d_t - \mu_2}{\sigma})(1-\pi_{t-1})} & \text{for } t < T^* \\ 1_{\{z_{T^*}=1\}} & \text{for } t \geq T^* \end{cases} \tag{2.12}$$

where $\phi(\cdot)$ is the standard normal density function and $1_{\{\cdot\}}$ is an indicator function. The price-

[9] For simplicity, we assume that variances of the dividend growth process in different state are identical, i.e. $\sigma_1 = \sigma_2 = \sigma$. However, in our empirical analysis, we estimate a Hamilton (1989) model for real-time GDP with regime switching both in mean and variance.

[10] One should note that setting $q_{11} = q_{22} = 1$ implies $q_{12} = q_{21} = 0$

dividend ratio of the risky asset is given by

$$\frac{P_t}{D_t} = k_1\pi_t + k_2(1-\pi_t) \tag{2.13}$$

where $k_{z_{T^*}} = (\beta e^{a_{z_{T^*}}})/(1-\beta e^{a_{z_{T^*}}})$ and $a_{z_{T^*}}$ are constants defined in Lemma 2.2.

The price-dividend ratio is a function of investors' posterior beliefs until the announcement day when uncertainty about the growth rate is completely resolved. Although the price-dividend ratio is time-varying before the announcement day, it is constant afterwards. This is a special case of the general model where uncertainty is never completely resolved, even in the limit. Although the simple model is a special case, it provides intuition about return dynamics on the announcement day relative to non-announcement days. The following proposition derives closed-form solutions for expected return and conditional volatility on the announcement day.

**Proposition 2.2.** *Let $r_{T^*}$ denote the return on the announcement day $T^*$, then*

$$r_{T^*} = \frac{(k_1 1_{\{z_{T^*}=1\}} + k_2 1_{\{z_{T^*}=2\}} + 1)e^{\mu_{z_{T^*}}+\sigma\varepsilon_{T^*}}}{k_1\pi_{T^*-1} + k_2(1-\pi_{T^*-1})} - 1 \tag{2.14}$$

*The expected return and the conditional volatility on the announcement day are given by, respectively,*

$$E_{T^*-1}[r_{T^*}] = \frac{(k_1+1)e^{\mu_1+\sigma^2/2}\pi_{T^*-1} + (k_2+1)e^{\mu_2+\sigma^2/2}(1-\pi_{T^*-1})}{k_1\pi_{T^*-1} + k_2(1-\pi_{T^*-1})} - 1 \tag{2.15}$$

$$\begin{aligned} var_{T^*-1}[r_{T^*}] = &\frac{(k_1+1)^2 e^{2\mu_1+2\sigma^2}\pi_{T^*-1} + (k_2+1)^2 e^{2\mu_2+2\sigma^2}(1-\pi_{T^*-1})}{(k_1\pi_{T^*-1} + k_2(1-\pi_{T^*-1}))^2} \\ &-\frac{((k_1+1)e^{\mu_1+\sigma^2/2}\pi_{T^*-1} + (k_2+1)e^{\mu_2+\sigma^2/2}(1-\pi_{T^*-1}))^2}{(k_1\pi_{T^*-1} + k_2(1-\pi_{T^*-1}))^2} \end{aligned} \tag{2.16}$$

*Proof.* All proofs are in the appendix. □

Notice that both the expected value and conditional volatility of equilibrium stock returns are functions of investors' beliefs. Although this model is simple, it generates time-varying dynamics both in the expected value and the conditional volatility of returns. Furthermore, since $\pi_t$ is autocorrelated, this model might be able to account for GARCH-type behavior of conditional volatility, which is a function of $\pi_t$. One should note that the standard Lucas-type model with no learning implies constant expected returns and conditional volatility and cannot account for empirical facts observed in the data. Before proceeding to summarizing the main implications of the simplified model for the mean return, a definition of the unanticipated news (or equivalently, surprise) is in order:

**Definition 2.1.** *Let $u_{T^*}$ denote the unanticipated news on the announcement day. $u_{T^*}$ is defined as follows:*

$$u_{T^*} = (1 - \pi_{T^*-1})1_{\{z_{T^*}=1\}} + \pi_{T^*-1}1_{\{z_{T^*}=2\}} \tag{2.17}$$

*where first term on the right-hand side is the unanticipated good news whereas the second term is the unanticipated bad news.*

The definition of the surprise is quite intuitive. If the announcement reveals good news in the sense that the economy is in the high growth state, i.e. $z_{T^*} = 1$, then $\pi_{T^*-1}$ is the anticipated (or expected) part of the announcement given investors' information set at time $T^* - 1$. The unanticipated part of the announcement is the difference between the true value of the announcement and the anticipated part. Similarly, for bad news, the anticipated part is $1 - \pi_{T^*-1}$ and the unanticipated part is $\pi_{T^*-1}$.

**Proposition 2.3** (Implications for the mean return on the announcement day)**.** *Assuming that the announcement is released on the announcement day before the stock market opens, then*

1. *Announcement-day return is a function of the unanticipated news. Specifically,*

$$r_{T^*} = \begin{cases} \frac{(k_1+1)e^{\mu_1+\sigma\varepsilon_{T^*}}}{k_1+(k_2-k_1)u_{T^*}} - 1 & \text{if } z_{T^*} = 1 \\ \frac{(k_2+1)e^{\mu_2+\sigma\varepsilon_{T^*}}}{k_2+(k_1-k_2)u_{T^*}} - 1 & \text{if } z_{T^*} = 2 \end{cases} \tag{2.18}$$

2. *If investors are more risk averse than a log utility investor, i.e $\gamma > 1$, then unanticipated positive news (negative) news about the state of the economy decreases (increases) the mean return on announcement days. In other words, in the case of positive (negative) news, the mean return is negatively (positively) correlated with the size of the surprise. On the other hand, unanticipated positive (negative) news is good (bad) for the mean announcement-day return if $\gamma < 1$. Finally, the unanticipated news has no effect on the mean return on announcement days if investors have log utility.*

3. *The effect of unanticipated news is asymmetric. In other words, the effect of a positive unanticipated news is different from that of a negative one. Specifically, if $(k_1 + 1)e^{\mu_1} > (k_2 + 1)e^{\mu_2}$, then the absolute effect of a positive unanticipated news on the mean stock return is greater than that of a negative unanticipated news of the same magnitude.*

*Proof.* All proofs are in the appendix. □

The first implication of our model is in line with the existing literature, which states that returns react to the unanticipated component of news on announcement days. The intuition is simple. Investors' beliefs about the announcement already includes the anticipated component of the announcement. Hence, the price already reflects the anticipated part of the announcement. On the announcement day, additional information which has not been incorporated into investors' beliefs is revealed, investors update their expectation about the future growth rate. Hence, the mean return reacts according to the change in investors' beliefs due to additional information in the announcement.

The intuition from a two-period model applies to the second implication. In a two-period model with a representative investor whose preferences are represented by a power utility, an unanticipated higher growth rate has two effects in equilibrium. The first effect is the income effect. An unanticipated good news about the growth rate results in a higher endowment in the second period. Investors are willing to pay more for the risky asset which is a claim on the second period consumption since the payoff is higher than previously expected. Hence, the income effect increases the current equilibrium price of the risky asset. The second effect is the substitution effect. Investors are willing to consume more in the current period due to a higher than expected consumption in the second period. In a power utility framework, a higher endowment in the second period increases the stochastic discount factor. Therefore, investors are discounting future payoffs at a higher rate. Hence, the substitution effect decreases the current equilibrium price of the risky asset. Which effect dominates in equilibrium depends on investors' risk aversion parameter, $\gamma$. If investors are more risk averse than a log-utility investor, i.e. $\gamma > 1$, the substitution effect dominates the income effect and the equilibrium asset price decreases. Hence, unanticipated positive news has a negative effect on returns on announcement days. The opposite holds when $\gamma < 1$. If investors have a log utility (i.e. $\gamma = 1$), income and substitution effects cancel out, hence the news does not have any effect on returns.

Among other factors such as investors' time impatience parameter, $\beta$, and risk aversion parameter, $\gamma$, the effect of surprises on returns depends on the difference between growth rates, $\mu_1$ and $\mu_2$. As the difference between the growth rates gets larger, the coefficient of $u_{T^*}$ will increase.

The second implication might give theoretical support for the recent empirical findings that returns react negatively to positive surprises. Boyd, Hu, and Jagannathan (2005) find that positive unemployment surprises have a negative effect on returns.

One should be careful interpreting the second implication. Our claim is about the unanticipated part of news, not the total effect of the announcement. The third implication is about the overall effect of the announcement. If the inequality in the third implication holds, then the mean return on an announcement day with positive news is higher than the mean return on another announcement day with negative news. In other words, the effect of the unanticipated news depends on the state of the economy revealed on the announcement day. Hence, the effect of unanticipated news is asymmetric and depends on whether it is good news or bad news. If $(k_1+1)e^{\mu_1} > (k_2+1)e^{\mu_2}$, then the absolute effect of a positive unanticipated news on the mean stock returns is greater than that of a negative unanticipated news of the same magnitude.

Before proceeding to the implications of the model for conditional volatility of returns on the announcement day, we first define the uncertainty about the announcement.

**Definition 2.2.** *Let $\omega_t$ denote the uncertainty about the announcement given investors' information set at time t. Then we define $\omega_t$ as follows:*

$$\omega_t = \pi_t(1-\pi_t). \tag{2.19}$$

Our definition of uncertainty is intuitive. $\omega_t$ is a quadratic concave function of investors' posterior beliefs about the state of the economy, $\pi_t$, and is maximized when $\pi_t$ is equal to 0.5, when investors are most uncertain about the growth rate. It is zero when investors are certain about the growth rate, i.e. $\pi_t = 0, 1$. Furthermore, the measure of uncertainty is independent of the announced value of the news variable.

**Proposition 2.4** (Implications for conditional volatility of returns on the announcement day)**.** *Conditional volatility of returns on announcement days is a nonlinear function of not only investors belief about the true growth rate of the economy but also uncertainty about the announcement. Specifically,*

$$var_{T^*-1}[r_{T^*}] = \frac{m_2^2(e^{\sigma^2}-1) + (m_1^2 - m_2^2)(e^{\sigma^2}-1)\pi_{T^*-1} + (m_1-m_2)^2\omega_{T^*-1}}{k_2^2 + (k_1^2 - k_2^2)\pi_{T^*-1} - (k_1-k_2)^2\omega_{T^*-1}} \tag{2.20}$$

*where $m_{z_{T^*}} = (k_{z_{T^*}}+1)e^{\mu_{z_{T^*}}+\sigma^2/2}$.*

*Proof.* All proofs are in the appendix. □

Although the effect of unanticipated news on announcement day returns is easy to characterize, the effect of uncertainty is somewhat ambiguous and depends on the model parameters. However, one would expect conditional volatility on announcement days to be a decreasing function of investors' uncertainty about the state of the economy prior to the announcement. Veronesi (1999) shows that the conditional volatility of returns is related to investors' uncertainty about the state of the economy and higher uncertainty leads to higher price sensitivity of the risky asset, hence to higher conditional volatility of returns. The higher conditional volatility is due to investors' willingness to hedge against their own uncertainty. In our model, the announcement reveals the true state of the economy and hence the uncertainty about the state of the economy is completely resolved on the announcement day. The higher the investors' prior uncertainty about the state of the economy, the smaller will be the conditional volatility of returns on the announcement day. One should note that the conditional volatility on non-announcement days is a increasing function of investors' uncertainty. The difference between announcement and non-announcement days is the resolution of uncertainty on announcement days. Our claim in this paper is that the resolution of investors' prior uncertainty about the state of the economy is the main reason for the observed behavior of conditional volatility on announcement days. As discussed in the empirical part of the paper, our model is capable of generating similar effects of uncertainty on conditional volatility to those observed in the data. However, our simulation results suggest that the effect of uncertainty on announcement day returns is sensitive to the risk aversion parameter $\gamma$.

One should note that the return on non-announcement days is also a function of investors' beliefs. As mentioned before, the dividend realizations between announcements can be considered as unscheduled news events. Return dynamics on non-announcement days react to these unscheduled news. Dividend realizations affect return dynamics through three channels. The mean return on non-announcement days react to unanticipated news in dividend realizations. However, differently from announcement-day returns, the dividend realization has an additional effect on returns on non-announcement days through its effect on investors' beliefs. Furthermore, the conditional moments of returns are affected by the covariance between dividend shocks and investors' beliefs. In our framework, the main difference between the return dynamics on announcement days and non-announcement days is the resolution of uncertainty on announcement days. On announcement days, investors do not update their beliefs about the state of the economy. Hence, the dividend shock affects returns on announcement days only through the first channel. It is the resolution uncertainty on announcement days why return dynamics on announcement days are different than those on non-announcement days. The reaction of conditional volatility depends on the degree of uncertainty resolved on the announcement day. In the next section, we describe the data set employed to quantify empirical measures of surprise and uncertainty.

## 2.4 Data

In this section, we describe the data set used in the empirical analysis. To quantify the model-based measures of surprise and uncertainty, we use real-time nominal GDP between quarterly vintages of 1970Q1 and 2004Q4. This data is available from the Federal Reserve Bank of Philadelphia. Quantifying the survey-based measures requires using nominal GDP forecasts of individual forecasters in addition to the real-time GDP data. We obtain individual forecasts from the Survey of Professional Forecasters data set that is also available from the Federal Reserve Bank of Philadelphia. The mean and standard deviation of individual forecasts are constructed using data between 1970Q1 and 2004Q4.

Estimating the empirical model requires daily stock returns, the date and the value of the announcement. We use daily (close-to-close) returns on the equal-weighted portfolio of all stocks in the Center for Research in Security Prices (CRSP) universe, from Jan/2/1970 to Dec/31/2004. The GDP announcement days are available from the Bureau of Economic Analysis (BEA) between 1970 and 2004. Since 1977, in a given quarter, BEA releases three estimates of GDP for the previous quarter, advance, preliminary and final estimates. Advance estimates, released towards the end of the first month in a given quarter, are the first official estimates of GDP in the previous quarter. Two subsequent releases, released towards the end of the second and third months of a quarter, are merely revisions to advance estimates. Between 1983 and 1985, the initial estimates of GDP (called flash estimates) were made available in the same quarter. Figure 2.1 presents the time line of events and release dates for GDP estimates in the third quarter of 2003 as an example.

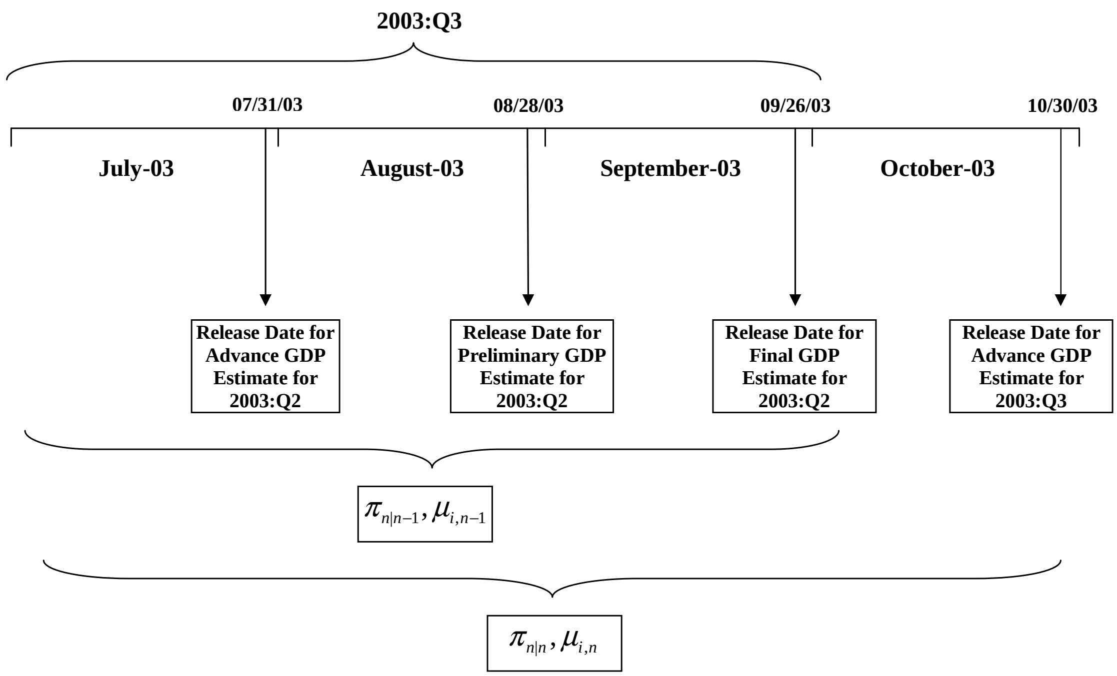



Figure 2.1: Time Line of GDP Announcements from the BEA

Notes: The figure presents the time line of GDP announcements for the third quarter of 2003 as an example. The advance GDP estimate for the second quarter of 2003 is released on 07/31/03. The preliminary and final estimates for the second quarter of 2003 that are revisions to the advance estimate are released on 08/28/03 and 09/26/03, respectively. The advance GDP estimate for the third quarter of 2003 is released on 10/30/03. The time line of events are similar for every quarter. The figure also presents the data used to construct the model based measures for the advance GDP announcement day for the third quarter of 2003, i.e. 10/30/03. $\pi_{n|n-1}$ and $\mu_{i,n-1}$ for $i = 1, 2$ denote investors' forecasts of the state and the growth rate of the economy in different states using data available before the advance GDP announcement day. The forecasts for the third quarter of 2003 are constructed based on final estimates of GDP up to and including the second quarter of 2003. $\pi_{n|n}$ and $\mu_{i,n}$ for $i = 1, 2$ are the corresponding realized values of the forecasts and are constructed based on all available data including the advance GDP estimate for the third quarter of 2003.

In this paper, we analyze the reaction of the stock market to advance GDP announcements since the other releases in a given quarter are revisions to the advance estimates and the flash estimates are only partially available. Therefore, we have only one announcement per quarter released towards the end of the first month of that quarter. The releases are generally announced at 8:30AM before the opening of the stock market. Hence, daily data frequency is adequate for this analysis. Furthermore, the release dates are publicly known in advance. The availability of historical release dates from BEA restricts our empirical analysis between 1970 and 2004.

Proxies for the daily risk-free rate and the daily dividend yield are used as control variables to check robustness of the empirical results to different specifications. The secondary market rate of 3-month US Government Treasury Bills, a proxy for the risk-free rate, is available from the Federal Reserve's H.15 release of daily interest rates. Return on income on equal-weighted portfolio of the NYSE-AMEX-NASDAQ market index, a proxy for dividend yield, is obtained from CRSP database.

## 2.5 Empirical Specification

In order to test the implications of our model, we need proxies for both investors' beliefs and uncertainty about the announcement. In this section, we develop two model-based and two survey-based measures of surprise and uncertainty. One should note that these measures are constructed using real-time data about the growth rate of the economy that could have been available to investors on the announcement day. As we discuss below, these measures are proxies for investors' beliefs and uncertainty one day before the announcement and are somewhat crude.

### 2.5.1 Model-Based Measures

Model-based measures, as the name suggests, are developed using the theoretical model for dividends in Equation (2.2). In order to construct the model-based measures, we need to form proxies of investors' beliefs about the state of the economy. Hence, we need to first estimate the model in Equation (2.2) using real-time nominal GDP growth rate.

For every announcement day $T_n$, a regime-switching model of Hamilton (1989) with two states is estimated using expanding window of data sets. The estimated regime-switching model can be expressed as:

$$\Delta \log(GDP_\tau) = gdp_\tau = \mu_{z_\tau} + \sigma_{z_\tau}\nu_\tau \tag{2.21}$$

where $GDP_\tau$ is the level of nominal GDP in quarter $\tau$, $z_\tau = 1, 2$ is the state of the economy in quarter $\tau$ and $\nu_\tau$ is a standard normal random variable. The log-likelihood of the estimation problem is:

$$\begin{aligned} \mathcal{L} &= \sum_{\tau=1}^{n} \log\Bigg[\frac{1}{\sqrt{2\pi\sigma_1^2}} \exp\left(-\frac{(gdp_\tau - \mu_1)^2}{2\sigma_1^2}\right) \Pr(S_\tau = 1|\mathcal{F}_{\tau-1}) \\ &+ \frac{1}{\sqrt{2\pi\sigma_2^2}} \exp\left(-\frac{(gdp_\tau - \mu_2)^2}{2\sigma_2^2}\right)(1 - \Pr(S_\tau = 1|\mathcal{F}_{\tau-1}))\Bigg] \end{aligned} \tag{2.22}$$

The optimal inference and forecast about the state of the economy for each quarter can be found by iterating on the following pair of equations:

$$\Pr(S_\tau = 1|\mathcal{F}_\tau) = \frac{\phi(\frac{gdp_\tau - \mu_1}{\sigma_1}) \Pr(S_\tau = 1|\mathcal{F}_{\tau-1})}{\sum_{i=1}^{2} \phi(\frac{gdp_\tau - \mu_i}{\sigma_i}) \Pr(S_\tau = i|\mathcal{F}_{\tau-1})} \tag{2.23}$$

$$\Pr(S_{\tau+1} = 1|\mathcal{F}_\tau) = q_{11} \Pr(S_\tau = 1|\mathcal{F}_\tau) + (1 - q_{22})(1 - \Pr(S_\tau = 1|\mathcal{F}_\tau)) \tag{2.24}$$

where $q_{11}$ and $q_{22}$ are the diagonal elements of the transition probability matrix of $z_\tau$. The model parameters are estimated by maximum likelihood estimation.

For every announcement day, $T_n$, the two-state regime-switching model is first estimated using quarterly real-time data up to but excluding the announcement to obtain investors' beliefs before the announcement, i.e. using revised estimates of GDP up to and including the $n-1^{\text{th}}$ quarter. Investors' beliefs about the current state of the economy are formed using estimated model parameters and Equation (2.23). Let $\hat{\pi}_{n|n-1}$ denote the forecast of the probability of the high growth state in the upcoming quarter that can be obtained from Equation (2.24). $\hat{\pi}_{n|n-1}$ is the investors' expectation about the future state of the economy in the following quarter. We next estimate the regime-switching model using quarterly real-time data up to and including the announcement on $T_n$ that reveals the growth rate of the economy in the $\text{n}^{\text{th}}$ quarter. We denote investors' beliefs about the state of the economy after the announcement by $\hat{\pi}_{n|n}$. $\hat{\pi}_{n|n}$ is the probability of high growth state given all available information including the announcement. One can think of our approach as an expanding window estimation approach for real-time GDP growth rate. Figure 2.1 exemplifies our estimation approach for the third quarter of 2003.

One should note that $\hat{\pi}_{n|n-1}$ is not investors' beliefs one period before the announcement but rather it is a proxy estimated using the latest data available to investors. By using real-time data, we employ the most recent data available to investors before and on the announcement day. Real-time data does not only include announcements but also the revisions to the announcements, an additional source of information about the growth rate between announcements. Hence, when forming beliefs, investors also make use of the information flow between announcement days.

Having obtained a proxy for investors' belief about the growth rate of the economy, the first model-based measures of surprise and uncertainty are derived from the corresponding theoretical measures defined in Equations (2.17) and (2.19), respectively. Specifically, we define a proxy for the surprise in the announcement as the percentage change in investors' beliefs due to the announcement[11], i.e. $\hat{u}_{T_n} \equiv (\hat{\pi}_{n|n} - \hat{\pi}_{n|n-1})/\hat{\pi}_{n|n}$. Similarly, the uncertainty about the $n^{th}$ announcement, $\hat{\omega}_{T_n}$, is defined as $\hat{\omega}_{T_n} = \hat{\pi}_{n|n-1}(1 - \hat{\pi}_{n|n-1})$. One should note that surprise in the $n^{th}$ announcement is observable on the announcement day, $T_n$, whereas uncertainty is observed before the announcement.

The first model-based measures of surprise and uncertainty are defined, respectively, as the forecast error and the standard deviation of the forecast when forecasting the state of the economy. By-products of the above recursive estimation are time-varying growth rate estimates for both states of the economy on every announcement day. The investors do not only update their beliefs about the state but also the growth rate of the economy. We can easily extend the first model-based measures as the forecast error and standard deviation of the forecast when forecasting the growth rate rather than the state of the economy. Let $\hat{\mu}_{i,n-1}$ denote the estimated growth rate in state $i$ using real-time data up to and including revised estimates for quarter $n-1$, whereas $\hat{\mu}_{i,n}$ is the estimated growth rate in state $i$ using real-time data including the advance announcement on $T_n$. The second model-based measures of surprise and uncertainty are defined as follows:

$$\hat{u}_{T_n} = \frac{\widehat{\overline{\mu}}_{n|n} - \widehat{\overline{\mu}}_{n|n-1}}{\overline{\mu}_{n|n}} \tag{2.25}$$

$$\hat{\omega}_{T_n} = (\hat{\mu}_{1,n-1} - \widehat{\overline{\mu}}_{n|n-1})^2 \hat{\pi}_{n|n-1} + (\hat{\mu}_{2,n-1} - \widehat{\overline{\mu}}_{n|n-1})^2 (1 - \hat{\pi}_{n|n-1}) \tag{2.26}$$

where $\widehat{\overline{\mu}}_{n|n-1} = \hat{\mu}_{1,n-1}\hat{\pi}_{n|n-1} + \hat{\mu}_{2,n-1}(1 - \hat{\pi}_{n|n-1})$ and $\widehat{\overline{\mu}}_{n|n} = \hat{\mu}_{1,n}\hat{\pi}_{n|n} + \hat{\mu}_{2,n}(1 - \hat{\pi}_{n|n})$.

[11] Or equivalently, one can think of the first model-based measure as the percentage forecast error made when forecasting the state of the economy.

### 2.5.2 Survey-Based Measures

Survey-based measures of surprise and uncertainty are constructed using the Survey of Professional Forecasters, described in detail in the data section. The survey-based measures are defined directly without using a proxy for investors' beliefs about the state of the economy.

The first measure is based on the level of nominal GDP. The measure of surprise is defined as the difference between the GDP announcement and the most recent mean forecast of nominal GDP. The measure of uncertainty is defined as the dispersion (disagreement) among forecasters. In particular, let $for_{in}$ denote forecaster $i$'s forecast of GDP in quarter $n$ and $GDP_n$ denote the real-time value of nominal GDP released on the announcement day $T_n$. Then the first survey-based measures of surprise and uncertainty in the GDP announcement for period $t$ are defined as follows:

$$\hat{u}_{T_n} = \frac{GDP_n - \overline{for}_n}{GDP_n} \tag{2.27}$$

$$\hat{\omega}_{T_n} = (\frac{1}{m_n - 1}\sum_{i=1}^{m_n}(for_{in} - \overline{for}_n)^2)^{1/2} \tag{2.28}$$

where $m_n$ is the number of forecasters in period $n$ and $\overline{for}_n$ is the mean forecast.

The second measure is based on forecasts of the growth rate of GDP and defined in a similar fashion:

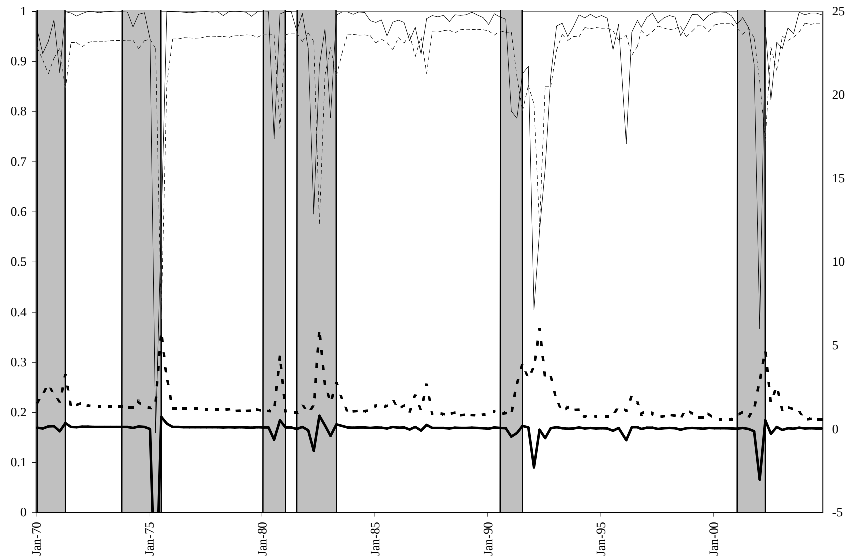
$$\hat{u}_{T_n} = \frac{gdp_n - \widetilde{for}_n}{gdp_n} \tag{2.29}$$

$$\hat{\omega}_{T_n} = (\frac{1}{m_n - 1}\sum_{i=1}^{m_n}(\log(for_{in}/for_{in-1}) - \widetilde{for}_n)^2)^{1/2} \tag{2.30}$$

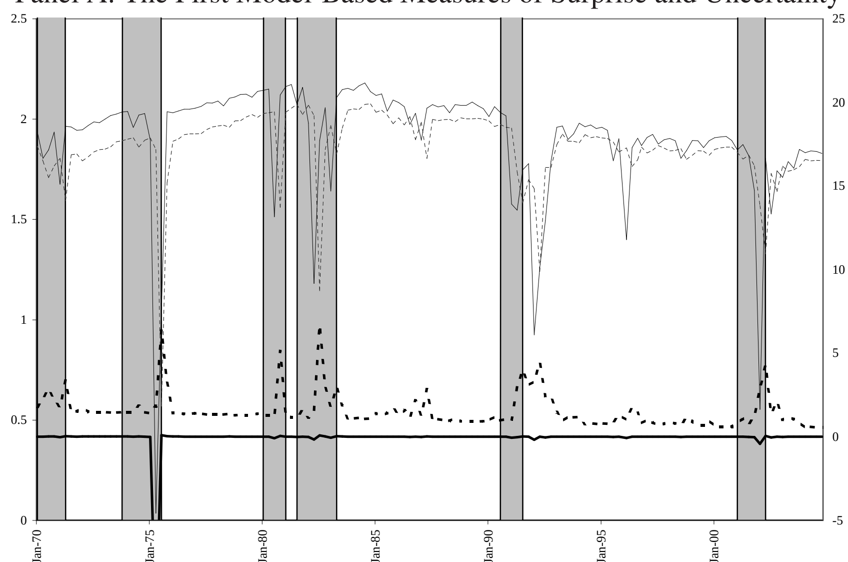
where $\widetilde{for}_n$ is the mean growth rate forecast defined as $\widetilde{for}_n = \frac{1}{m_n}\sum_{i=1}^{m_n}\log(for_{in}/\,for_{in-1})$.

As before, both measures of surprise are observed on the announcement day and both uncertainty measures are observed before the announcement day.

In order to obtain a consistent measure of unanticipated news and uncertainty across different approaches, we standardize each measure by its standard deviation. Figures 2.2 and 2.3 present model-based and survey-based measures of surprise and uncertainty, respectively.



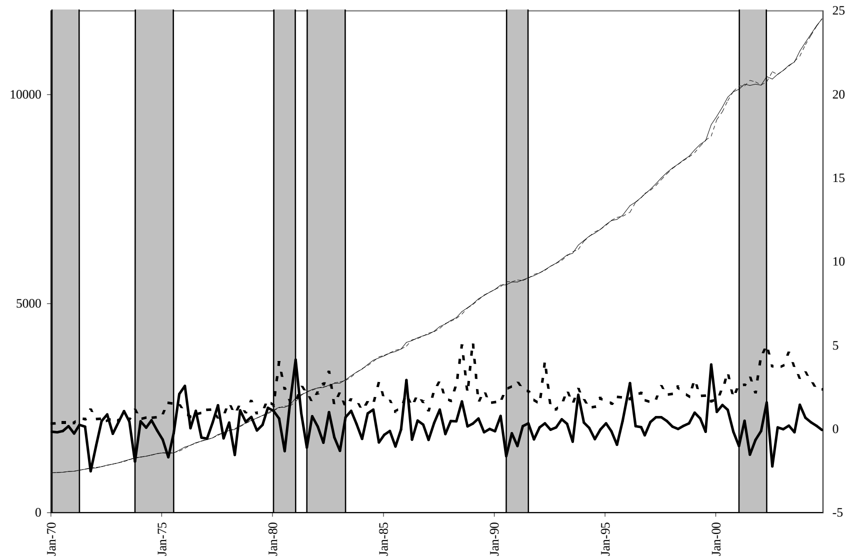

Panel A: The First Model-Based Measures of Surprise and Uncertainty



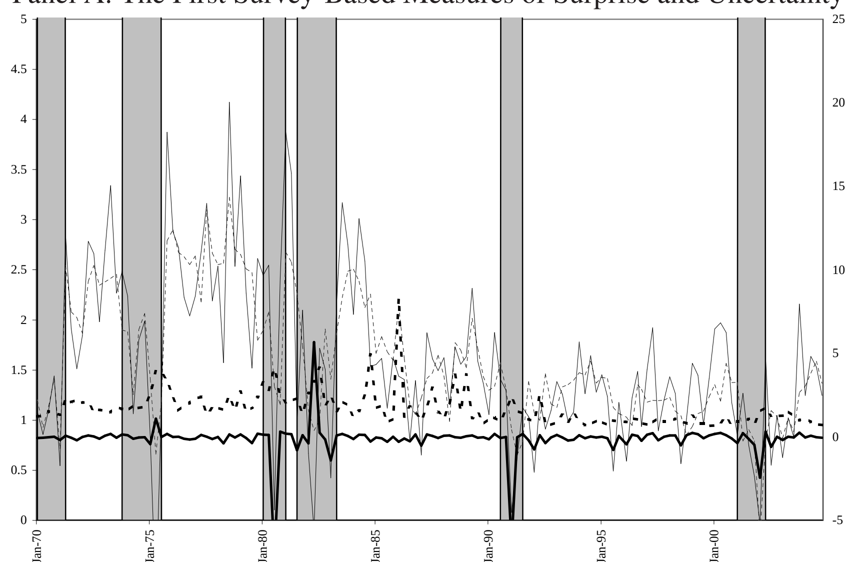

Panel B: The Second Model-Based Measures of Surprise and Uncertainty

Figure 2.2: Model-based Measures of Surprise and Uncertainty

Notes: Panel A presents the forecasts (thin dotted line) and the realizations (thin solid line) of the state of the economy whereas Panel B presents the forecasts (thin dotted line) and the realizations (thin solid line) of the growth rate of the economy using the model-based approach discussed in text. The figure also presents model-based measures of surprise (thick solid line) and uncertainty (thick dotted line) between 1970 and 2004 as described in 2.5.1. The vertical axis in Panel A is the probability of the high growth state, whereas the vertical axis in Panel B is the percentage growth rate of the economy. The shaded regions are the NBER recession periods.




Panel A: The First Survey-Based Measures of Surprise and Uncertainty




Panel B: The Second Survey-Based Measures of Surprise and Uncertainty

Figure 2.3: Survey-based measures of Surprise and Uncertainty

Notes: Panel A presents the forecasts (thin dotted line) and the realizations (thin solid line) of the level of nominal GDP whereas Panel B presents the forecasts (thin dotted line) and the realizations (thin solid line) of the growth rate of GDP using the survey-based approach discussed in text. The figure presents survey-based measures of surprise (thick solid line) and uncertainty (thick dotted line) between 1970 and 2004 as described in Section 2.5.2. The vertical axis in Panel A is the level of nominal US GDP in billion dollars, whereas the vertical axis in Panel B is the percentage growth rate of the economy. The shaded regions are the NBER recession periods.

Tables 2.1 and 2.2 summarize the correlation across different measures of unanticipated news and uncertainty, respectively.

Table 2.1: Correlations between Different Measures of Unanticipated News

| | Model Based 1 | Model Based 2 | Survey Based 1 | Survey Based 2 |
|---|---|---|---|---|
| Model Based 1 | 1 | | | |
| Model Based 2 | 0.939 | 1 | | |
| Survey Based 1 | 0.207 | 0.170 | 1 | |
| Survey Based 2 | -0.010 | -0.092 | 0.187 | 1 |

Notes: The table presents the correlation between different measures of unanticipated news for whole sample period between 1970 and 2004. First column denoted "Model-Based 1" presents the correlations between the first model-based measure of unanticipated news and other measures of unanticipated news. Similarly, the other columns present the correlations between different measures of unanticipated news.

Table 2.2: Correlations between Different Measures of Uncertainty, $w$

| | Model Based 1 | Model Based 2 | Survey Based 1 | Survey Based 2 |
|---|---|---|---|---|
| Model Based 1 | 1 | | | |
| Model Based 2 | 0.975 | 1 | | |
| Survey Based 1 | 0.071 | 0.005 | 1 | |
| Survey Based 2 | 0.232 | 0.298 | 0.131 | 1 |

Notes: The table presents the correlation between different measures of uncertainty for whole sample period between 1970 and 2004. First column denoted "Model-Based 1" presents the correlations between the first model-based measure of uncertainty and other measures of uncertainty. Similarly, the other columns present the correlations between different measures of uncertainty.

One should note that there are several issues with both the model- and survey-based measures related to the time line of events. Figure 2.4 summarizes the construction time line of measures for third quarter of 2003 as an example.

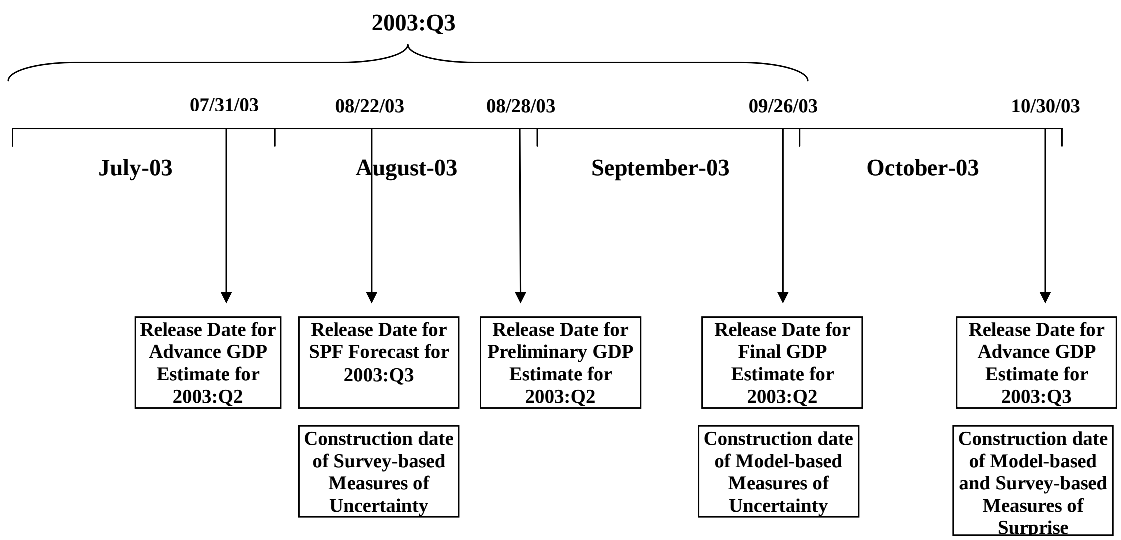



Figure 2.4: Time Line of Events in the Construction of Measures

Notes: The figure presents when different measures of unanticipated news and uncertainty would be available to investors for the third quarter of 2003 as an example. The survey-based measures of uncertainty is available on 08/22/03, the release date of the SPF. The model-based measure of uncertainty is available on 09/26/03, the release date of final GDP estimates for the second quarter of 2003. Both model-based and survey-based measures of unanticipated news is observed on 10/30/03, the advance GDP announcement day for the third quarter of 2003.

First of all, real-time data employed to obtain model-based measures uses all the available data before the announcement. It includes the final revision of the previous quarter's advance GDP estimates that is released in the last month of the current quarter. One caveat is that there is a one month gap between the release of the final revision to the previous quarter's GDP and the release of the advance estimate of the current quarter's GDP. The model-based measures are somewhat crude since investors might observe other informative variables and update their beliefs about the health of the economy between the final estimate and advance estimate release dates. For example, between final estimate and advance estimate release dates, investors might observe the unemployment figures that might reveal some information about the growth rate of the economy. Final estimates are the most recent data available about the GDP. Similar criticism is also relevant for the survey-based measures. Survey results are released in the middle of the quarter. Therefore, there is a 2.5 month gap between the survey release date and the announcement day. This criticism is more problematic for the uncertainty measures than for the surprise measures. The surprise measures are obtained using the release on the announcement day. On the other hand, the uncertainty measures are obtained using real-time and survey data, which are based on information 1 and 2.5 months before the announcement.

One should note that any study on the effect of public announcements would be subject to the same criticism. There would be a time gap between the announcement day and release date of any measure of surprise or uncertainty constructed using either macroeconomic or survey data.

### 2.5.3 Model Specification

Using these four different measures of surprise and uncertainty, we analyze the return dynamics on announcement days using a GARCH specification with unanticipated news in the return equation and uncertainty in the variance equation. In this strand of literature, it is quite common to fit a modified GARCH model with explanatory variables to daily returns and analyze the dynamics on and around announcement days. Following Flannery and Protopapadakis (2002), Bomfim (2003) and Li and Engle (1998), we first fit a simple GARCH(1,1) to daily stock returns with explanatory variables implied by our model. The empirical specification can be summarized by the following set of equations:

$$\begin{aligned} r_t &= \delta_0 + \delta_1 u_t + e_t & (2.31) \\ E_{t-1}[e_t] &= 0 \\ E_{t-1}[e_t^2] &= \upsilon_t^2 \\ \upsilon_t^2 &= \theta_0 + \theta_1 \omega_{t-1} + \theta_2 \omega_{t-1}^2 + \theta_3 \upsilon_{t-1}^2 + \theta_4 e_{t-1}^2 & (2.32) \end{aligned}$$

where $e_t \sim N(0, \upsilon_t^2)$. One should note that the conditional volatility is not a function of the surprise since the surprise is only observed on the announcement day.

The choice of a simple GARCH model is a natural one. First of all, one can think of the GARCH specification as a first approximation to the conditional volatility implied by our model, rather than a non-parametric volatility model. This fact relatively simplifies the empirical analysis. More importantly, a GARCH specification lets us compare the empirical results in this paper to those in the existing literature.

The implications of our theoretical model for the coefficients of the empirical specification can be summarized as follows: Our model implies that a positive unanticipated news decreases the mean return on announcement days. In other words, the coefficient of unanticipated news, $u_t$, in the empirical specification should be negative and significant, i.e. $\delta_1 < 0$. On the other hand, we expect the resolution investors' prior uncertainty about the announcement to decrease the conditional volatility of returns on announcement days. Therefore, the coefficient of uncertainty, $\omega_{t-1}$ should be negative, i.e. $\theta_1 < 0$. On the other hand, the magnitudes of these parameters depend on the risk aversion parameter, the time impatience parameters and the difference between the growth rates in different states. We analyze the magnitudes of these parameters in the empirical results.

To account for possible heteroskedasticity in the data, the empirical GARCH model is estimated using quasi-maximum likelihood estimation described in Bollerslev and Wooldridge (1992). The heteroskedasticity-consistent Bollerslev-Wooldridge standard errors are presented in parenthesis under coefficient estimates.

The model is initially estimated without any asymmetric effect components or control variables to analyze the effect of surprises and uncertainty on stock return dynamics on and around announcement days, the main interest of this paper. As a robustness check, we also estimate this basic empirical specification with several control variables both in mean and volatility such as the dividend yield, the risk-free rate and dummy variables for announcement days. Our model implies that the return should be a function of the price-dividend ratio. Hence, including these control variables makes the empirical specification more realistic and similar to the actual return equation implied by our model. In order to analyze the pure effect of announcements, we do not include these variables into the original empirical specification.

In order to analyze the asymmetric effect of news, we define positive unanticipated news as $u_t^+ \equiv u_t 1_{\{u_t>0\}}$ whereas negative unanticipated news is defined as $u_t^- \equiv -u_t 1_{\{u_t<0\}}$. We then estimate the empirical model by replacing the unanticipated news by measures of positive and negative unanticipated news.

One should note that by definition, the empirical measures of surprises and uncertainty are quarterly variables. When estimating the model with daily stock return data, we assume that the surprise and uncertainty are zero on non-announcement days.

## 2.6 Empirical Results

### 2.6.1 Simulation Results

Before we proceed to the analysis of the empirical results, we analyze whether our theoretical model is capable of generating dynamics in returns observed in the data. To do this, we simulate daily dividends from the theoretical model described in Section 2.2. To simplify our analysis, we assume that there are two states of the economy, high growth state and low growth state. We first estimate a two-state regime switching model of Hamilton (1989) using the quarterly US nominal GDP data described above. The estimates are scaled to their corresponding daily values by assuming 60 trading days in a quarter. We calibrate the parameters of the daily dividend growth process in Equation (2.2) to the corresponding estimates of the US nominal GDP data. Risk aversion parameter $\gamma$ and the time impatience parameter $\beta$ are set equal to $1.3$ and $0.9992$, respectively. Table 2.3 summarizes calibrated values of the model parameters.

Table 2.3: Calibrated Model Parameters

| Parameter | Calibrated Value |
|---|---|
| $\gamma$ | 1.3 |
| $\beta$ | 0.9992 |
| $\mu_1$ | 0.000307 |
| $\mu_2$ | -0.000070 |
| $\sigma_1$ | 0.001267 |
| $\sigma_2$ | 0.001233 |
| $q_1$ | 0.9 |
| $q_2$ | 0.7 |

Notes: The table presents the calibrated values of the model parameters that are used to simulate daily dividend realizations. $\gamma$ and $\beta$ are the investor's risk aversion and time impatience parameters, respectively. $\gamma$ and $\beta$ are not calibrated but are assigned to reasonable values. $\mu_1$ and $\mu_2$ are the average growth rates of nominal US GDP in different states of the economy, whereas $\sigma_1$ and $\sigma_2$ are the corresponding standard deviations of the growth rates. First state is assumed to be the high growth state. $q_1$ and $q_2$ are the diagonal elements of the transition probability matrix. The two-state regime switching model discussed in the text is estimated using the whole sample.

We simulate 8330 daily observations with a public announcement every 60 days corresponding to a total number of 138 public announcements. The daily price-dividend ratio, investors' beliefs, daily returns, unanticipated news and uncertainty are calculated from the simulated daily dividends using the corresponding equations in Section 2.2. One should note that we employ only the first model-based measure in our simulation results. We do not calculate the second model-based measure or the survey-based measures since our theoretical model does not guide us on the construction of those measures. We scale the measures of unanticipated news and uncertainty by their standard deviation. Figure 2.5 presents simulated daily returns.

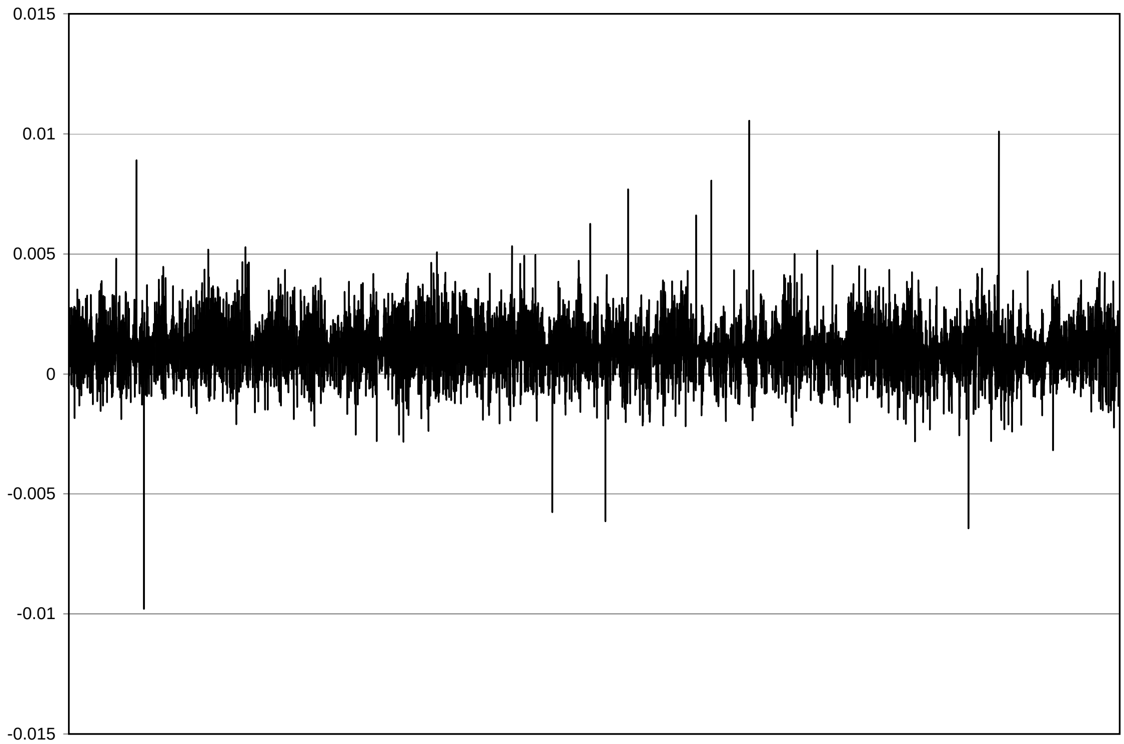



Figure 2.5: Simulated Daily Returns

Notes: The figure presents daily simulated returns calculated via Equation (2.10) from daily simulated dividend realizations. There are 8830 daily observations with 138 periodic (every 60 days) announcements about the state of the economy.

Several facts emerge from the graph of the simulated returns. First of all, the volatility of returns is time-varying. In other words, there are periods of high volatility and low volatility. Hence, the claim that our model is capable of generating time-varying volatility is supported by our simulation results. Although it is not immediately clear from Figure 2.5, most extreme returns are realized on announcement days supporting our claim that the returns react to available new information released on the announcement day.

In order to analyze whether the implications of our model hold for simulated returns and whether the empirical specification is appropriate for our research questions, we estimate the empirical specification for simulated returns. Tables 2.4 and 2.5 summarize our estimation results for simulated returns.

Table 2.4: Estimation Results for Simulated Returns

| Return Equation | |
|---|---|
| Constant | 0.103 |
| | (0.001)*** |
| $u_t$ | -0.029 |
| | (0.001)*** |
| | |
| **Variance Equation** | |
| Constant | 4.5E-04 |
| | (0.000)*** |
| $e^2_{t-1}$ | 0.112 |
| | (0.007)*** |
| $\upsilon^2_{t-1}$ | 0.854 |
| | (0.011)*** |
| $\omega_{t-1}$ | -9.4E-04 |
| | (0.000)*** |
| $\omega^2_{t-1}$ | 4.5E-05 |
| | (0.000)*** |

Notes: The table presents the coefficients estimates of the empirical specification described in Equations (2.31)-(2.32) for simulated returns. The return equation is Equation (2.31), whereas the variance equation is Equation (2.32). $u_t$ is the unanticipated news about the state of the economy, whereas $\omega_{t-1}$ is investors' uncertainty about the announcement. $e^2_{t-1}$ and $\upsilon^2_{t-1}$ are the ARCH and GARCH terms, respectively. The heteroskedasticity consistent asymptotic standard errors of the coefficient estimates are presented in parenthesis under the corresponding coefficient estimate. *** indicates a significant coefficient estimate at 1% confidence level, whereas ** and * indicate significant coefficient estimates at 5% and 10% confidence levels, respectively.

Table 2.5: Estimation Results for the Asymmetric Effect of News on Simulated Returns

| | |
|---|---|
| Return Equation | |
| Constant | 0.103 |
| | (0.001)*** |
| $u_t^+$ | -0.030 |
| | (0.001)*** |
| $u_t^-$ | 0.029 |
| | (0.001)*** |
| Variance Equation | |
| Constant | 4.5E-04 |
| | (0.000)*** |
| $e_{t-1}^2$ | 0.112 |
| | (0.007)*** |
| $\upsilon_{t-1}^2$ | 0.854 |
| | (0.011)*** |
| $\omega_{t-1}$ | -9.4E-04 |
| | (0.000)*** |
| $\omega_{t-1}^2$ | 4.5E-05 |
| | (0.000)*** |
| F-Statistic | 0.002 |
| | (0.001)*** |

Notes: The table presents the coefficients estimates of the empirical specification described in Equations (2.31)-(2.32) with asymmetric news effect for simulated returns. The return equation is Equation (2.31), whereas the variance equation is Equation (2.32). $u_t^{(+)}$ is positive unanticipated news and $u_t^{(-)}$ is negative unanticipated news about the state of the economy, whereas $\omega_{t-1}$ is investors' uncertainty about the announcement. F-statistic is the test statistic where the null hypothesis is the equality of the coefficient estimates of $u_t^{(+)}$ and $u_t^{(-)}$. $e_{t-1}^2$ and $\upsilon_{t-1}^2$ are the ARCH and GARCH terms, respectively. The heteroskedasticity consistent asymptotic standard errors of the coefficient estimates are presented in parenthesis under the corresponding coefficient estimate. *** indicates a significant coefficient estimate at 1% confidence level, whereas ** and * indicate significant coefficient estimates at 5% and 10% confidence levels, respectively.

The fact that the conditional volatility of simulated returns is time-varying as observed in Figure 2.5 is also supported by significant coefficient estimates of ARCH and GARCH terms. The coefficient estimates of unanticipated news and uncertainty also support the implications of our theoretical model. We defer the discussion of these empirical results and the intuition behind them to the next section. We compare estimation results for simulated returns with those for return on the equal-weighted CRSP portfolio in the next section.

### 2.6.2 Effect of GDP Announcements on the Stock Market Return

In this section, we analyze the effect of advance GDP announcements on daily returns on the equal-weighted CRSP portfolio. The empirical specification is estimated separately using the four measures described above. Table 2.6 summarizes the estimation results of our empirical model without any control variables.

First of all, the estimation results without any control variables support the implications of our model about the mean return. Our theoretical model implies a negative effect of surprises on the mean return on announcement days if investors are more risk averse than a log utility investor. The coefficient estimate of unanticipated news is negative with respect to all four measures and it is significant with respect to three of the four measures. These empirical results suggest that investors are more risk averse than log-utility. Hence, returns react negatively to positive unanticipated news in advance GDP announcements. In other words, a positive surprise in the GDP announcement decreases the mean return on the announcement day, whereas a negative surprise increases the mean return. The effect of surprises on the mean return on announcement days is robust to different measures of surprises. The results are stronger when the model is estimated with model-based measures. This may be due to the fact that model-based measures employ more recent information than survey-based measures as discussed in Section 2.5.

One should note that the advance GDP announcements are released 8:30 AM before the stock market opens on the announcement day. Hence, the empirical specification can be considered as a predictive model as well as an explanatory model. The economic significance of these empirical results is the predictive relationship between news in advance GDP announcements and the stock market's reaction. Significant coefficient estimates suggest that one can predict how the stock market will react on the announcement day after the GDP news is released. The empirical results for the first model-based measure of unanticipated news suggest that if there is a one percent positive standardized surprise about the state of the economy in the

Table 2.6: The Effect of Advance GDP Announcements on the Stock Market Returns

| | Model-Based 1 | Model-Based 2 | Survey-Based 1 | Survey-Based 2 |
|---|---|---|---|---|
| | | Return Equation | | |
| Constant | 0.124 | 0.123 | 0.125 | 0.124 |
| | (0.005)*** | (0.005)*** | (0.005)*** | (0.005)*** |
| $u_t$ | -0.057 | -0.055 | -0.080 | -0.036 |
| | (0.008)*** | (0.001)*** | (0.049)* | (0.036) |
| | | Variance Equation | | |
| Constant | 0.021 | 0.021 | 0.021 | 0.021 |
| | (0.003)*** | (0.003)*** | (0.003)*** | (0.003)*** |
| $e^2_{t-1}$ | 0.191 | 0.190 | 0.190 | 0.192 |
| | (0.019)*** | (0.019)*** | (0.019)*** | (0.019)*** |
| $\upsilon^2_{t-1}$ | 0.776 | 0.778 | 0.778 | 0.776 |
| | (0.018)*** | (0.018)*** | (0.018)*** | (0.018)*** |
| $\omega_{t-1}$ | -0.058 | -0.058 | -0.044 | -0.034 |
| | (0.022)*** | (0.022)*** | (0.021)** | (0.017)** |
| $\omega^2_{t-1}$ | 0.010 | 0.010 | 0.005 | 0.002 |
| | (0.006)* | (0.006)* | (0.005) | (0.003) |

Notes: The table presents the coefficients estimates of the empirical specification described in Equations (2.31)-(2.32) for daily returns on equal-weighted CRSP portfolio. The return equation is Equation (2.31), whereas the variance equation is Equation (2.32). $u_t$ is unanticipated news in advance GDP announcements, whereas $\omega_{t-1}$ is investors' uncertainty about the announcement. $e^2_{t-1}$ and $\upsilon^2_{t-1}$ are the ARCH and GARCH terms, respectively. The first column denoted "Model-Based 1" presents the empirical results when the empirical specification is estimated with the first model-based measures. Similarly, the other columns present the estimation results when the empirical specification is estimated with the measure in the column heading. The heteroskedasticity consistent asymptotic standard errors of the coefficient estimates are presented in parenthesis under the corresponding coefficient estimate. *** indicates a significant coefficient estimate at 1% confidence level, whereas ** and * indicate significant coefficient estimates at 5% and 10% confidence levels, respectively.

announcement, the mean stock market return will drop by 0.057% on that announcement day. A similar logic applies to other measures as well. The fact that the empirical specification is predictive might have important implications for financial decisions that investors face.

Not surprisingly, there are significant ARCH and GARCH effects in the conditional variance of daily returns. More importantly, uncertainty has a significant effect on the conditional volatility of returns on announcement days. The degree of uncertainty resolved on the announcement day decreases the conditional volatility of returns. This effect is significant and robust across different measures of uncertainty. The intuition behind this result is straightforward. The uncertainty about the current growth rate of the economy is resolved on the announcement day. Hence, the conditional volatility of returns react to the resolution of uncertainty. Since the investors are less uncertain about the growth rate of the economy, the conditional volatility is lower. In other words, the higher the degree of uncertainty resolved, the lower the conditional volatility of returns would be on announcement days. One should note that the empirical results are concerned with announcement days. The conditional volatility of returns on two announcement days would be different if the degrees of uncertainty resolved are different. The conditional volatility of returns on announcement days might still be higher than the conditional volatility on non-announcement days. The difference between announcement days and non-announcement days is the resolution of uncertainty on announcement days. Although we do not present the results here, the implications of our model for non-announcement days are inline with the existing literature (Veronesi (1999)). The conditional volatility of returns are higher during periods of high uncertainty.

We include the quadratic function of uncertainty to analyze whether there is a nonlinear relationship between uncertainty and conditional volatility. In models with model-based measures, uncertainty has a significant positive quadratic effect on announcement-day volatility. Although not significant at any conventional level, the effect of uncertainty on announcement-day volatility is also positive in models with survey-based measures. These results suggest that uncertainty about the announcement has a nonlinear effect on announcement-day volatility, as predicted by our theoretical model.

Although the empirical results suggest that our model is capable of predicting the right sign of reaction, it remains to be determined if it is capable of matching the magnitudes of the reaction. Therefore, we next compare the empirical results for the first model-based measures with the empirical results for simulated returns in Table 2.4. First of all, the mean of our simulated returns matches that of historical returns on equal-weighted CRSP portfolio. The volatility of simulated returns is smaller than that of market returns. However, the ARCH and GARCH coefficients in Table 2.4 closely match those in Table 2.6. More importantly, the magnitude of reaction to unanticipated news for simulated returns is close that for market returns. In other words, the coefficient estimates of $u_t$ in Tables 2.4 and 2.6 are similar in sign and magnitude. Although the coefficient estimate of uncertainty in the variance equation for simulated returns has the same sign, it fails to match the magnitude. This fact is due to the smaller variance of our simulated returns compared to the variance of the market returns.

These initial results are promising and consistent with implications of our theoretical model, so we next analyze whether our initial results are robust to different empirical specifications and control variables.

### 2.6.3 Robustness Checks

In this section, we examine the extent to which our initial results might depend on the particular specification of Equations (2.31)-(2.32). We evaluate the robustness of our results either by changing the empirical specification or by including explanatory variables in the original specification.

In order to analyze whether the empirical results are robust to different empirical specifications, we first estimate an exponential GARCH (EGARCH) model proposed by Nelson (1991). The EGARCH specification estimated is similar to the GARCH specification described in Equations (2.31)-(2.32) except the conditional volatility is expressed in the following exponential form:

$$\log(\upsilon_t^2) = \theta_0 + \theta_1\omega_{t-1} + \theta_2\omega_{t-1}^2 + \theta_3\log(\upsilon_{t-1}^2) + \theta_4\left|\frac{e_{t-1}}{\upsilon_{t-1}}\right| + \theta_5\frac{e_{t-1}}{\upsilon_{t-1}} \tag{2.33}$$

One of the key advantages of Nelson's EGARCH specification is that it allows for asymmetric effects in the conditional volatility. The empirical results on conditional volatility might be due to the asymmetric effect of news on the conditional volatility. Hence, the EGARCH specification is appropriate to analyze whether the empirical results for conditional volatility is robust to an asymmetric GARCH specification. Another advantage of the EGARCH specification is that since Equation (2.33) describes the log of $\upsilon_t^2$, the variance itself ($\upsilon_t^2$) is guaranteed to be positive independent of parameter values. Table 2.7 summarizes the estimated coefficients of the EGARCH specification.

The coefficient estimates of the EGARCH specification are similar to the coefficients

Table 2.7: The Effect of Advance GDP Announcements on the Stock Market Returns (EGARCH Specification)

| | Model-Based 1 | Model-Based 2 | Survey-Based 1 | Survey-Based 2 |
|---|---|---|---|---|
| | | Return Equation | | |
| Constant | 0.117 | 0.117 | 0.118 | 0.117 |
| | (0.006)*** | (0.006)*** | (0.006)*** | (0.006)*** |
| $u_t$ | -0.053 | -0.055 | -0.094 | -0.047 |
| | (0.014)*** | (0.009)*** | (0.052)* | (0.033) |
| | | Variance Equation | | |
| Constant | -0.270 | -0.249 | -0.266 | -0.269 |
| | (0.022)*** | (0.022)*** | (0.022)*** | (0.022)*** |
| $\|e_{t-1}/\upsilon_{t-1}\|$ | 0.288 | 0.268 | 0.286 | 0.287 |
| | (0.025)*** | (0.025)*** | (0.025)*** | (0.025)*** |
| $e_{t-1}/\upsilon_{t-1}$ | -0.066 | -0.062 | -0.065 | -0.066 |
| | (0.010)*** | (0.009)*** | (0.010)*** | (0.010)*** |
| $\log(\upsilon^2_{t-1})$ | 0.949 | 0.954 | 0.950 | 0.949 |
| | (0.007)*** | (0.007)*** | (0.007)*** | (0.007)*** |
| $\omega_{t-1}$ | -0.197 | -0.224 | -0.251 | -0.111 |
| | (0.091)** | (0.083)*** | (0.096)*** | (0.074) |
| $\omega^2_{t-1}$ | 0.041 | 0.050 | 0.054 | -0.002 |
| | (0.021)* | (0.019)*** | (0.026)** | (0.017) |

Notes: The table presents the coefficients estimates of the empirical specification described in Equations (2.31) and (2.33) for daily returns on equal-weighted CRSP portfolio. The return equation is Equation (2.31), whereas the variance equation is Equation (2.33). $u_t$ is unanticipated news in advance GDP announcements, whereas $\omega_{t-1}$ is investors' uncertainty about the announcement. $|e_{t-1}/\upsilon_{t-1}|$, $e_{t-1}/\upsilon_{t-1}$ and $\log(\upsilon^2_{t-1})$ are the EGARCH terms. The first column denoted "Model-Based 1" presents the empirical results when the empirical specification is estimated with the first model-based measures. Similarly, the other columns present the estimation results when the empirical specification is estimated with the measure in the column heading. The heteroskedasticity consistent asymptotic standard errors of the coefficient estimates are presented in parenthesis under the corresponding coefficient estimate. *** indicates a significant coefficient estimate at 1% confidence level, whereas ** and * indicate significant coefficient estimates at 5% and 10% confidence levels, respectively.

estimates of the original GARCH specification independent of the measure used to estimate the specification. The unanticipated news has a significant negative coefficient estimate whereas the degree of uncertainty resolved on the announcement day decreases the conditional volatility. In other words, the empirical results and the interpretation of these results are robust with respect to the empirical specification used.

The empirical specification could possibly include a variety of additional explanatory variables, such as leading, current and lagging values of the announcement-day dummy, current and lagged values of the daily risk-free rate and the daily dividend yield in both the mean and the conditional volatility equations. Table 2.8 summarizes the estimation results with leading and lagging values of the announcement-day dummies. The model estimated is described by Equations (2.31)-(2.32) where $1_t^{(A)}$ is an indicator variable indicating the announcement day and $1_t^{(A-)}, 1_t^{(A+)}$ are unity on trading days that immediately precede and follow an announcement day, respectively.

Table 2.8: The Effect of Advance GDP Announcements on the Stock Market Returns (Including the Announcement-day Dummy Variables)

| | Model-Based 1 | Model-Based 2 | Survey-Based 1 | Survey-Based 2 |
|---|---|---|---|---|
| | | Return Equation | | |
| Constant | 0.120 | 0.120 | 0.121 | 0.121 |
| | (0.005)*** | (0.005)*** | (0.005)*** | (0.005)*** |
| $1_t^{(A-)}$ | 0.065 | 0.061 | 0.062 | 0.067 |
| | (0.037)* | (0.037) | (0.038) | (0.038)* |
| $1_t^{(A)}$ | 0.052 | 0.044 | 0.095 | 0.051 |
| | (0.024)** | (0.038) | (0.040)** | (0.040) |
| $1_t^{(A+)}$ | 0.071 | 0.068 | 0.052 | 0.056 |
| | (0.043)* | (0.044) | (0.044) | (0.044) |
| $u_t$ | -0.086 | -0.051 | -0.096 | -0.040 |
| | (0.027)*** | (0.003)*** | (0.050)* | (0.031) |
| | | Variance Equation | | |
| Constant | 0.024 | 0.021 | 0.021 | 0.021 |
| | (0.003)*** | (0.003)*** | (0.003)*** | (0.003)*** |
| $e_{t-1}^2$ | 0.199 | 0.190 | 0.190 | 0.191 |
| | (0.020)*** | (0.019)*** | (0.019)*** | (0.019)*** |
| $\upsilon_{t-1}^2$ | 0.765 | 0.778 | 0.779 | 0.778 |
| | (0.019)*** | (0.018)*** | (0.018)*** | (0.018)*** |
| $1_t^{(A-)}$ | -0.076 | -0.077 | -0.076 | -0.076 |
| | (0.018)*** | (0.017)*** | (0.017)*** | (0.017)*** |
| $1_t^{(A)}$ | 0.065 | 0.075 | 0.084 | 0.024 |
| | (0.056) | (0.067) | (0.088) | (0.058) |
| $1_t^{(A+)}$ | 0.019 | 0.011 | 0.005 | -0.003 |
| | (0.025) | (0.028) | (0.027) | (0.029) |
| $\omega_{t-1}$ | -0.081 | -0.084 | -0.074 | -0.012 |
| | (0.031)*** | (0.051)* | (0.065) | (0.038) |
| $\omega_{t-1}^2$ | 0.011 | 0.013 | 0.011 | 0.000 |
| | (0.005)** | (0.009) | (0.011) | (0.006) |

Notes: The table presents the coefficients estimates of the empirical specification described in Equations (2.31) and (2.32) for daily returns on equal-weighted CRSP portfolio. $1_t^{(A)}$ is a dummy variable that is equal to 1 if day $t$ is an advance GDP announcement day. Similarly, $1_t^{(A-)}$ and $1_t^{(A+)}$ before and after the announcement day dummy variables.

Several interesting facts emerge from Table 2.8. The coefficient estimate of the effect of surprises on the mean announcement-day return remains negative and significant. Thus, the effect of surprises is robust to including the announcement-day dummy variables ($1^{(A-)}$, $1^{(A)}$ and $1^{(A+)}$). The announcement day dummy is significant for two measures of unanticipated news (first model-based and survey-based measures) suggesting that there is an additional effect of the announcement on the daily stock returns in addition to the unanticipated news in the announcement. This fact might be due to the failure of these two measures correctly measuring the unanticipated news. However, the second model-based measure has a significant coefficient while making the announcement day dummy insignificant. This fact suggests that the second model-based measure performs better in terms of measuring the unanticipated news. The resolution of uncertainty on announcement days has the same effect on the conditional volatility as in the original specifications. The degree of uncertainty resolved on the announcement day significantly decreases the conditional volatility when the empirical specification is estimated with model-based measures of uncertainty. Although the coefficient estimates are similar in sign and magnitude, the effect is only marginally significant for survey-based measures.

Although the announcement day dummy in the variance equation has a positive coefficient estimate with respect to all measures, it is not significant in any of the models. Hence, the conditional volatility of returns increases on GDP announcement days, but insignificantly. The results about the after-announcement dummy ($1_t^{(A+)}$) are mixed and suggest that the effect of the announcement on conditional volatility is not persistent. In other words, any effect that the announcement has on the conditional volatility is incorporated in the return dynamics on the announcement day. This result is in line with findings in the existing literature. On the other hand, the before-announcement dummy ($1_t^{(A-)}$) has a significant and negative effect on conditional volatility in all models. This result is consistent with the findings of Jones, Lamont, and Lumsdaine (1998) on bond market volatility. They dubbed the relatively low conditional volatility of bond returns before announcement days the "calm-before-the-storm". Our findings suggest that calm-before-the-storm effects are present in the stock market around advance GDP announcement days.

We follow Flannery and Protopapadakis (2002) in adding the dividend yield and the risk-free rate as control variables to the return equation. Adding control variables to the return equation accounts for possibly time-varying expected returns. We also include lagged values of these control variables in the variance equation to account for possible forecastability of conditional volatility by these control variables. We include the lagged values of these control variables since they have to be measurable with respect to the information set on the previous day. Table 2.9 summarizes our estimation results with these control variables, where $r_t^f$ and $yld_t$ denote the risk-free rate and the dividend yield, respectively.

Table 2.9: The Effect of Advance GDP Announcements on the Stock Market Returns (Including the Dividend Yield and the Risk-free Rate)

| | Model-Based 1 | Model-Based 2 | Survey-Based 1 | Survey-Based 2 |
|---|---|---|---|---|
| | | Return Equation | | |
| Constant | 0.2223 | 0.2228 | 0.2234 | 0.2225 |
| | (0.014)*** | (0.014)*** | (0.014)*** | (0.222)*** |
| $1_t^{(A-)}$ | 0.0624 | 0.0636 | 0.0608 | 0.0666 |
| | (0.037)* | (0.037)* | (0.037) | (0.067)* |
| $1_t^{(A)}$ | 0.0255 | 0.0213 | 0.0807 | 0.0367 |
| | (0.033) | (0.035) | (0.039)** | (0.037) |
| $1_t^{(A+)}$ | 0.0595 | 0.0583 | 0.0441 | 0.0486 |
| | (0.043) | (0.044) | (0.045) | (0.049) |
| $r_t^f$ | -4.5829 | -4.6187 | -4.6492 | -4.5993 |
| | (0.764)*** | (0.764)*** | (0.768)*** | (-4.599)*** |
| $yld_t$ | -3.3065 | -3.3056 | -3.2638 | -3.2877 |
| | (0.685)*** | (0.684)*** | (0.685)*** | (-3.288)*** |
| $u_t$ | -0.0578 | -0.0525 | -0.0897 | -0.0378 |
| | (0.010)*** | (0.004)*** | (0.049)* | (-0.038) |
| | | Variance Equation | | |
| Constant | 0.0230 | 0.0215 | 0.0206 | 0.0208 |
| | (0.006)*** | (0.006)*** | (0.006)*** | (0.021)*** |
| $e_{t-1}^2$ | 0.1971 | 0.1928 | 0.1917 | 0.1921 |
| | (0.019)*** | (0.019)*** | (0.019)*** | (0.192)*** |
| $\upsilon_{t-1}^2$ | 0.7702 | 0.7763 | 0.7779 | 0.7773 |

Continued on next page

Table 2.9, Continued

| | Model-Based 1 | Model-Based 2 | Survey-Based 1 | Survey-Based 2 |
|---|---|---|---|---|
| | (0.018)*** | (0.018)*** | (0.018)*** | (0.777)*** |
| $1_t^{(A-)}$ | -0.0837 | -0.0826 | -0.0821 | -0.0826 |
| | (0.017)*** | (0.017)*** | (0.017)*** | (-0.083)*** |
| $1_t^{(A)}$ | 0.0627 | 0.0690 | 0.0901 | 0.0163 |
| | (0.058) | (0.062) | (0.095) | (0.016) |
| $1_t^{(A+)}$ | 0.0167 | 0.0155 | 0.0095 | -0.0021 |
| | (0.027) | (0.028) | (0.030) | (-0.002) |
| $r_{t-1}^f$ | 0.0883 | 0.0902 | 0.1207 | 0.1240 |
| | (0.213) | (0.208) | (0.206) | (0.124) |
| $yld_{t-1}$ | -0.2870 | -0.2530 | -0.2377 | -0.2546 |
| | (0.433) | (0.424) | (0.419) | (-0.255) |
| $\omega_{t-1}$ | -0.0737 | -0.0780 | -0.0835 | -0.0047 |
| | (0.038)* | (0.044)* | (0.072) | (-0.005) |
| $\omega_{t-1}^2$ | 0.0104 | 0.0117 | 0.0132 | -0.0011 |
| | (0.007) | (0.008) | (0.012) | (-0.001) |

Notes: The table presents the coefficients estimates of the empirical specification described in Equations (2.31) and (2.32) for daily returns on equal-weighted CRSP portfolio. The return equation is Equation (2.31), whereas the variance equation is Equation (2.32). $u_t$ is unanticipated news in advance GDP announcements, whereas $\omega_{t-1}$ is investors' uncertainty about the announcement. $e_{t-1}^2$ and $\upsilon_{t-1}^2$ are the ARCH and GARCH terms, respectively. $1_t^{(A)}$ is a dummy variable that is equal to 1 if day $t$ is an advance GDP announcement day. Similarly, $1_t^{(A-)}$ and $1_t^{(A+)}$ before and after the announcement day dummy variables. $r_t^f$ and $yld_t$ are the risk-free rate and the dividend yield, respectively. The first column denoted "Model-Based 1" presents the empirical results when the empirical specification is estimated with the first model-based measures. Similarly, the other columns present the estimation results when the empirical specification is estimated with the measure in the column heading. The heteroskedasticity consistent asymptotic standard errors of the coefficient estimates are presented in parenthesis under the corresponding coefficient estimate. *** indicates a significant coefficient estimate at 1% confidence level, whereas ** and * indicate significant coefficient estimates at 5% and 10% confidence levels, respectively.

The effect of surprises on announcement-day returns is robust to including control variables to account for time-varying expected returns. With respect to three of the four measures, the surprise has a significant and negative effect on the mean announcement-day return as in the original specification. The annoucement-day dummy in the return equation becomes insignificant with respect to almost all measures when one controls for time-varying expected return. This result is in line with our model which implies that the mean stock return should only react to unanticipated news on announcement days. An insignificant coefficient estimate for the announcement day dummy suggest that the unanticipated news captures the whole effect of the announcement. Furthermore, the daily risk-free rate and the dividend yield have significant and negative effects on daily returns. The effect of uncertainty on announcement-day volatility remains the same with significant coefficient estimates with respect to the model-based measures. The calm-before-storm effect is robust to adding control variables to the variance equation. Lagged values of risk-free rate and dividend yield do not have significant effect on volatility in any of the models. Overall, our findings in Table 2.8 are robust to adding control variables, such as the risk-free rate and the dividend yield.

Although we do not present the results here, we examine the robustness of our results to several other specifications. Our results are similar to those presented in Tables 2.8 and 2.9. The effect of surprise on annoucement-day returns is robust in all specifications. The effect of uncertainty is robust in any specification with model-based measures.

To summarize, the empirical results are in line with the implications of our model. Our empirical results suggest that surprises have a negative effect on announcement-day returns and the degree of uncertainty resolved causes the conditional volatility to decrease on announcement days.

### 2.6.4 The Asymmetric Effect of GDP Announcements on the Stock Market Returns

Our theoretical model predicts that a positive unanticipated news not only has a negative effect on stock returns but also has a bigger absolute effect than a negative unanticipated news. Or equivalently, the stock returns react asymmetrically to unanticipated news. In this section, we analyze whether the empirical evidence presented above for the stock market's reaction to advance GDP announcements is asymmetric. In order to test for asymmetric effects, we replace the unanticipated news in the return equation of the empirical specification by positive ($u_t^+$) and negative ($u_t^-$) unanticipated news which are described in Section 2.5.3. We estimate the original empirical specification with control variables and four measures of positive and negative unanticipated news. One should note that the measures of positive and negative unanticipated news are in percentage terms and standardized by standard deviations of the corresponding measure of unanticipated news. Table 2.10 summarizes the empirical results for the asymmetric effect of unanticipated news.

Table 2.10: The Asymmetric Effect of Advance GDP Announcements on the Stock Market Returns

| | Model-Based 1 | Model-Based 2 | Survey-Based 1 | Survey-Based 2 |
|---|---|---|---|---|
| | | Return Equation | | |
| Constant | 0.222 | 0.221 | 0.224 | 0.222 |
| | (0.014)*** | (0.014)*** | (0.014)*** | (0.222)*** |
| $1_t^{(A-)}$ | 0.066 | 0.068 | 0.060 | 0.066 |
| | (0.037)* | (0.037)* | (0.037) | (0.066)* |
| $1_t^{(A)}$ | 0.068 | 0.059 | 0.054 | 0.053 |
| | (0.048) | (0.046) | (0.056) | (0.053) |
| $1_t^{(A+)}$ | 0.061 | 0.060 | 0.045 | 0.049 |
| | (0.043) | (0.043) | (0.045) | (0.049) |
| $r_t^f$ | -4.564 | -4.538 | -4.665 | -4.597 |
| | (0.766)*** | (0.765)*** | (0.768)*** | (-4.597)*** |
| $yld_t$ | -3.322 | -3.331 | -3.260 | -3.287 |
| | (0.686)*** | (0.687)*** | (0.685)*** | (-3.287)*** |
| $u_t^+$ | -0.412 | -2.690 | -0.059 | -0.355 |
| | (0.157)*** | (1.050)** | (0.073) | (-0.355) |
| $u_t^-$ | 0.062 | 0.060 | 0.153 | 0.034 |
| | (0.014)*** | (0.013)*** | (0.094)* | (0.034) |
| F-Statistic | 4.584 | 6.233 | 0.458 | 1.330 |
| | (0.032)** | (0.013)** | (0.498) | (0.249) |

Continued on next page

Table 2.10, Continued

| | Model-Based 1 | Model-Based 2 | Survey-Based 1 | Survey-Based 2 |
|---|---|---|---|---|
| | | Variance Equation | | |
| Constant | 0.026 | 0.027 | 0.021 | 0.021 |
| | (0.006)*** | (0.006)*** | (0.006)*** | (0.021)*** |
| $e^2_{t-1}$ | 0.202 | 0.204 | 0.192 | 0.192 |
| | (0.020)*** | (0.020)*** | (0.019)*** | (0.192)*** |
| $\upsilon^2_{t-1}$ | 0.762 | 0.759 | 0.777 | 0.777 |
| | (0.019)*** | (0.019)*** | (0.018)*** | (0.777)*** |
| $1^{(A-)}_t$ | -0.088 | -0.090 | -0.082 | -0.083 |
| | (0.017)*** | (0.017)*** | (0.017)*** | (-0.083)*** |
| $1^{(A)}_t$ | 0.068 | 0.076 | 0.093 | 0.013 |
| | (0.059) | (0.059) | (0.095) | (0.013) |
| $1^{(A+)}_t$ | 0.016 | 0.015 | 0.012 | -0.004 |
| | (0.026) | (0.026) | (0.031) | (-0.004) |
| $r^f_{t-1}$ | 0.089 | 0.098 | 0.122 | 0.124 |
| | (0.219) | (0.221) | (0.206) | (0.124) |
| $yld_{t-1}$ | -0.379 | -0.420 | -0.235 | -0.255 |
| | (0.448) | (0.454) | (0.419) | (-0.255) |
| $\omega_{t-1}$ | -0.084 | -0.090 | -0.089 | -0.002 |
| | (0.042)** | (0.040)** | (0.073) | (-0.002) |
| $\omega^2_{t-1}$ | 0.013 | 0.013 | 0.014 | -0.001 |
| | (0.008) | (0.007)* | (0.012) | (-0.001) |

Notes: The table presents the coefficients estimates of the empirical specification described in Equations (2.31) and (2.32) for daily returns on equal-weighted CRSP portfolio. The return equation is Equation (2.31), whereas the variance equation is Equation (2.32). $u^{(+)}_t$ and $u^{(-)}_t$ are respectively positive and negative unanticipated news, whereas $\omega_{t-1}$ is investors' uncertainty about the announcement. F-statistic is the test statistic where the null hypothesis is the equality of the coefficient estimates of $u^{(+)}_t$ and $u^{(-)}_t$. $e^2_{t-1}$ and $\upsilon^2_{t-1}$ are the ARCH and GARCH terms, respectively. $1^{(A)}_t$ is a dummy variable that is equal to 1 if day $t$ is an advance GDP announcement day. Similarly, $1^{(A-)}_t$ and $1^{(A+)}_t$ before and after the announcement day dummy variables. $r^f_t$ and $yld_t$ are the risk-free rate and the dividend yield, respectively. The first column denoted "Model-Based 1" presents the empirical results when the empirical specification is estimated with the first model-based measures. Similarly, the other columns present the estimation results when the empirical specification is estimated with the measure in the column heading. The heteroskedasticity consistent asymptotic standard errors of the coefficient estimates are presented in parenthesis under the corresponding coefficient estimate. *** indicates a significant coefficient estimate at 1% confidence level, whereas ** and * indicate significant coefficient estimates at 5% and 10% confidence levels, respectively.

First of all, one should note that the coefficient estimates of other variables are almost identical to those in Table 2.9. The estimates of interest in Table 2.10 are the coefficients of positive and negative unanticipated news. The coefficient estimate of positive unanticipated news is positive with respect to all measures, whereas the coefficient estimate of negative unanticipated news is positive. These empirical results supports the empirical findings in Table 2.6 that the effect of unanticipated news on stock returns is negative. However, the estimates are significant with respect to only model-based measures. The F-statistics in Table 2.10 report test statistics for the null hypothesis which states that the coefficients of positive and negative unanticipated news are equal in magnitude. For model-based measures of unanticipated news, we reject the null hypothesis suggesting that the effect of positive unanticipated news is bigger in magnitude than the effect of negative unanticipated news. This distinction is not as clear for the survey-based measures for which we fail to reject the null hypothesis. These empirical results agree with the implication of our theoretical model.

### 2.6.5 Effect of GDP Announcements on the Risk-Free Rate and the Excess Market Return

In this section, we analyze the effect of GDP announcements on the daily secondary market rate of 3-month US Treasury Bills and the excess market return defined as excess returns on the equal-weighted market portfolio over the risk-free rate. We estimate the empirical model described in Equations (2.31)-(2.32) for percentage daily risk-free rate scaled by 100 and percentage excess market return. Table 2.11 summarizes our estimation results for the risk-free rate.

The empirical results for the daily risk-free rate are somewhat mixed. The effect of unanticipated news is positive with respect most of the measures but significant only in the specification with the first model-based measure. Hence, when significant, a positive surprise about GDP increases the short-term interest rate on announcement days. When we control for the unanticipated part of the announcement, the announcement dummy variables have no significant effect on the mean risk-free rate on announcement days.

In the variance equation, the only variable that has significant coefficient estimates across different measures is the ARCH term. More importantly, the resolution of uncertainty on announcement days does not seem to have a clear effect on the conditional volatility of the risk-free rate. These mixed empirical results about the risk-free rate suggest that the empirical results for the excess market return will be mostly driven by the risky market return.

Table 2.11: The Effect of Advance GDP Announcements on the Risk-free Rate

| | Model-Based 1 | Model-Based 2 | Survey-Based 1 | Survey-Based 2 |
|---|---|---|---|---|
| | | Return Equation | | |
| Constant | 1.571 | 1.572 | 1.579 | 1.590 |
| | (0.001)*** | (0.001)*** | (0.001)*** | (0.001)*** |
| $1_t^{(A-)}$ | -0.004 | -0.003 | -0.007 | -0.005 |
| | (0.003) | (0.005) | (0.004)* | (0.007) |
| $1_t^{(A)}$ | -0.001 | -0.001 | -0.001 | 0.001 |
| | (0.007) | (0.004) | (0.015) | (0.028) |
| $1_t^{(A+)}$ | -0.001 | -0.002 | -0.004 | -0.004 |
| | (0.005) | (0.005) | (0.004) | (0.006) |
| $u_t$ | 0.022 | 0.046 | -0.004 | 0.024 |
| | (0.006)*** | (0.032) | (0.008) | (0.017) |
| | | Variance Equation | | |
| Constant | 0.001 | 0.001 | 0.001 | 0.005 |
| | (0.000)*** | (0.000)*** | (0.000)*** | (0.000)*** |
| $e_{t-1}^2$ | 0.993 | 0.972 | 1.063 | 1.103 |
| | (0.044)*** | (0.045)*** | (0.058)*** | (0.021)*** |
| $\upsilon_{t-1}^2$ | 0.004 | 0.001 | 0.013 | -0.130 |
| | (0.044) | (0.046) | (0.054) | (0.021)*** |
| $1_t^{(A-)}$ | 0.000 | 0.000 | 0.000 | 0.001 |
| | (0.000)** | (0.000) | (0.000) | (0.001) |
| $1_t^{(A)}$ | 0.000 | 0.003 | -0.004 | -0.011 |
| | (0.000) | (0.001)*** | (0.001)*** | (0.008) |
| $1_t^{(A+)}$ | 0.000 | 0.000 | 0.000 | 0.001 |
| | (0.000)** | (0.000)*** | (0.000) | (0.001) |
| $\omega_{t-1}$ | -0.001 | -0.003 | 0.004 | 0.013 |
| | (0.000) | (0.001)*** | (0.001)*** | (0.010) |
| $\omega_{t-1}^2$ | 0.000 | 0.001 | -0.001 | -0.003 |
| | (0.000) | (0.000)*** | (0.000)*** | (0.002) |

Notes: The table presents the coefficients estimates of the empirical specification described in Equations (2.31) and (2.32) for daily risk-free rate. The first column denoted "Model-Based 1" presents the empirical results when the empirical specification is estimated with the first model-based measures. Similarly, the other columns present the estimation results when the empirical specification is estimated with the measure in the column heading. *** indicates a significant coefficient estimate at 1% confidence level, whereas ** and * indicate significant coefficient estimates at 5% and 10% confidence levels, respectively.

The empirical results for the effect of GDP announcements on stock market return and risk-free rate have immediate implications for the excess market return. The excess market return, defined as the difference between risky return and risk-free return, would react stronger to the unanticipated component of the announcement than risky return. This follows from negative reaction of risky returns and positive reaction of risk-free returns to the unanticipated news in the announcement. In other words, positive unanticipated news in the announcement would decrease the excess market return more strongly and significantly than the risky return. On the other hand, the effect of uncertainty is not immediately clear. The conditional volatility of the excess market return is a function of conditional volatilities of risky and risk-free returns and the conditional covariance between them. We expect conditional volatility of the excess market return to react similarly as the market return since the empirical results for the risk-free rate are mixed. Table 2.12 summarizes supporting empirical results for these conjectures about the excess market return.

Table 2.12: The Effect of Advance GDP Announcements on the Excess Market Returns

| | Model-Based 1 | Model-Based 2 | Survey-Based 1 | Survey-Based 2 |
|---|---|---|---|---|
| | | Return Equation | | |
| Constant | 0.222 | 0.222 | 0.223 | 0.222 |
| | (0.014)*** | (0.014)*** | (0.014)*** | (0.222)*** |
| $1_t^{(A-)}$ | 0.063 | 0.064 | 0.061 | 0.067 |
| | (0.037)* | (0.037)* | (0.037) | (0.067)* |
| $1_t^{(A)}$ | 0.029 | 0.021 | 0.081 | 0.037 |
| | (0.033) | (0.035) | (0.039)** | (0.037) |
| $1_t^{(A+)}$ | 0.059 | 0.057 | 0.044 | 0.049 |
| | (0.043) | (0.043) | (0.045) | (0.049) |
| $r_t^f$ | -5.583 | -5.571 | -5.649 | -5.599 |
| | (0.764)*** | (0.765)*** | (0.768)*** | (-5.599)*** |
| $yld_t$ | -3.307 | -3.306 | -3.264 | -3.288 |
| | (0.685)*** | (0.685)*** | (0.685)*** | (-3.288)*** |

Continued on next page

Table 2.12, Continued

| | Model-Based 1 | Model-Based 2 | Survey-Based 1 | Survey-Based 2 |
|---|---|---|---|---|
| $u_t$ | -0.056 | -0.052 | -0.090 | -0.038 |
| | (0.010)*** | (0.003)*** | (0.049)* | (-0.038) |
| | | Variance Equation | | |
| Constant | 0.023 | 0.023 | 0.021 | 0.021 |
| | (0.006)*** | (0.006)*** | (0.006)*** | (0.021)*** |
| $e^2_{t-1}$ | 0.198 | 0.197 | 0.192 | 0.192 |
| | (0.019)*** | (0.019)*** | (0.019)*** | (0.192)*** |
| $\upsilon^2_{t-1}$ | 0.769 | 0.770 | 0.778 | 0.777 |
| | (0.018)*** | (0.018)*** | (0.018)*** | (0.777)*** |
| $1^{(A-)}_t$ | -0.084 | -0.084 | -0.082 | -0.083 |
| | (0.017)*** | (0.017)*** | (0.017)*** | (-0.083)*** |
| $1^{(A)}_t$ | 0.058 | 0.064 | 0.090 | 0.016 |
| | (0.058) | (0.060) | (0.095) | (0.016) |
| $1^{(A+)}_t$ | 0.016 | 0.014 | 0.010 | -0.002 |
| | (0.027) | (0.027) | (0.030) | (-0.002) |
| $r^f_{t-1}$ | 0.089 | 0.091 | 0.121 | 0.124 |
| | (0.214) | (0.214) | (0.206) | (0.124) |
| $yld_{t-1}$ | -0.295 | -0.301 | -0.238 | -0.255 |
| | (0.435) | (0.436) | (0.419) | (-0.255) |
| $\omega_{t-1}$ | -0.069 | -0.072 | -0.084 | -0.005 |
| | (0.036)* | (0.040)* | (0.072) | (-0.005) |
| $\omega^2_{t-1}$ | 0.010 | 0.010 | 0.013 | -0.001 |
| | (0.006) | (0.007) | (0.012) | (-0.001) |

Notes: The table presents the coefficients estimates of the empirical specification described in Equations (2.31) and (2.32) for daily excess returns on equal-weighted CRSP portfolio. The return equation is Equation (2.31), whereas the variance equation is Equation (2.32). $u_t$ is unanticipated news in advance GDP announcements, whereas $\omega_{t-1}$ is investors' uncertainty about the announcement. $e^2_{t-1}$ and $\upsilon^2_{t-1}$ are the ARCH and GARCH terms, respectively. $1^{(A)}_t$ is a dummy variable that is equal to 1 if day $t$ is an advance GDP announcement day. Similarly, $1^{(A-)}_t$ and $1^{(A+)}_t$ before and after the announcement day dummy variables. $r^f_t$ and $yld_t$ are the risk-free rate and the dividend yield, respectively. The first column denoted "Model-Based 1" presents the empirical results when the empirical specification is estimated with the first model-based measures. Similarly, the other columns present the estimation results when the empirical specification is estimated with the measure in the column heading. The heteroskedasticity consistent asymptotic standard errors of the coefficient estimates are presented in parenthesis under the corresponding coefficient estimate. *** indicates a significant coefficient estimate at 1% confidence level, whereas ** and * indicate significant coefficient estimates at 5% and 10% confidence levels, respectively.

As expected, the excess market return reacts similarly to advance GDP announcements as the risky return. Although not presented here, the effect of unanticipated news on the excess market return is also asymmetric. A positive unanticipated news has a bigger effect on the excess market return than a negative unanticipated news of the same magnitude. The intuition from risky return follows for the excess market return.

### 2.6.6 Does the Effect of Unanticipated News Persist?

Is there a delayed effect of GDP announcements on daily stock returns? Another way to ask the same question is "Is all unanticipated information released on advance GDP announcement days incorporated into prices on the announcement day?". The answer to this question might have important implications for market efficiency. In this section, we address this question by analyzing possible delayed effect of GDP announcements on daily market returns in our framework.

If all unanticipated news released on the announcement day is incorporated into asset prices, we would not expect a delayed effect in daily stock returns. On the other hand, if prices react to the announcement slower than the efficient market hypothesis predict, then we would expect a significant delayed effect of unanticipated news on daily stock returns. Our model, in line with the efficient market hypothesis, predicts that available new information released on announcement days is incorporated into prices on the announcement day.

The empirical specification employed to test for possible delayed effect of the announcement is similar to the specification described by Equations (2.31)-(2.32). We include lagged values of unanticipated news, $u_{t-1}$, in both the return and the variance equations along with control variables discussed before. Table 2.13 summarizes the empirical results.

Table 2.13: The Persistence of the Effect of Advance GDP Announcements on the Stock Market Returns

| | Model-Based 1 | Model-Based 2 | Survey-Based 1 | Survey-Based 2 |
|---|---|---|---|---|
| | | Return Equation | | |
| Constant | 0.222 | 0.215 | 0.223 | 0.182 |
| | (0.014)*** | (0.014)*** | (0.014)*** | (0.182)*** |
| $1_t^{(A-)}$ | 0.062 | 0.069 | 0.063 | 0.025 |
| | (0.037)* | (0.037)* | (0.037)* | (0.025) |
| $1_t^{(A)}$ | 0.030 | 0.024 | 0.085 | -0.008 |
| | (0.033) | (0.036) | (0.039)** | (-0.008) |
| $1_t^{(A+)}$ | 0.059 | 0.060 | 0.040 | 0.045 |
| | (0.043) | (0.044) | (0.047) | (0.045) |
| $r_t^f$ | -4.595 | -4.793 | -4.658 | -5.537 |
| | (0.764)*** | (0.766)*** | (0.766)*** | (-5.537)*** |
| $yld_t$ | -3.308 | -3.642 | -3.255 | -3.838 |
| | (0.685)*** | (0.700)*** | (0.684)*** | (-3.838)*** |
| $u_t$ | -0.058 | -0.340 | -0.086 | -0.072 |
| | (0.010)*** | (0.282) | (0.049)* | (-0.072) |
| $u_{t-1}$ | **-0.011** | **-0.102** | **0.022** | **-0.012** |
| | **(0.027)** | **(0.122)** | **(0.047)** | **(-0.012)** |
| | | Variance Equation | | |
| Constant | 0.023 | 0.039 | 0.020 | 0.078 |
| | (0.006)*** | (0.007)*** | (0.006)*** | (0.078)*** |
| $e_{t-1}^2$ | 0.197 | 0.216 | 0.190 | 0.232 |
| | (0.019)*** | (0.020)*** | (0.019)*** | (0.232)*** |
| $\upsilon_{t-1}^2$ | 0.770 | 0.740 | 0.780 | 0.716 |
| | (0.018)*** | (0.020)*** | (0.018)*** | (0.716)*** |

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Table 2.13, Continued

| | Model-Based 1 | Model-Based 2 | Survey-Based 1 | Survey-Based 2 |
|---|---|---|---|---|
| $1_t^{(A-)}$ | -0.083 | -0.115 | -0.082 | -0.131 |
| | (0.017)*** | (0.018)*** | (0.017)*** | (-0.131)*** |
| $1_t^{(A)}$ | 0.063 | 0.059 | 0.090 | 0.026 |
| | (0.059) | (0.075) | (0.096) | (0.026) |
| $1_t^{(A+)}$ | 0.016 | -0.006 | 0.007 | -0.051 |
| | (0.027) | (0.037) | (0.030) | (-0.051) |
| $r_{t-1}^f$ | 0.086 | 0.204 | 0.138 | 0.759 |
| | (0.213) | (0.238) | (0.202) | (0.759)*** |
| $yld_{t-1}$ | -0.289 | -0.782 | -0.251 | -1.913 |
| | (0.434) | (0.493) | (0.415) | (-1.913)*** |
| $\omega_{t-1}$ | -0.075 | -0.065 | -0.084 | -0.058 |
| | (0.039)* | (0.032)** | (0.073) | (-0.058) |
| $\omega_{t-1}^2$ | 0.011 | 0.007 | 0.013 | 0.004 |
| | (0.007) | (0.005) | (0.012) | (0.004) |
| $u_{t-1}$ | **-0.005** | **0.224** | **0.017** | **-0.047** |
| | **(0.014)** | **(0.443)** | **(0.026)** | **(-0.047)** |

Notes: The table presents the coefficients estimates of the empirical specification described in Equations (2.31) and (2.32) for daily returns on equal-weighted CRSP portfolio. The return equation is Equation (2.31), whereas the variance equation is Equation (2.32). $u_t$ is unanticipated news in advance GDP announcements, whereas $\omega_{t-1}$ is investors' uncertainty about the announcement. $u_{t-1}$ is the lagged value of the unanticipated news. $e_{t-1}^2$ and $\upsilon_{t-1}^2$ are the ARCH and GARCH terms, respectively. $1_t^{(A)}$ is a dummy variable that is equal to 1 if day $t$ is an advance GDP announcement day. Similarly, $1_t^{(A-)}$ and $1_t^{(A+)}$ before and after the announcement day dummy variables. $r_t^f$ and $yld_t$ are the risk-free rate and the dividend yield, respectively. The first column denoted "Model-Based 1" presents the empirical results when the empirical specification is estimated with the first model-based measures. Similarly, the other columns present the estimation results when the empirical specification is estimated with the measure in the column heading. The heteroskedasticity consistent asymptotic standard errors of the coefficient estimates are presented in parenthesis under the corresponding coefficient estimate. *** indicates a significant coefficient estimate at 1% confidence level, whereas ** and * indicate significant coefficient estimates at 5% and 10% confidence levels, respectively.

Empirical results provide supporting evidence for our model and the efficient market hypothesis. The effect of lagged unanticipated news on the mean of returns is negative but insignificant. In other words, the unanticipated news in the announcement is incorporated into stock price on the announcement day and returns react to news only on the announcement day. The effect of unanticipated news after the initial reaction on the announcement day diminishes in one day. Similarly, the effect of lagged unanticipated news on conditional volatility of returns after the announcement is insignificant. The conditional volatility reacts to the resolution of uncertainty on the announcement day and the effect of the announcement on volatility diminishes on the announcement day. These findings are in line with the existing literature that finds that the effect of announcements are short-lived.

## 2.7 Sources of the Stock Market's Reaction to Announcements

The unanticipated news affects the stock market returns on announcement days through two possible channels: the change in expectations of future dividends and the change in expectations of future returns. The discount factor and the cash flows are closely linked due to the general equilibrium nature of our model. Hence, we do not distinguish between news about the discount factor or future dividends in our analysis. General equilibrium implies that both the discount factor and future cash flows react to news about future dividends. The main implication of our theoretical model is that the stock market returns react to news about the state or the growth rate of dividends. Hence, the unanticipated news should affect the stock market return through its effect on the change in expectations of future dividends. In this section, we decompose returns into three components: the expected return, the change in expectations of future dividends and the change in expectations of future returns. We analyze the effect of unanticipated news on these three components of returns. Our claim is that the change in expectations of future dividends should react to unanticipated news about the growth rate of the economy.

Following Campbell and Shiller (1988a) and Campbell (1991), we employ a loglinear approximation of log returns to decompose unexpected returns into different components. One can think of their model as a dynamic generalization of the Gordon growth model. Let $r_t^*$ denote the log return in period $t$, defined as $r_t^* \equiv \log(1 + r_t)$ where $r_t$ is the return defined in Equation

(2.10). By definition, the log return can be expressed as follows:

$$\begin{aligned} r_t^* &= \log(P_t + D_t) - \log(P_{t-1}) \\ &= p_t - p_{t-1} + \log(1 + \exp(d_t - p_t)) \end{aligned} \tag{2.34}$$

where $p_t$ is the log price. The last term on the right-hand side of Equation (2.34) is a nonlinear function of the log dividend-price ratio. Using a first-order Taylor expansion, we obtain an approximation for log returns given as follows:

$$r_t^* \approx \theta + \rho p_t + (1-\rho) d_t - p_{t-1}$$

where $\theta$ and $\rho$ are parameters of linearization defined by $\rho \equiv 1/(1 + \exp(\overline{d-p}))$ and $\theta \equiv -\log(\rho) - (1 - rho)\log(1/\rho - 1)$. $(\overline{d-p})$ is the average log dividend-price ratio. Imposing transversality condition, we can express asset returns as linear combinations of revisions in expected future dividends and returns as follows:

$$\begin{aligned} \eta_t \equiv r_t^* - E_{t-1}[r_t^*] &= E_t\left[\sum_{j=0}^{\infty} \rho^j \Delta d_{t+j}\right] - E_{t-1}\left[\sum_{j=0}^{\infty} \rho^j \Delta d_{t+j}\right] \\ &- \left(E_t\left[\sum_{j=1}^{\infty} \rho^j r_{t+j}^*\right] - E_{t-1}\left[\sum_{j=1}^{\infty} \rho^j r_{t+j}^*\right]\right) \\ &\equiv \eta_{d,t} - \eta_{r,t} \end{aligned} \tag{2.35}$$

This equation has the following economic interpretation. If the unexpected return, $\eta_t$, is positive, then either expected future dividend growth $\eta_{d,t}$ must be higher than previously expected, or the excess future returns $\eta_{r,t}$ must be lower than expected, or any combination of these two must hold true.

In order to identify the sources of the stock market's reaction on announcement days, we analyze the effect of unanticipated news on $\eta_{d,t}$ and $\eta_{r,t}$. We use the structural VAR(1) approach of Campbell and Shiller (1988b) and Campbell (1991) to obtain estimates of $\eta_{d,t}$ and $\eta_{r,t}$. Specifically, we specify a vector $\mathbf{x}_t$ whose first element is the daily stock return and whose second element is the daily dividend yield, a relevant forecasting variable for returns. The assumption that the VAR is first-order is not restrictive, since a higher-order VAR can always be stacked into first-order form. The following VAR is estimated to obtain $\eta_{d,t}$ and $\eta_{r,t}$ via GMM.

$$\mathbf{x}_t \equiv \begin{bmatrix} r_t \\ yld_t \end{bmatrix} = \mathbf{A_0} + \mathbf{A_1}\mathbf{x}_{t-1} + \boldsymbol{\xi}_t \tag{2.36}$$

The GMM estimates are numerically identical to standard OLS estimates, but GMM delivers a heteroskedasticity-consistent variance-covariance matrix. Table 2.14 presents VAR estimation results.

Table 2.14: Coefficient Estimates for the VAR

| | $r_t$ | $yld_t$ |
|---|---|---|
| Constant | 0.0006 | 0.0001 |
| | (0.000) | (0.000) |
| $r_{t-1}$ | 0.3297 | 0.0002 |
| | (0.018) | (0.000) |
| $yld_{t-1}$ | -0.5010 | 0.1417 |
| | (0.834) | (0.011) |
| $R^2$ | 0.1091 | 0.0201 |

Notes: The table presents the coefficients estimates of the VAR in Equation (2.36). The column headings denote the dependent variable whereas the row headings are the independent variables. $R^2$ denotes the adjusted $R^2$ of the estimation. The heteroskedasticity consistent asymptotic standard errors of the coefficient estimates are presented in parenthesis under the corresponding coefficient estimate. *** indicates a significant coefficient estimate at 1% confidence level, whereas ** and * indicate significant coefficient estimates at 5% and 10% confidence levels, respectively.

Let " $\hat{\cdot}$ " denote the estimated values, e.g. $\hat{\boldsymbol{\xi}}_t$ denote the residuals (or equivalently, one-period forecast errors) from the VAR estimation. By definition, $\hat{\eta}_{r,t}$ can be expressed as follows:

$$\hat{\eta}_{r,t} = \mathbf{e}_1' \sum_{j=1}^{\infty} \hat{\rho}^j \hat{\mathbf{A}}_1^j \hat{\boldsymbol{\xi}}_t = \mathbf{e}_1' \hat{\rho} \hat{\mathbf{A}}_1 (\mathbf{I} - \hat{\rho}\hat{\mathbf{A}}_1)^{-1} \hat{\boldsymbol{\xi}}_t \tag{2.37}$$

From Equation (2.35) the revision in expectations of future dividends, $\hat{\eta}_{d,t}$ can be treated as a residual:

$$\hat{\eta}_{d,t} = (r_t^* - \hat{E}_{t-1}[r_t^*]) + \hat{\eta}_{r,t} = \mathbf{e}_1'(\mathbf{I} + \hat{\rho}\hat{\mathbf{A}}_1(\mathbf{I} - \hat{\rho}\hat{\mathbf{A}}_1)^{-1})\hat{\boldsymbol{\xi}}_t \tag{2.38}$$

The returns can be decomposed into its components as follows: $r_t^* = \hat{E}_{t-1}[r_t^*] + \hat{\eta}_{d,t} - \hat{\eta}_{r,t}$. To disentangle the source of the stock market's reaction on announcement days, we regress the three components of returns on unanticipated news. Table 2.15 presents the empirical results.

Table 2.15: Sources of the Stock Market's Reaction to Advance GDP Announcements

| | Model-Based 1 | | | Model-Based 2 | | | Survey-Based 1 | | | Survey-Based 2 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $\hat{E}_{t-1}[r_t^*]$ | $\hat{\eta}_{d,t}$ | $\hat{\eta}_{r,t}$ | $\hat{E}_{t-1}[r_t^*]$ | $\hat{\eta}_{d,t}$ | $\hat{\eta}_{r,t}$ | $\hat{E}_{t-1}[r_t^*]$ | $\hat{\eta}_{d,t}$ | $\hat{\eta}_{r,t}$ | $\hat{E}_{t-1}[r_t^*]$ | $\hat{\eta}_{d,t}$ | $\hat{\eta}_{r,t}$ |
| Constant | 0.084 | 0.000 | 0.000 | 0.084 | 0.000 | 0.000 | 0.084 | 0.000 | 0.000 | 0.084 | 0.000 | 0.000 |
| | (0.004)*** | (0.012) | (0.004) | (0.004)*** | (0.012) | (0.004) | (0.004)*** | (0.012) | (0.004) | (0.004)*** | (0.012) | (0.004) |
| $1_t^{(A-)}$ | 0.030 | -0.021 | -0.006 | 0.030 | -0.021 | -0.006 | 0.030 | -0.021 | -0.006 | 0.030 | -0.021 | -0.006 |
| | (0.025) | (0.093) | (0.031) | (0.025) | (0.093) | (0.031) | (0.025) | (0.093) | (0.031) | (0.025) | (0.093) | (0.031) |
| $1_t^{(A)}$ | 0.006 | 0.035 | 0.014 | 0.006 | 0.033 | 0.013 | 0.010 | 0.048 | 0.018 | 0.002 | 0.034 | 0.013 |
| | (0.019) | (0.075) | (0.025) | (0.019) | (0.075) | (0.025) | (0.019) | (0.073) | (0.024) | (0.018) | (0.075) | (0.025) |
| $1_t^{(A+)}$ | 0.012 | -0.012 | -0.003 | 0.012 | -0.012 | -0.003 | 0.012 | -0.012 | -0.003 | 0.012 | -0.012 | -0.003 |
| | (0.018) | (0.104) | (0.034) | (0.018) | (0.104) | (0.034) | (0.018) | (0.104) | (0.034) | (0.018) | (0.104) | (0.034) |
| $u_t$ | -0.004 | -0.087 | -0.028 | -0.006 | -0.077 | -0.025 | -0.016 | -0.038 | -0.012 | -0.033 | -0.049 | -0.016 |
| | (0.010) | (0.024)*** | (0.008)*** | (0.002)*** | (0.008)*** | (0.003)*** | (0.018) | (0.066) | (0.022) | (0.014)** | (0.045) | (0.015) |

Notes: The table presents linear regression results for the components of the mean return on announcement day dummy variables and unanticipated news in advance GDP announcements with respect to different measures. The components are estimated by employing the approach discussed in text. $\hat{E}_{t-1}[r_t^*]$ is the estimated expected return given the information set at time $t-1$, whereas $\hat{\eta}_{d,t}$ and $\hat{\eta}_{r,t}$ are the change in expected future dividends and the change in expected future returns, respectively. $u_t$ is unanticipated news in advance GDP announcements. $1_t^{(A)}$ is a dummy variable that is equal to 1 if day $t$ is an advance GDP announcement day. Similarly, $1_t^{(A-)}$ and $1_t^{(A+)}$ before and after the announcement day dummy variables. The first three columns denoted "Model-Based 1" present the empirical results when the regression is estimated with the first model-based measure of unanticipated news. Similarly, the other blocks of columns present the empirical results when the regression is estimated with the measure in the column heading. The heteroskedasticity consistent asymptotic standard errors of the coefficient estimates are presented in parenthesis under the corresponding coefficient estimate. *** indicates a significant coefficient estimate at 1% confidence level, whereas ** and * indicate significant coefficient estimates at 5% and 10% confidence levels, respectively.

As mentioned before, the unanticipated news about the growth rate of the economy affects the stock market return through two possible channels. The coefficient estimates of unanticipated news in estimation results for $\hat{\eta}_{d,t}$ and $\hat{\eta}_{r,t}$ with model-based measures are significant and negative. Hence, a positive unanticipated news has similar effects on the expectations of future dividends and future returns and decreases them significantly. However, one should note that a negative change in expectations of future returns has a positive effect on the stock market return due to the decomposition of return in Equation (2.35). In other words, if the expected future returns is lower than previously expected due to the unanticipated news, then stock market returns will increase. The overall effect of a positive unanticipated news on the stock market through the change in expectations of future returns is positive. On the other hand, a decrease in expectations of future dividends decreases the stock market return. Hence, the observed negative reaction of stock market returns to positive unanticipated news in advance GDP announcements is due to the change in expectations about future dividends on announcement days. Furthermore, the empirical results suggest that the effect of unanticipated news on future expected dividends dominates that on future expected returns.

## 2.8 Effect of "Employment Situation" Announcements on the Stock Market Return

So far, we have analyzed the effect of advance GDP announcements on the stock market return. The choice of GDP announcements is a natural one in our theoretical model since we derive implications about the news on the growth rate of the economy. GDP announcements are the most important announcement about the growth rate of the economy. However, one can easily consider the effect of news variables that are not perfectly correlated with the growth rate of the economy unlike GDP news. The implications of our model can be easily extended to news variable that provide imperfect information about the state of the economy. Employment news is one such news variable. It is considered as the most newsworthy announcement among various macroeconomic announcements. Boyd, Hu, and Jagannathan (2005) notes that it has frequently been the reference point of the Federal Reserve policy and the target of wide speculation on Wall Street. Li and Engle (1998) calls the employment announcements as the "king" of announcements and Flannery and Protopapadakis (2002) claims that the market "watches" it. In this section, we analyze the effect of employment news on the stock market return. The underlying assumption of this analysis is that the employment news provide information about the state and the growth rate of the economy. In particular, we assume that investors learn about the state of the economy through the employment news and analyze the effect of a change in their beliefs due to the employment announcement.

In this analysis, we focus on one type of employment announcement, namely monthly announcements of "The Employment Situation" from Bureau of Labor Statistics (BLS). Beginning of every month, the BLS releases, among other information, the nonfarm payroll employment and the unemployment rate in the previous quarter. These two estimates are arguably the most important figures in the Employment Situation announcement.

In order to obtain a proxy for investors' beliefs about the state of the economy as they observe the employment situation announcements, we estimate a Markov-switching vector autoregression (MS-VAR) of Krolzig (1997) for real-time monthly change in the nonfarm payroll employment and the unemployment rate. Real-time monthly the nonfarm payroll employment and the unemployment rate are available from the Federal Reserve Bank of Philadelphia. We assume that change in log nonfarm payroll employment and unemployment rate have a common state (the state of the economy) that follows a Markov chain with two possible states. Specifically, the joint process for the nonfarm payroll employment and the unemployment rate can be expressed as:

$$\begin{pmatrix} \Delta \log(NFEMP_t) \\ \Delta \log(UNEMP_t) \end{pmatrix} = \boldsymbol{\kappa}_{S_t} + \boldsymbol{\Omega}_{S_t}\boldsymbol{\xi}_t \tag{2.39}$$

where $NFEMP_t$ and $UNEMP_t$ are real-time values of the nonfarm payroll employment and the unemployment rate in month $t$, respectively. $S_t = 1, 2$ denotes the common state and $\boldsymbol{\kappa}_{S_t}$ and $\boldsymbol{\Omega}_{S_t}$ are the $(2 \times 1)$ mean vector and the $(2 \times 2)$ variance matrix as a function of the common state variable. For every employment situation announcement day, we first estimate the MS-VAR in Equation (2.39) using all available real-time data for the nonfarm payroll employment and the unemployment rate excluding the announcement. We next estimate it using all available data including the announcement. We construct model-based measures for unanticipated news about the state of the economy and uncertainty for employment news by the approach discussed in

Section 2.5.1.[12,13] We estimate the empirical GARCH(1,1) specification described in Equations (2.31) and (2.32) for daily stock market returns with employment news instead of GDP news. Table 2.16 presents empirical results for the effect of employment news on daily stock market returns.

[12]The approach employed to construct measures of unanticipated news and uncertainty news for employment news is identical to the model-based approach for GDP news except the approach used for the construction of $\hat{\pi}_{n|n-1}$. We estimate a MS-VAR model for two variables (the nonfarm payroll employment and the unemployment rate) instead of a simple regime-switching model for one variable (GDP). The details of the estimation of MS-VAR can be found in the appendix and Krolzig (1997). In the first model-based measure of unanticipated news and uncertainty, we do not distinguish between the nonfarm payroll employment news and the unemployment rate news. This follows from the assumption of a common state for the nonfarm payroll employment and the unemployment rate. In other words, we assume investors learn about the state of the economy by observing the nonfarm payroll employment and the unemployment rate on employment situation announcement days. The unanticipated news in the employment situation announcements is about the state of the economy. However, in the second model-based measure, we distinguish between the nonfarm payroll employment news and the unemployment rate news. Similar to GDP measures, second model-based measures for employment news are related to the forecasts of change in the nonfarm payroll employment and the unemployment rate.

[13]We were not able to obtain necessary data to construct survey-based measures. The Survey of Professional Forecasters (SPF) data used to construct survey-based measures for advance GDP announcement is not suitable for the monthly employment announcements. First of all, forecasts from SPF are available on a quarterly basis whereas the employment figures are released on a monthly basis. Secondly, only survey data on the unemployment rate is available for the whole period of our sample. The quarterly forecasts of the nonfarm payroll employment have recently been added to the SPF and is available since the fourth quarter of 2003.On the other hand, monthly forecasts of the nonfarm payroll employment and the unemployment rate are available from survey data of Money Market Services International (MMS) since 1985. However, forecasts of individual forecasters necessary to construct the uncertainty measures were not available to the author at the time of this study. Although MMS survey data would be appropriate for the purposes of this study, we were not able to obtain individual forecaster data.

Table 2.16: The Effect of "Employment Situation" News on the Stock Market Return

| | Model-Based 1 | Model-Based 2 |
|---|---|---|
| | Return Equation | |
| Constant | 0.119 | 0.118 |
| | (0.005)*** | (0.005)*** |
| $1_t^{(A-)}$ | 0.054 | 0.056 |
| | (0.023)** | (0.023)** |
| $1_t^{(A)}$ | 0.135 | 0.119 |
| | (0.028)*** | (0.026)*** |
| $1_t^{(A+)}$ | -0.097 | -0.108 |
| | (0.031)*** | (0.030)*** |
| $u_t$ | -0.078 | - |
| | (0.017)*** | - |
| $u_t^{NFEMP}$ | - | -0.050 |
| | - | (0.015)*** |
| $u_t^{UNEMP}$ | - | -0.042 |
| | - | (0.040) |
| | Variance Equation | |
| Constant | 0.021 | 0.021 |
| | (0.003)*** | (0.004)*** |
| $e_{t-1}^2$ | 0.194 | 0.192 |
| | (0.019)*** | (0.019)*** |
| $\upsilon_{t-1}^2$ | 0.773 | 0.772 |
| | (0.019)*** | (0.019)*** |
| $1_t^{(A-)}$ | -0.066 | -0.065 |
| | (0.016)*** | (0.016)*** |
| $1_t^{(A)}$ | 0.005 | -0.011 |

Continued on next page

Table 2.16, Continued

| | Model-Based 1 | Model-Based 2 |
|---|---|---|
| | (0.089) | (0.037) |
| $1_t^{(A+)}$ | 0.010 | 0.028 |
| | (0.034) | (0.037) |
| $\omega_{t-1}$ | 0.032 | - |
| | (0.127) | - |
| $\omega_{t-1}^2$ | 0.007 | - |
| | (0.028) | - |
| $\omega_{t-1}^{NFEMP}$ | - | -0.599 |
| | - | (0.375) |
| $\omega_{t-1}^{UNEMP}$ | - | 0.647 |
| | - | (0.401) |

Notes: The table presents the coefficients estimates of the empirical specification described in Equations (2.31) and (2.32) for daily returns on equal-weighted CRSP portfolio where the news is about the employment situation announcements. The return equation is Equation (2.31), whereas the variance equation is Equation (2.32). $u_t$ is unanticipated news about the state of the economy in employment situation announcements, whereas $\omega_{t-1}$ is investors' uncertainty about the state of the economy. $u_t^{NFEMP}$ and $u_t^{UNEMP}$ are respectively unanticipated news about the change in the nonfarm payroll employment and the unemployment rate, whereas $\omega_{t-1}^{NFEMP}$ and $\omega_{t-1}^{UNEMP}$ are the corresponding uncertainty measures. $e_{t-1}^2$ and $\upsilon_{t-1}^2$ are the ARCH and GARCH terms, respectively. $1_t^{(A)}$ is a dummy variable that is equal to 1 if day $t$ is an advance GDP announcement day. Similarly, $1_t^{(A-)}$ and $1_t^{(A+)}$ before and after the announcement day dummy variables. The first column denoted "Model-Based 1" presents the empirical results when the empirical specification is estimated with the first model-based measures about the state of the economy. Similarly, the other column presents the estimation results when we distinguish between the nonfarm payroll employment news and the unemployment rate news. The heteroskedasticity consistent asymptotic standard errors of the coefficient estimates are presented in parenthesis under the corresponding coefficient estimate. *** indicates a significant coefficient estimate at 1% confidence level, whereas ** and * indicate significant coefficient estimates at 5% and 10% confidence levels, respectively.

The effect of unanticipated employment news as measured by the first model-based measure on daily stock market returns is similar to the effect of unanticipated GDP news. A positive unanticipated news about the state of the economy in employment announcements has a negative effect on the stock market return. A one percent standardized positive surprise about the state of the economy in the employment news decreases the stock market return by 0.078% on employment situation announcement days. However, the effect of the resolution of uncertainty on the conditional volatility is not significant for employment situations announcement days. The conditional volatility of daily stock market returns decrease significantly before employment situation announcement days suggesting a calm-before-the-storm effect of employment announcements. On the other hand, when we distinguish between the nonfarm payroll employment news and the unemployment rate news on employment situation announcement days, we find that the stock market's reaction to employment situation announcements is due to unanticipated news in the nonfarm payroll employment. The coefficient estimate of unanticipated news in the nonfarm payroll employment is negative and significant whereas the coefficient estimate of unanticipated news in the unemployment rate is negative but insignificant. Furthermore, the coefficient estimate of uncertainty about the nonfarm payroll employment in the variance equation is negative and marginally[14] significant. These empirical results suggest that the implications of our theoretical model hold not only for news about the growth rate of the economy but also for news correlated with the growth rate.

## 2.9 Conclusion

In this paper, we analyze how the stock market reacts to news about fundamentals. Specifically, we analyze how the stock market reacts to scheduled public macroeconomic announcements that reveal information about the state of the economy. We develop a dynamic general equilibrium asset pricing model with periodic public announcements where investors learn about the unobserved state of the economy through dividend realizations and public announcements. Returns react significantly on announcement days only if there is a significant change in investors' beliefs due to the announcement. Furthermore, a positive unanticipated news about the state of the economy decreases the stock market return on announcement days if investors are more risk averse than log utility. The stock market reacts asymmetrically to unanticipated news. In other words, the effect of a positive unanticipated news is stronger than the

[14] at 11% confidence level

effect of a negative unanticipated news of the same magnitude. On the other hand, the conditional volatility of returns reacts to the resolution of uncertainty on announcement days. The higher the degree of uncertainty resolved on the announcement day, the smaller the conditional volatility will be. We claim that the resolution of uncertainty about the state of the economy is the main theoretical link between news about fundamentals and the behavior of conditional volatility on announcement days. Additionally, we find that the information revealed on announcement days is incorporated into the stock price in a single period. Using real-time data, we develop model-based and survey-based measures of unanticipated news and uncertainty to test the implications of our model. We find supporting evidence for our theoretical model in the aggregate stock market data. We claim that our model provides theoretical support for recent empirical findings about the effect of news on the stock market.

Our model is realistic and analytically tractable and most importantly suitable for the question addressed in this paper. It is possible to obtain analytical solutions to several possible extensions of our model. First of all, one can think of modeling consumption and dividend processes separately (Cecchetti, Lam, and Mark (1993)) to analyze possibly different effects of dividend and GDP announcements. Cecchetti, Lam, and Mark (1993) develop a representative agent model where consumption and dividends grow according to a regime-switching VAR. This framework is a partial equilibrium model and it would be more suitable for analyzing individual stocks rather than the aggregate stock market. Furthermore, in the framework of Cecchetti, Lam, and Mark (1993), one can think of the difference between consumption and dividends as labor income which would have implications for the effect of employment news on returns. Another possible generalization is to model dividends and the price of the consumption good. David and Veronesi (2004) show that analytical solutions to equilibrium asset prices are still available in this framework. One can easily use their model to analyze the effect of releases about interest rates, such as Federal Open Market Committee meetings.

One of the shortcomings of our model is lack of implications for volume on announcement days. A possible way to generate volume in this framework is information asymmetry among investors. Future research should focus on developing an asset pricing model with public announcements and asymmetric information about announcements among investors. Furthermore, our preliminary empirical results suggest that announcement about fundamentals have heterogenous effects on the cross-section of returns. Analyzing the effect of macroeconomic announcements on cross-section of returns might provide intuition for whether unanticipated news is a risk factor on announcement days.

# Chapter 3

# Asymmetries in the Reaction of Stock Prices to Macroeconomic News

## 3.1 Introduction

The reaction of prices to new information in the market has been at the center of studies in theoretical and empirical economics. In a recent paper, Andersen, Bollerslev, Diebold, and Vega (2005) note that the price discovery process is probably one of the most important topics in economics. More specifically, the price reaction of financial assets to macroeconomic announcements has been the interest of many articles in recent finance literature. With the availability of higher frequency data along with survey data on expectations of the market, there have recently been a revived interest in the price and the volatility reaction of financial assets to macroeconomic announcements.

However, there are still many dimensions of the reaction of financial assets to macroeconomic announcements that remain poorly understood. The empirical findings of the earlier literature have suggested that the stock prices and fundamentals are mostly disconnected. Recent literature addressed few dimensions of this central question of "How do markets arrive at prices?". Unfortunately, the literature mostly focused on the reaction of the aggregate stock market rather than the reaction of individual assets. The differential reaction across assets with different characteristics remains to be analyzed.

In this paper, we focus on the stock market rather than the bond or the foreign exchange markets and address several questions about the reaction of stock returns with different characteristics. The first question that we address in this paper is "Do the effects of macroeconomic news on stock returns differ across assets?". More specifically, we address whether the stock returns of firms with high market capitalization and/or high book equity to market equity ratio react differently than the stock returns of firms with low market capitalization and/or low book equity to market equity ratio. Since the size and the book-to-market ratio are related to the sensitivity of the firm to state of the aggregate economy, we would definitely expect the reaction to news to be significantly different across firms. After documenting empirical evidence on the differential reaction to news across firms with different characteristics, we analyze the possible sources of these asymmetries. These questions are central to understanding the sensitivity of different stocks to macroeconomic conditions. To our best knowledge, our paper is the first paper to address these questions.

Using a data set of news about several macroeconomic variables, we test several hypotheses implied by the theoretical findings on asymmetries across firms with different characteristics. We first analyze asymmetries in the reaction to news across firms with different market capitalizations. Recent imperfect capital market theories (Gertler and Gilchrist (1994)) predict that small firms with little collateral would be sensitive to news that reveal unexpected information about the market's future discount rates whereas large firms that are more established and more dependent on the performance of the aggregate economy would be more sensitive to news about the market's future cash flows. Furthermore, we expect large firms to react stronger to news that are important for the aggregate market than small firms since small firms have higher idiosyncratic risk and are less correlated with the aggregate market. We then analyze the effect of book-to-market ratio on the reaction of returns to macroeconomic news. Recent literature (Cornell (1999) and Campbell and Vuolteenaho (2004)) argue that growth firms are similar to longer duration bonds whose profits are realized in the distant future, thus more sensitive to fluctuations in the market's discount rates. Hence, we expect returns on growth firms to react stronger to news that are correlated with the aggregate discount rate. On the other hand, we expect that growth firms would be sensitive to fewer macroeconomic variables than value firms which are more established firms than growth firms.

For completeness, we also analyze the reaction of the aggregate stock market to macroeconomic news. Unsurprisingly, we find that the reaction of the aggregate stock market depends on the aggregation method used. Specifically, the equal-weighted portfolio of all stocks in the Center for Research in Security Prices (CRSP, hereafter) universe reacts differently than the value-weighted portfolio of same stocks. Of all the macroeconomic announcements considered in this paper, the value-weighted portfolio reacts significantly to fewer news than the equal-weighted portfolio suggesting that stocks with high market capitalization are sensitive to fewer macroeconomic news than stocks with low market capitalization. On the other hand, the reaction of the value-weighted portfolio is stronger than that of the equal-weighted portfolio for most of the macroeconomic news considered, especially when both portfolios react significantly.

These asymmetries in the reaction of the aggregate portfolios motivated our analysis of firms with different characteristics. Our empirical results can be summarized as follows. We find that only large firms react significantly to news about *Employees on Nonfarm Payrolls* and *Trade Balance of Goods and Services* whereas only small firms react significantly to news about *Export Price Index* and *Producer Price Index*. Both small and large firms react significantly to news about *Consumer Price Index* and *Core Consumer Price Index*. This empirical finding confirms our hypothesis about the higher sensitivity of small firms to news about the market's future discount rates. Of the six price announcements[1] considered, small firms react significantly to four whereas large firms only react significantly to the most important ones, i.e. CPI and Core CPI. As expected, we find that the reaction of large firms is generally stronger than that of small firms, however, significantly different for only news about *Employees on Nonfarm Payrolls* and *Initial Unemployment Claims*. We further analyze the effect of news on five book-to-market ratio sorted portfolios and find that growth firms are sensitive to fewer news than value firms whereas growth firms react stronger than value firms when the reaction is significant for both. Specifically, only growth firms react significantly to news about *Employees on Nonfarm Payrolls* whereas only value firms significantly react to news about *Hourly Earnings*, *Producer Price Index* and *Housing Starts*. Both growth and value firms react significantly to news about *Trade Balance of Goods and Services*, *Consumer Price Index* and *Core Consumer Price Index*. When both growth and value firms react significantly, the reaction of growth firms is stronger than that of value firms confirming our hypothesis that growth firms are more sensitive to macroeconomic variables that reveal information about future discount rates. The results are robust to the number of size or book-to-market sorted portfolios, i.e. three or ten portfolios. The results are also robust to using the cross sorted portfolios, i.e. 25 value- or equal-weighted size and book-to-market ratio sorted portfolios.

Our paper is related to two strands of literature. Our paper extends the analysis of the previous literature on the reaction of stock returns to macroeconomic news which focuses mainly on the aggregate market reaction. To our best knowledge, this is the first study to analyze the differential reaction across assets with different characteristics. Among other studies, in a

[1] Price announcements such as PPI and CPI are generally considered to be highly correlated with future discount rates.

recent paper, Andersen, Bollerslev, Diebold, and Vega (2005) find that the equity markets react differently to the same news depending on the state of the U.S. economy, with bad news having a positive impact during expansions and the traditionally-expected negative impact during recessions. Boyd, Hu, and Jagannathan (2005) find that unemployment news has asymmetric effects on the mean S&P 500 returns depending on the state of the economy. Unanticipated news in unemployment announcements seems to affect the aggregate stock return positively in contractions and negatively in expansions. McQueen and Roley (1993) find a strong relation between aggregate stock returns and macroeconomic news surprises, such as inflation, industrial production, and unemployment news. Flannery and Protopapadakis (2002) use a GARCH model of daily equity returns in which both realized returns and their conditional volatility are allowed to vary with 17 macroeconomic series' announcements. Of these 17 macroeconomic announcements, they identify three nominal variables (CPI, PPI, and Money Aggregate-M1 or M2) and three real variables (Employment Report, Balance of Trade, and Housing Starts) as possible candidates for risk factors. They find that the two nominal variables that affect the level of returns are CPI and PPI. Bernanke and Kuttner (2003) analyze the effect of unanticipated changes in the federal funds rate target on the value-weighted portfolio of all assets in the Center for Research in Security Prices (CRSP) universe. They find that an unanticipated rate cut of 25 basis points increases the level of stock prices by approximately 1 percent.

There is ample evidence on the effect of news on return volatility. Recently, Flannery and Protopapadakis (2002) and Bomfim (2003) find strong evidence on the effects of macroeconomic announcements on the volatility of the stock market returns. Flannery and Protopapadakis (2002) analyze daily conditional volatility of the value-weighted NYSE-AMEX-NASDAQ market index from CRSP between January 1980 and December 1996. They find that the conditional volatility reacts to announcements about the money supply, and three real variables (Employment Report, Balance of Trade, and Housing Starts). Bomfim (2003) analyzes the pre-announcement and the news effects on the stock market in the context of public disclosure of monetary policy decisions. He finds that the stock market tends to be relatively quiet, conditional volatility is abnormally low, on days preceding regularly scheduled policy announcements.

Although there is evidence that asset returns respond to new macroeconomic information, little theoretical work has been done on the stock market's reaction to public macroeconomic news. Recently, in an unpublished paper, Cenesizoglu (2005) finds that the effect of news on the aggregate stock market depends on opposite competing effects of the cash flow and the discount rate news which in turn depends on investors' risk aversion. The author notes that the volatility of stock returns reacts to the resolution of uncertainty by the information release. Kim and Verrecchia (1991) develop a three-period partial equilibrium model to analyze the market reaction to anticipated announcements. They conclude that a price change reflects the change in investors' expectations due to the arrival of new information, whereas volume arises due to information asymmetries.

The second strand of literature that our paper contributes to is the finance literature on the asymmetries in the cross-section of returns. In a recent unpublished paper, Xing and Zhang (2004) find that the fundamentals of value firms are more adversely affected by negative business cycle shocks than those of growth firms. Perez-Quiros and Timmermann (2000) analyze the differential reaction between small and large firms to tighter credit market conditions. They find that small firms have a higher sensitivity of their expected stock returns with respect to the variables that measure credit market conditions. Rai (1996) finds that market reactions to negative earnings surprises are more pronounced for growth firms than for value firms, whereas market reactions to positive earnings surprises are more pronounced for value firms than for growth firms. Ertimur, Livnat, and Martikainen (2003) analyze investors reactions to revenue and expense surprises around preliminary earnings announcements. They show that the differential market reactions to revenue and expense surprises vary systematically for growth and value firms. Vuolteenaho (2002) finds that firms with different market capitalizations react differently to both the cash flow news and the discount rate news. He finds that large firms react to the cash flow news stronger than small firms. Campbell and Vuolteenaho (2004) find that value stocks and small stocks have higher cash flow betas than growth stocks and large stocks suggesting that value stocks and small stocks are more sensitive to macroeconomic news that reveal information about future cash flows. In another paper, Campbell, Polk, and Vuolteenaho (2005) find that growth stocks have higher betas with the market's discount rate shocks whereas value stocks have higher betas with the market's cash flow shocks. Our paper contributes to this strand of literature by testing the empirical implications of these studies using an extensive data set on macroeconomic news variables.

The rest of the paper is organized as follows. In Section 3.2, we describe our data sets on stock returns and macroeconomic announcements. In Section 3.3, we present our empirical results. In Section 3.4, we provide an explanation for our empirical findings. In Section 3.5 we conclude.

## 3.2 Data

In this section, we describe the data set used to analyze the effect of macroeconomic news on stock returns. We first describe the returns data and present its salient features. We then provide a detailed description of the macroeconomic announcements data set and discuss the method for calculating the standardized macroeconomic news.

### 3.2.1 Returns Data

We use daily (close-to-close) returns on the equal-weighted and the value-weighted portfolio of all stocks in the CRSP universe between January 1980 and December 2004 from the CRSP files. We obtain daily returns on the equal-weighed and the value-weighted five size (market equity(ME)) sorted, five book-to-market (BE/ME) ratio sorted and 25 size and book-to-market ratio cross sorted portfolios from Ken French's web site between January 1980 and December 2004. However, we should note that returns on both the equal-weighted and the value-weighted five size sorted and five book-to-market sorted portfolios obtained from Ken French's web site are exactly identical.

Table 3.1: Summary Statistics for the Aggregate Portfolios, the Size Sorted and the Book-to-Market Sorted Portfolios

| | Aggregate Portfolio | | 5 Portfolios Formed on Size | | | | | 5 Portfolios Formed on Book-to-Market Ratio | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | EW | VW | Small | $2^{nd}$ Q | $3^{rd}$ Q | $4^{th}$ Q | Large | Growth | $2^{nd}$ Q | $3^{rd}$ Q | $4^{th}$ Q | Value |
| Mean | 0.096 | 0.053 | 0.051 | 0.054 | 0.055 | 0.058 | 0.054 | 0.052 | 0.056 | 0.056 | 0.060 | 0.066 |
| Median | 0.153 | 0.078 | 0.110 | 0.110 | 0.110 | 0.090 | 0.060 | 0.070 | 0.070 | 0.070 | 0.070 | 0.090 |
| Maximum | 6.904 | 8.662 | 6.420 | 7.340 | 7.760 | 8.700 | 8.770 | 9.970 | 8.080 | 7.910 | 8.310 | 7.180 |
| Minimum | -10.398 | -17.117 | -10.600 | -11.790 | -12.770 | -15.070 | -19.260 | -17.040 | -18.480 | -16.700 | -17.950 | -16.940 |
| Std. Dev. | 0.734 | 0.971 | 0.797 | 0.937 | 0.954 | 0.964 | 1.042 | 1.127 | 0.983 | 0.911 | 0.854 | 0.892 |
| Skewness | -1.311 | -1.024 | -1.562 | -0.886 | -0.711 | -0.809 | -1.041 | -0.582 | -1.258 | -1.162 | -1.600 | -1.370 |
| Kurtosis | 20.530 | 23.452 | 20.205 | 13.307 | 13.294 | 17.897 | 25.706 | 15.835 | 27.256 | 25.784 | 38.793 | 28.452 |
| $1^{st}$ AC | 0.266 | 0.077 | 0.257 | 0.174 | 0.166 | 0.151 | 0.028 | 0.070 | 0.089 | 0.094 | 0.078 | 0.088 |
| $2^{nd}$ AC | 0.095 | -0.020 | 0.095 | 0.036 | 0.004 | -0.008 | -0.035 | -0.024 | -0.006 | -0.013 | -0.020 | 0.001 |
| $3^{rd}$ AC | 0.094 | -0.020 | 0.090 | 0.050 | 0.032 | 0.000 | -0.034 | -0.031 | -0.011 | -0.009 | -0.011 | -0.001 |
| $4^{th}$ AC | 0.110 | -0.004 | 0.099 | 0.050 | 0.033 | 0.017 | -0.020 | 0.000 | -0.011 | -0.012 | -0.030 | -0.013 |
| $5^{th}$ AC | 0.092 | -0.001 | 0.084 | 0.024 | 0.008 | 0.008 | -0.001 | -0.006 | 0.010 | 0.006 | 0.015 | 0.017 |

Notes: EW and VW denote the equal-weighted aggregate portfolio and the value-weighted aggregate portfolio, respectively. $i^{\text{th}}$ Q denotes the $i^{\text{th}}$ quintile portfolio and $i^{\text{th}}$ AC denotes the $i^{\text{th}}$ order autocorrelation.

Table 3.1 presents summary statistics of daily returns of these portfolios. Several facts emerge from these summary statistics. The return on the equal-weighted portfolio has a higher mean and first order autocorrelation, a lower standard deviation, skewness and kurtosis than the return on the value-weighted portfolio. These summary statistics on the aggregate portfolios suggest that returns on small firms would also have a higher mean, a lower standard deviation, skewness and kurtosis compared to large firms which are confirmed by the summary statistics on five size sorted portfolios. On the other hand, value firms have a higher average return and a smaller standard deviation and are more serially correlated than growth firms. The summary statistics for both 25 equal-weighted and value-weighted cross portfolios formed on size and book-to-market ratio are similar.

Table 3.2 presents contemporaneous correlations between the equal-weighted and the value-weighted aggregate portfolios and five portfolios formed on size and five portfolios formed on BM ratio.

Table 3.2: Correlations between Portfolios

| | Aggregate Portfolio | | 5 Portfolios Formed on Size | | | | | 5 Portfolios Formed on Book-to-Market Ratio | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | EW | VW | Small | $2^{nd}$ Q | $3^{rd}$ Q | $4^{th}$ Q | Large | Growth | $2^{nd}$ Q | $3^{rd}$ Q | $4^{th}$ Q | Value |
| EW | 1.000 | 0.838 | 0.956 | 0.939 | 0.923 | 0.892 | 0.754 | 0.788 | 0.787 | 0.787 | 0.752 | 0.754 |
| VW | | 1.000 | 0.773 | 0.853 | 0.908 | 0.948 | 0.982 | 0.973 | 0.951 | 0.930 | 0.900 | 0.874 |
| Small | | | 1.000 | 0.934 | 0.888 | 0.845 | 0.681 | 0.726 | 0.725 | 0.725 | 0.701 | 0.710 |
| $2^{nd}$ Q | | | | 1.000 | 0.965 | 0.918 | 0.771 | 0.813 | 0.801 | 0.800 | 0.773 | 0.773 |
| $3^{rd}$ Q | | | | | 1.000 | 0.959 | 0.837 | 0.870 | 0.853 | 0.848 | 0.818 | 0.809 |
| $4^{th}$ Q | | | | | | 1.000 | 0.895 | 0.908 | 0.902 | 0.892 | 0.871 | 0.854 |
| Large | | | | | | | 1.000 | 0.972 | 0.954 | 0.928 | 0.900 | 0.866 |
| Growth | | | | | | | | 1.000 | 0.914 | 0.876 | 0.838 | 0.809 |
| $2^{nd}$ Q | | | | | | | | | 1.000 | 0.941 | 0.902 | 0.868 |
| $3^{rd}$ Q | | | | | | | | | | 1.000 | 0.912 | 0.878 |
| $4^{th}$ Q | | | | | | | | | | | 1.000 | 0.915 |
| Value | | | | | | | | | | | | 1.000 |

Notes: EW and VW denote the equal-weighted aggregate portfolio and the value-weighted aggregate portfolio, respectively. $i^{th}$ Q denotes the $i^{th}$ quintile portfolio.

The contemporaneous correlation between the equal-weighted and the value-weighted aggregate portfolios is 0.838. As expected, the contemporaneous correlation between the equal-weighted aggregate portfolio and five portfolios formed on size decreases with size whereas the contemporaneous correlation between the value-weighted aggregate portfolio and five portfolios formed on size increases with size. On the other hand, the contemporaneous correlation between the value-weighted aggregate portfolio and five portfolios formed on BM ratio decreases with BM ratio and is greater than the contemporaneous correlation between the equal-weighted aggregate portfolio and five portfolios formed on BM ratio. The contemporaneous correlations for both 25 equal-weighted and value-weighted cross portfolios formed on size and book-to-market ratio are similar.

### 3.2.2 Macroeconomics News Data

We obtain data on real-time macroeconomic variables as first reported and the market's expectations about these macroeconomic variables from the Money Market Services International (MMS) data set. The benchmark MMS International U.S. weekly survey has been conducted since 1980 and is the most complete history of US macroeconomic variables as first reported and the market consensus available. Every Friday, except holidays, MMS surveyed approximately 40 economists, market strategist from major commercial banks, top brokerage houses, consulting firms, some major universities and some fund management companies by telephone, fax or e-mail for their forecasts. The survey results are released around 1:30 P.M. EST every Friday for the upcoming week. The effect of most of the macroeconomic variables in our data set have been studied in the previous literature. However, there are few variables that have not been analyzed previously such as announcements on Domestic Light Truck Sales, Hourly Earnings, Core Consumer Price Index, Import and Export price indexes etc. We define the news as the unexpected part of the data release, i.e. the difference between the realizations (the announced value as first reported) and the consensus median expectation (forecast) from the MMS International data set.

The MMS International did not survey participants about a macroeconomic variable prior to the start date of availability presented in Table 3.3. Hence, although the data set is available from January 1980 to December 2004, the availability of consensus forecasts and realized values for individual macroeconomic variables is different. Table 3.3 summarizes several features of our macroeconomic news data set, the number of announcements, the number of news observations, the reporting agency, the start and the end date of availability, the announcement release time and summary statistics for standardized news which we discuss below.

Table 3.3: Summary Statistics for the Macroeconomic News Variables

| Announcement | No of Ann. | No of Obs. | Source | Start Date | End Date | Ann. Time | Mean | Min | Max |
|---|---|---|---|---|---|---|---|---|---|
| **Quarterly Announcements** | | | | | | | | | |
| 1. Real GDP: Advance, Q/Q %Change at an Annual Rate, (SAAR, %) | 59 | 59 | BEA | 4/27/1990 | 10/29/2004 | 8:30 A.M. | 0.3097 | -1.5174 | 2.1497 |
| 2. GDP Chain Price Index: Advance, Q/Q %Change, (SAAR, %) | 53 | 52 | BEA | 10/29/1991 | 10/29/2004 | 8:30 A.M. | -0.3879 | -3.5149 | 1.1716 |
| 3. Real GDP: Preliminary, Q/Q %Change at an Annual Rate, (SAAR, %) | 58 | 58 | BEA | 5/24/1990 | 11/30/2004 | 8:30 A.M. | 0.0842 | -5.0584 | 1.9187 |
| 4. GDP Chain Price Index: Prelim, Q/Q %Change at an Ann Rate, (SA, %) | 52 | 51 | BEA | 12/4/1991 | 12/22/2004 | 8:30 A.M. | 0.1182 | -2.0097 | 2.6797 |
| 5. Real GDP: Final, Q/Q %Change at an Annual Rate, (SAAR, %) | 59 | 59 | BEA | 6/21/1990 | 12/22/2004 | 8:30 A.M. | 0.0994 | -2.4691 | 3.0864 |
| 6. GDP Chain Price Index: Final, Q/Q %Change, (SAAR, %) | 53 | 52 | BEA | 12/20/1991 | 12/22/2004 | 8:30 A.M. | 0.4134 | -2.2237 | 2.2237 |
| **Monthly Announcements** | | | | | | | | | |
| **Real Activity** | | | | | | | | | |
| 7. Domestic Light Truck Sales, (SAAR, Mil.Units) | 134 | 131 | | 11/3/1993 | 12/1/2004 | | 0.2213 | -2.1745 | 5.1947 |
| 8. Employees on Nonfarm Payrolls, M/M Change, (SA, Thous) | 299 | 239 | BLS | 2/7/1980 | 12/14/2004 | 8:30 A.M. | -0.0595 | -2.7675 | 3.4425 |
| 9. Unemployment Rate, (SA, %) | 299 | 299 | BLS | 2/1/1980 | 12/3/2004 | 8:30 A.M. | -0.2803 | -3.5038 | 3.5038 |
| 10. Hourly Earnings, M/M %Change, (SA, %) | 190 | 177 | BLS | 3/10/1989 | 12/3/2004 | 8:30 A.M. | 0.0333 | -2.3595 | 2.8313 |
| 11. Manufacturing Payrolls, M/M Change, (SA, Thous) | 71 | 71 | BLS | 2/5/1999 | 12/3/2004 | 8:30 A.M. | -0.7073 | -3.0649 | 1.5930 |
| 12. Average Weekly Hours, (SA, Hours) | 74 | 74 | BLS | 11/5/1998 | 12/3/2004 | 8:30 A.M. | -0.3346 | -4.2691 | 1.7076 |
| 13. Retail Sales, M/M %Chg, (SA, %) | 299 | 299 | BC | 2/11/1980 | 12/13/2004 | 8:30 A.M. | -0.0254 | -3.2078 | 6.6830 |
| 14. Retail Sales ex Motor Vehicles, M/M %Chg, (SA, %) | 299 | 185 | BC | 2/11/1980 | 12/13/2004 | 8:30 A.M. | -0.1150 | -3.1133 | 2.5944 |
| 15. Industrial Production, M/M %Chg, (SA, %) | 299 | 299 | FRB | 2/15/1980 | 12/14/2004 | 9:15 A.M. | -0.0068 | -3.0307 | 5.3880 |
| 16. Capacity Utilization Rate: Total Industry, (SA, %) | 201 | 201 | FRB | 4/18/1988 | 12/14/2004 | 9:15 A.M. | 0.0869 | -2.8313 | 4.4042 |
| 17. Personal Income, M/M %Change, (SAAR, %) | 297 | 285 | BEA | 2/19/1980 | 12/23/2004 | 10:00/8:30 A.M. | 0.0429 | -12.4978 | 2.7169 |
| 18. Consumer Credit, M/M Change, (SA, Bil.$) | 202 | 201 | FRB | 3/7/1988 | 12/7/2004 | 3:00 P.M. | 0.1234 | -3.1566 | 3.7931 |

Continued on next page

Table 3.3, Continued

| Announcement | No of Ann. | No of Obs. | Source | Start Date | End Date | Ann. Time | Mean | Min | Max |
|---|---|---|---|---|---|---|---|---|---|
| **Consumption** | | | | | | | | | |
| 19. Existing Home Sales, (SAAR, Mil) | 97 | 97 | NAR | 12/30/1996 | 12/29/2004 | 10:00 A.M. | 0.2742 | -2.9944 | 3.6109 |
| 20. New Home Sales, (SAAR, Thous) | 202 | 200 | BC | 3/2/1988 | 12/23/2004 | 10:00 A.M. | 0.1677 | -2.6550 | 4.7825 |
| 21. PCE, M/M %Change, (SAAR, %) | 237 | 232 | BEA | 2/20/1985 | 12/23/2004 | 10:00/8:30 A.M. | 0.1274 | -4.1324 | 4.1324 |
| **Investment** | | | | | | | | | |
| 22. New Orders: Advance Durable Goods, M/M %Change, (SA, %) | 298 | 296 | BC | 2/22/1980 | 12/23/2004 | 9:00/10:00 A.M. | 0.0174 | -2.4604 | 3.6085 |
| 23. Construction Spending, M/M %Change, (SAAR, %) | 199 | 199 | BC | 4/4/1988 | 12/1/2004 | 10:00 A.M. | 0.1191 | -2.4349 | 2.4818 |
| 24. New Orders, M/M %Change, (SA, %) | 201 | 200 | BC | 3/2/1988 | 12/2/2004 | 10:00 A.M. | 0.0814 | -3.4383 | 6.3152 |
| 25. Business Inventories, M/M %Change, (SA, %) | 202 | 201 | BC | 3/14/1988 | 12/13/2004 | 10:00/8:30 A.M. | 0.1880 | -3.8219 | 2.9726 |
| **Government Purchases** | | | | | | | | | |
| 26. Government Surplus/Deficit, (NSA, Bil.$) | 199 | 198 | FMO | 2/22/1988 | 12/16/2004 | 2:00 P.M. | 0.0719 | -7.5070 | 7.8742 |
| **Net Exports** | | | | | | | | | |
| 27. Trade Balance: Goods & Services [BOP], (SA, Bil.$) | 298 | 298 | BEA | 2/28/1980 | 12/14/2004 | 8:30 A.M. | -0.1551 | -4.7282 | 3.7929 |
| 28. Exports: Goods & Services [BOP], (SA, Bil.$) | 201 | 198 | BEA | 4/14/1988 | 12/14/2004 | 8:30 A.M. | 0.0725 | -2.7255 | 3.2147 |
| 29. Imports: Goods & Services [BOP], (SA, Bil.$) | 200 | 198 | BEA | 4/14/1988 | 12/14/2004 | 8:30 A.M. | 0.1590 | -4.9620 | 3.1801 |
| **Prices** | | | | | | | | | |
| 30. Import Price Index, M/M %Change, (NSA, %) | 74 | 74 | BLS | 11/18/1998 | 12/9/2004 | 8:30 A.M. | -0.0985 | -3.2087 | 2.0419 |
| 31. Export Price Index, M/M %Change, (NSA, %) | 74 | 74 | BLS | 11/18/1998 | 12/9/2004 | 8:30 A.M. | -0.0176 | -2.9374 | 2.6111 |
| 32. Producer Price Index, M/M %Change, (SA, %) | 299 | 299 | BLS | 2/15/1980 | 12/10/2004 | 8:30 A.M. | -0.1732 | -3.8570 | 3.5603 |
| 33. Core PPI, Month/Month Change, (SA, %) | 299 | 185 | BLS | 2/15/1980 | 12/10/2004 | 8:30 A.M. | -0.1585 | -4.8206 | 3.2137 |
| 34. Consumer Price Index, M/M %Change, (SA, %) | 299 | 299 | BLS | 2/22/1980 | 12/17/2004 | 8:30 A.M. | -0.0636 | -4.0755 | 3.3963 |
| 35. Core CPI, M/M %Change, (SA, %) | 299 | 185 | BLS | 2/22/1980 | 12/17/2004 | 8:30 A.M. | 0.0435 | -1.6931 | 3.3861 |

Continued on next page

Table 3.3, Continued

| Announcement | No of Ann. | No of Obs. | Source | Start Date | End Date | Ann. Time | Mean | Min | Max |
|---|---|---|---|---|---|---|---|---|---|
| **Forward-looking** | | | | | | | | | |
| 36. Phil. Fed Current Business Condition Diffusion Index, (SA, %) | 74 | 74 | PHIL FED | 11/19/1998 | 12/16/2004 | 12:00 A.M. | 0.0035 | -3.1737 | 1.9445 |
| 37. Consumer Confidence, (SA, 1985=100) | 162 | 162 | CB | 7/30/1991 | 12/28/2004 | 10:00 A.M. | 0.0440 | -2.5676 | 2.6268 |
| 38. Chicago Purchasing Managers Index, (SA, 50+=Econ Growth) | 75 | 75 | NAPM | 10/30/1998 | 12/30/2004 | 10:00 A.M. | 0.0571 | -2.4878 | 1.8344 |
| 39. ISM: Manufacturing Composite Index, (SA, 50+ = Econ Expand) | 179 | 179 | NAPM | 2/1/1990 | 12/1/2004 | 10:00 A.M. | -0.0372 | -2.3876 | 2.6363 |
| 40. Housing Starts, (SAAR, Thous) | 297 | 297 | BC | 3/18/1980 | 12/16/2004 | 8:30 A.M. | 0.1464 | -2.6432 | 4.0665 |
| 41. Composite Index of Leading Indicators, M/M %Change, (%) | 299 | 299 | CB | 2/29/1980 | 12/20/2004 | 8:30 A.M. | 0.0270 | -5.3027 | 5.8918 |
| **Weekly Announcements** | | | | | | | | | |
| 42. Initial Claims, (Thous) | 701 | 693 | ETA | 7/18/1991 | 12/30/2004 | 8:30 A.M. | -0.0219 | -3.5788 | 4.6090 |

Notes: No of Ann. and No of Obs. denote the number of announcements and number of standardized news variable available, respectively. Source is the reporting agency where Bureau of Economic Analysis (BEA), Bureau of Labor Statistics (BLS), Bureau of the Census (BC), , Federal Reserve Board (FRB), National Association of Realtors (NAR), Financial Management Office (FMO), Federal Reserve Bank of Philadelphia (PHIL FED), Conference Board (CB), National Association of Purchasing Managers (NAPM). Start Date and End Date denote the start and end of the data set for the corresponding macroeconomic variable. Ann. Time is the time of the day when the corresponding macroeconomic variable is announced. Mean, Min and Max refer to the the mean, the minimum and the maximum of the standardized news variable for the corresponding macroeconomic variable.

Following Andersen, Bollerslev, Diebold, and Vega (2003), we first group macroeconomic variables into three main groups with respect to their announcement frequency; quarterly, monthly and weekly. Most of macroeconomic variables considered in our paper are monthly announcements. The GDP variables are quarterly variables while there is only one weekly variable, Initial Unemployment Claims. We then group monthly variables into 7 subgroups; Real Activity, Consumption, Investment, Government Purchases, Net Exports, Prices, and Forward-Looking. Macroeconomic variables in a given category are arranged chronologically with respect to their corresponding release date in a given month, the earlier announced variable is assigned a smaller number within each group. The reader is referred to Table 3.3 for details.

There are several problems with matching an announcement day of a macroeconomic variable to a trading day. If there is an announcement on a non-trading day, instead of losing that observation, we assume that the effect of that announcement would be realized in the first trading day after the announcement. For example, the stock market is closed on Good Fridays whereas most reporting agencies are still open. Hence, we assign those announcements made on Good Fridays to the first Monday following the announcement. The second problem is due to the release of two announcements of the same macroeconomic variable on the same day. This is not very common in our data set and generally happens due to a delay of the release on the previous announcement day. We take a simple average of the two news released on that day.

We use the market expectations or forecasts about macroeconomic variables from the MMS International data set rather than forecasts produced from extrapolative methods such as ARMA models. There are several reasons why the survey expectations contain more valuable information than extrapolative approaches. First of all, the survey expectations contain more recent information about a macroeconomic variable than extrapolative approaches. Survey expectations reflect the market's information set at most one week before the announcement whereas extrapolative approaches such as ARMA models need periodic data and produce forecasts based on the information set one month (week, quarter) before the announcement for monthly (weekly, quarterly) announcements. Secondly, the previous literature has shown that the MMS expectations are unbiased, more efficient than ARMA model forecasts and contain valuable information about the forecasted macroeconomic variable.

Following the previous literature (Balduzzi, Elton, and Green (2001), Andersen, Bollerslev, Diebold, and Vega (2003) and Andersen, Bollerslev, Diebold, and Vega (2005)), we use the standardized news defined as the difference between the actual released announcement and the consensus median market forecast from the MMS divided by the sample standard deviation of this difference. Specifically, the standardized news for macroeconomic variable $j$ on the announcement day $t$, $S_{jt}$, is defined as

$$S_{jt} = \frac{A_{jt} - F_{jt}}{\hat{\sigma}_j} \tag{3.1}$$

where $A_{jt}$ is the actual released value for the macroeconomic variable $j$ on the announcement day $t$, $F_{jt}$ is the consensus market expectation obtained as the median forecast from the MMS International data set. The difference $A_{jt} - F_{jt}$ is the news (non-standardized) whereas $\hat{\sigma}_j$ is the sample standard deviation of the news, i.e. $\hat{\sigma}_j = \sqrt{\text{var}(A_{jt} - F_{jt})}$. The standardization of the news allows us to compare the effect of different macroeconomic variables with different units of measurement. In this paper, our focus is the effect of standardized news on assets with different characteristics, hence we refer the reader to Balduzzi, Elton, and Green (1999), Balduzzi, Elton, and Green (2001) and Andersen, Bollerslev, Diebold, and Vega (2003) for a further discussion of the usefulness of the MMS International forecasts.

Table 3.3 also presents summary statistics for the standardized news for each macroeconomic variable in our data set. The standardized news for most macroeconomic variables has a mean around zero confirming the findings of the previous literature on the unbiasedness of the MMS forecasts. There is no macroeconomic variable with a standardized news that has a mean significantly different than zero. However, one should note that there are few variables such as Government Surplus/Deficit and Composite Index of Leading Indicators that have outliers, i.e. observations that are 4 standard deviations away from their corresponding means. In our robustness checks, we check whether our empirical results are affected by these outliers.

Table 3.4 presents summary statistics on the number of announcement days in our sample.

Table 3.4: Summary Statistics for Announcement Days

| | No of Ann. | Percentage | No of Obs. | Percentage |
|---|---|---|---|---|
| Number of Trading Days | 6312 | 100.00% | 6312 | 100.00% |
| with no announcements | 2587 | 40.99% | 2609 | 41.33% |
| with announcements | 3725 | 59.01% | 3703 | 58.67% |
| with one announcement | 1329 | 21.06% | 1562 | 24.75% |
| with two announcements | 1037 | 16.43% | 915 | 14.50% |
| with three announcements | 652 | 10.33% | 567 | 8.98% |
| with four announcements | 357 | 5.66% | 324 | 5.13% |
| with five announcements | 225 | 3.56% | 216 | 3.42% |
| with six announcements | 83 | 1.31% | 80 | 1.27% |
| with seven announcements | 24 | 0.38% | 23 | 0.36% |
| with eight announcements | 15 | 0.24% | 13 | 0.21% |
| with nine announcements | 0 | 0.00% | 0 | 0.00% |
| with ten announcements | 2 | 0.03% | 2 | 0.03% |
| with eleven announcements | 0 | 0.00% | 0 | 0.00% |
| with twelve announcements | 1 | 0.02% | 1 | 0.02% |

Notes: No of Ann. and No of Obs. denote the number of announcements and number of standardized news variable available, respectively.

There are 6312 trading days in our sample between January 2, 1980 and December 31, 2004. There are 3725 trading days (58.67% of our sample) with at least one announcement corresponding to 3703 observations of standardized news variable. This discrepancy between the number of announcements and the number of observations on standardized news is due to the fact that for some announcement days we do not have either survey expectations or realizations. Hence, for those trading days we know that it is an announcement day but we do not have observations on standardized news. There are trading days with as many as 12 announcements in our sample. There are are also two trading days with 10 announcements, one of which is the first trading day after September 11, 2001. We analyze the effect of these extreme days on our empirical results in our robustness checks.

Tables 3.5 and 3.6 summarizes mean and standard deviation of returns on the portfolios analyzed in this paper.

Table 3.5: Mean of Returns on Announcement Days

| | Mean | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Aggregate Portfolio | | 5 Portfolios Formed on Size | | | | | 5 Portfolios Formed on Book-to-Market Ratio | | | | |
| | EW | VW | Small | $2^{nd}$ Qnt | $3^{rd}$ Qnt | $4^{th}$ Qnt | Large | Growth | $2^{nd}$ Qnt | $3^{rd}$ Qnt | $4^{th}$ Qnt | Value |
| Whole Sample | 0.096 | 0.053 | 0.051 | 0.054 | 0.055 | 0.058 | 0.054 | 0.052 | 0.056 | 0.056 | 0.060 | 0.066 |
| with no announcements | 0.050 | 0.035 | 0.019 | 0.030 | 0.029 | 0.036 | 0.041 | 0.028 | 0.039 | 0.048 | 0.050 | 0.061 |
| with announcements | 0.128 | 0.066 | 0.074 | 0.070 | 0.073 | 0.073 | 0.064 | 0.068 | 0.069 | 0.061 | 0.066 | 0.069 |
| with one announcement | 0.098 | 0.048 | 0.046 | 0.047 | 0.046 | 0.045 | 0.052 | 0.060 | 0.047 | 0.034 | 0.040 | 0.057 |
| with two announcements | 0.134 | 0.062 | 0.090 | 0.094 | 0.080 | 0.075 | 0.056 | 0.061 | 0.068 | 0.062 | 0.074 | 0.061 |
| with three announcements | 0.138 | 0.069 | 0.069 | 0.055 | 0.072 | 0.068 | 0.069 | 0.056 | 0.082 | 0.079 | 0.063 | 0.092 |
| with four announcements | 0.185 | 0.084 | 0.134 | 0.108 | 0.116 | 0.142 | 0.061 | 0.082 | 0.074 | 0.083 | 0.093 | 0.081 |
| with five announcements | 0.185 | 0.205 | 0.092 | 0.137 | 0.191 | 0.184 | 0.220 | 0.222 | 0.203 | 0.205 | 0.204 | 0.189 |
| with six announcements | 0.160 | 0.091 | 0.196 | 0.127 | 0.109 | 0.137 | 0.064 | 0.070 | 0.079 | 0.062 | 0.081 | 0.007 |
| with seven announcements | 0.012 | -0.090 | -0.090 | -0.242 | -0.205 | -0.148 | -0.085 | -0.147 | -0.076 | -0.069 | -0.029 | -0.068 |
| with eight announcements | -0.015 | -0.219 | -0.160 | -0.225 | -0.256 | -0.222 | -0.285 | -0.201 | -0.269 | -0.467 | -0.291 | -0.495 |

Notes: EW and VW denote the equal-weighted aggregate portfolio and the value-weighted aggregate portfolio, respectively. $i^{\text{th}}$ Qnt denotes the $i^{\text{th}}$ quintile portfolio.

Table 3.6: Standard Deviation of Returns on Announcement Days

| | Standard Deviation | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Aggregate Portfolio | | 5 Portfolios Formed on Size | | | | | 5 Portfolios Formed on Book-to-Market Ratio | | | | |
| | EW | VW | Small | $2^{nd}$ Qnt | $3^{rd}$ Qnt | $4^{th}$ Qnt | Large | Growth | $2^{nd}$ Qnt | $3^{rd}$ Qnt | $4^{th}$ Qnt | Value |
| Whole Sample | 0.734 | 0.971 | 0.797 | 0.937 | 0.954 | 0.964 | 1.042 | 1.127 | 0.983 | 0.911 | 0.854 | 0.892 |
| with no announcements | 0.712 | 0.968 | 0.760 | 0.895 | 0.927 | 0.957 | 1.052 | 1.123 | 1.004 | 0.943 | 0.889 | 0.904 |
| with announcements | 0.747 | 0.973 | 0.822 | 0.965 | 0.972 | 0.968 | 1.036 | 1.129 | 0.968 | 0.888 | 0.830 | 0.883 |
| with one announcement | 0.791 | 0.942 | 0.865 | 0.975 | 0.967 | 0.943 | 1.008 | 1.107 | 0.938 | 0.854 | 0.799 | 0.849 |
| with two announcements | 0.657 | 0.902 | 0.732 | 0.857 | 0.870 | 0.883 | 0.970 | 1.074 | 0.903 | 0.845 | 0.777 | 0.806 |
| with three announcements | 0.719 | 0.955 | 0.814 | 0.981 | 0.973 | 0.960 | 1.023 | 1.102 | 0.963 | 0.879 | 0.830 | 0.895 |
| with four announcements | 0.740 | 1.068 | 0.786 | 0.970 | 1.026 | 1.039 | 1.141 | 1.198 | 1.070 | 0.982 | 0.928 | 0.982 |
| with five announcements | 0.863 | 1.199 | 0.929 | 1.133 | 1.184 | 1.190 | 1.244 | 1.355 | 1.152 | 1.041 | 0.964 | 1.023 |
| with six announcements | 0.802 | 1.184 | 0.925 | 1.133 | 1.147 | 1.190 | 1.191 | 1.307 | 1.080 | 0.925 | 0.884 | 0.944 |
| with seven announcements | 0.707 | 0.809 | 0.795 | 0.884 | 0.798 | 0.770 | 0.862 | 0.932 | 0.781 | 0.702 | 0.765 | 0.885 |
| with eight announcements | 0.823 | 1.011 | 0.894 | 1.281 | 1.173 | 1.135 | 1.013 | 1.086 | 0.902 | 1.034 | 1.098 | 1.143 |

Notes: EW and VW denote the equal-weighted aggregate portfolio and the value-weighted aggregate portfolio, respectively. $i^{th}$ Qnt denotes the $i^{th}$ quintile portfolio.

Both the average and the standard deviation of returns are higher on announcements days than on non-announcement days for each portfolio considered. The returns on most portfolios considered have higher average return and more volatile on announcement days with higher number of announcements. Furthermore, small firms have lower average returns than large firms on non-announcement days while the opposite is true on announcement days. Growth firms have lower average returns than value firms on non-announcement days whereas approximately the same average return on announcement days. An interesting fact is that small firms and growth firms are more volatile on announcement days whereas large firms and value firms become less volatile on announcement days. These simple summary statistics suggest that small firms and growth firms are more sensitive to news about state of the economy.

## 3.3 Empirical Results

In this section, we first specify an empirical model to analyze the effect of macroeconomic news on the aggregate portfolios, the size sorted portfolios and the BM sorted portfolios. We discuss the estimation method for the empirical specification. We then present our empirical results. Our main goal is to determine whether there are any differential reaction to news across these portfolios.

### 3.3.1 Empirical Specification

We specify a simple regression framework of the following form to analyze the effect of macroeconomic news on different portfolios,

$$r_{it} = \beta_{0,ij} + \beta_{1,ij} S_{j,t} + \varepsilon_{ij,t} \tag{3.2}$$

where $r_{it}$ is the return on portfolio $i$ ($i = 1, 2, \ldots, 12$ where $i = 1, 2$ are the equal-weighted portfolio and the value-weighted portfolio, respectively; $i = 3, 4, \ldots, 7$ are the 5 size sorted portfolios, $i = 3$ being the small firm portfolio and $i = 7$ being the large firm portfolio, respectively; $i = 8, 9, \ldots, 12$ are the 5 BM sorted portfolios, $i = 8$ being the growth firm portfolio and $i = 12$ being the value firm portfolio) on the announcement day $t$ for the macroeconomic variable $j = 1, 2, \ldots, 42$ (as described in Table 3.3), $\beta_{0,ij}$ is the average return of portfolio $i$ on announcement days for the macroeconomic variable $j$ and $\beta_{1,ij}$ is the effect of news about the macroeconomic variable $j$ on the return of portfolio $i$. The empirical specification in Equation (3.2) is estimated for each macroeconomic variable separately using data only on announcement days for that macroeconomic variable. This approach is equivalent to estimating a specification of the form: $r_{it} = \beta_{0,ij} 1^A_{jt} + \beta_{1,ij} S_{j,t} 1^A_{jt} + \varepsilon_{ij,t}$ where $1^A_{jt}$ is an indicator function that takes the value 1 if trading day $t$ is an observation day for macroeconomic variable $j$, 0 otherwise. The coefficient estimates from estimating the specification only on announcements are almost identical to the coefficient estimates obtained by estimating the specification over the whole sample. However, one should note that this approach rather than estimating the specification over the whole sample allows us to analyze the explanatory power of news on announcement days.

### 3.3.2 Empirical Results on Aggregate Portfolios

We initially estimate the empirical specification in Equation (3.2) as a system by running a seemingly unrelated regression (SUR) for the aggregate portfolios. The seemingly unrelated regression produces coefficient estimates identical to the ordinary least squares (OLS) approach and accounts for heteroskedasticity and contemporaneous correlation in the errors across the equations. Table 3.7 presents our empirical results for the equal-weighted and the value-weighted aggregate portfolios.

Table 3.7: The Effect of Macroeconomic News on the Aggregate Portfolios

| | Equal-Weighted Portfolio | | | Value-Weighted Portfolio | | | |
|---|---|---|---|---|---|---|---|
| Announcement | $\beta_0$ | $\beta_1$ | $R^2$ | $\beta_0$ | $\beta_1$ | $R^2$ | Wald Test |
| **Quarterly Announcements** | | | | | | | |
| 1. Real GDP: Advance | 0.1538 | 0.0686 | 0.0104 | 0.0288 | 0.0614 | 0.0035 | 0.0086 |
| 2. GDP Chain Price Index: Advance | 0.1679 | -0.0572 | 0.0068 | -0.0264 | -0.2336 | 0.0457 | 4.7303* |
| 3. Real GDP: Preliminary | 0.1658 | 0.0612 | 0.0077 | -0.1204 | 0.1338 | 0.0234 | 1.3131 |
| 4. GDP Chain Price Index: Preliminary | 0.1234 | 0.1000 | 0.0188 | -0.1913 | 0.0972 | 0.0123 | 0.0017 |
| 5. Real GDP: Final | 0.2572** | -0.0014 | 0.0000 | 0.1175 | -0.0042 | 0.0000 | 0.0015 |
| 6. GDP Chain Price Index: Final | 0.2827* | -0.0656 | 0.0072 | 0.1624 | -0.1536 | 0.0239 | 1.3399 |
| **Monthly Announcements** | | | | | | | |
| **Real Activity** | | | | | | | |
| 7. Domestic Light Truck Sales | 0.1865* | -0.1164 | 0.0190 | 0.2547* | -0.1078 | 0.0088 | 0.0227 |
| 8. Employees on Nonfarm Payrolls | 0.1789** | -0.0886 | 0.0140 | 0.0527 | -0.1997** | 0.0313 | 8.4036** |
| 9. Unemployment Rate | 0.2046** | 0.0375 | 0.0025 | 0.0952 | 0.0625 | 0.0033 | 0.5945 |
| 10. Hourly Earnings | 0.2047** | -0.1114 | 0.0183 | 0.1250 | -0.1589 | 0.0188 | 1.2575 |
| 11. Manufacturing Payrolls | 0.3145* | 0.0760 | 0.0056 | 0.3341 | 0.1333 | 0.0083 | 0.5024 |
| 12. Average Weekly Hours | 0.2875* | 0.0283 | 0.0008 | 0.3180 | 0.1284 | 0.0083 | 1.6427 |
| 13. Retail Sales | 0.1301** | -0.0123 | 0.0003 | 0.0708 | -0.0653 | 0.0043 | 3.3593 |

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Table 3.7, Continued

| | Equal-Weighted Portfolio | | | Value-Weighted Portfolio | | | |
|---|---|---|---|---|---|---|---|
| Announcement | $\beta_0$ | $\beta_1$ | $R^2$ | $\beta_0$ | $\beta_1$ | $R^2$ | Wald Test |
| 14. Retail Sales ex Motor Vehicles | 0.1523** | -0.0593 | 0.0059 | 0.0874 | -0.0533 | 0.0022 | 0.0207 |
| 15. Industrial Production | 0.0662 | 0.0408 | 0.0029 | 0.0307 | 0.0868 | 0.0075 | 2.7557 |
| 16. Capacity Utilization Rate | 0.0427 | 0.0702 | 0.0071 | 0.0284 | 0.1304 | 0.0149 | 2.4224 |
| 17. Personal Income | 0.1729** | -0.0177 | 0.0005 | 0.1238* | -0.0376 | 0.0015 | 0.4491 |
| 18. Consumer Credit | 0.0583 | 0.1060* | 0.0261 | 0.0141 | 0.1087 | 0.0148 | 0.0056 |
| **Consumption** | | | | | | | |
| 19. Existing Home Sales | 0.1415 | -0.0774 | 0.0066 | 0.0847 | -0.0152 | 0.0002 | 1.0575 |
| 20. New Home Sales | 0.2028** | -0.0012 | 0.0000 | 0.0914 | -0.0306 | 0.0010 | 0.4979 |
| 21. PCE | 0.2009** | 0.0210 | 0.0006 | 0.1309 | 0.0113 | 0.0001 | 0.0830 |
| **Investment** | | | | | | | |
| 22. New Orders: Advance Durable Goods | 0.1354** | -0.0062 | 0.0001 | 0.1185* | -0.0459 | 0.0031 | 1.8893 |
| 23. Construction Spending | 0.1989** | -0.0266 | 0.0011 | 0.2908** | -0.0753 | 0.0052 | 1.4130 |
| 24. New Orders | 0.2578** | -0.0334 | 0.0021 | 0.1297 | -0.0410 | 0.0019 | 0.0402 |
| 25. Business Inventories | 0.0497 | -0.0224 | 0.0006 | 0.0035 | -0.0180 | 0.0002 | 0.0101 |
| **Government Purchases** | | | | | | | |
| 26. Government Surplus/Deficit | -0.0425 | 0.0636 | 0.0079 | -0.1387* | 0.0633 | 0.0044 | 0.0001 |

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Table 3.7, Continued

| | Equal-Weighted Portfolio | | | Value-Weighted Portfolio | | | |
|---|---|---|---|---|---|---|---|
| Announcement | $\beta_0$ | $\beta_1$ | $R^2$ | $\beta_0$ | $\beta_1$ | $R^2$ | Wald Test |
| **Net Exports** | | | | | | | |
| 27. Trade Balance: Goods & Services [BOP] | 0.0488 | 0.1074* | 0.0203 | -0.0239 | 0.1499** | 0.0242 | 1.6676 |
| 28. Exports: Goods & Services [BOP] | 0.0259 | 0.0966* | 0.0196 | -0.0696 | 0.1073 | 0.0112 | 0.0674 |
| 29. Imports: Goods & Services [BOP] | 0.0333 | -0.0304 | 0.0020 | -0.0564 | -0.0552 | 0.0030 | 0.3616 |
| **Prices** | | | | | | | |
| 30. Import Price Index | 0.0350 | -0.0979 | 0.0090 | -0.0677 | -0.0405 | 0.0009 | 0.6327 |
| 31. Export Price Index | 0.0414 | -0.1888 | 0.0334 | -0.0670 | -0.1845 | 0.0178 | 0.0036 |
| 32. Producer Price Index | 0.1450** | -0.1071** | 0.0224 | 0.0537 | -0.1233* | 0.0136 | 0.2833 |
| 33. Core PPI | 0.1677** | -0.0620 | 0.0066 | 0.0759 | -0.1138 | 0.0099 | 1.5234 |
| 34. Consumer Price Index | 0.0720 | -0.1303** | 0.0349 | 0.0450 | -0.1744** | 0.0336 | 2.1811 |
| 35. Core CPI | 0.0952 | -0.2235** | 0.0837 | 0.0390 | -0.3104** | 0.0868 | 4.8165* |
| **Forward-looking** | | | | | | | |
| 36. Phil Fed Current Bus. Cond. Diff. Index | 0.1638 | -0.0539 | 0.0034 | 0.1783 | -0.1247 | 0.0104 | 1.0498 |
| 37. Consumer Confidence | 0.1935** | 0.0933 | 0.0175 | 0.1636* | 0.0843 | 0.0071 | 0.0384 |
| 38. Chicago Purchasing Managers Index | 0.5492** | 0.0467 | 0.0036 | 0.2367* | -0.0243 | 0.0007 | 0.8425 |
| 39. ISM: Manufacturing Composite Index | 0.1835** | -0.0123 | 0.0002 | 0.2443** | 0.0362 | 0.0012 | 0.9740 |
| 40. Housing Starts | 0.0457 | 0.0096 | 0.0001 | 0.0768 | 0.0627 | 0.0042 | 1.7100 |

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Table 3.7, Continued

| | Equal-Weighted Portfolio | | | Value-Weighted Portfolio | | | |
|---|---|---|---|---|---|---|---|
| Announcement | $\beta_0$ | $\beta_1$ | $R^2$ | $\beta_0$ | $\beta_1$ | $R^2$ | Wald Test |
| 41. Composite Index of Leading Indicators | 0.2199** | 0.0406 | 0.0031 | 0.1597** | 0.0210 | 0.0005 | 0.4449 |
| **Weekly Announcements** | | | | | | | |
| 42. Initial Claims | 0.1537** | 0.0234 | 0.0009 | 0.0343 | -0.0070 | 0.0000 | 2.2745 |

Notes: $\beta_0$ and $\beta_1$ are the coefficient estimates of the regression model in Equation 3.2. The Wald Test is the Wald statistic testing the equality of $\beta_1$ for the equal-weighted aggregate portfolio and $\beta_1$ for the value-weighted aggregate portfolio.

The first three columns present the empirical results for the equal-weighted portfolio where the first column is the average return of the equal-weighted aggregate portfolio on corresponding announcement days, the second column is the estimated effect of standardized news about the corresponding macroeconomic variable and the third column is the $R^2$. The next three columns present results for the value-weighted portfolio in the same order and the last column of Table 3.7 presents the Wald test statistics testing the equality of the effect of the corresponding news on the equal-weighted and the value-weighted portfolios, i.e. $\beta_{1,1j} = \beta_{1,2j}$. The daily average return on the equal-weighted portfolio is significantly greater than zero on announcement days for most macroeconomic variables considered in this paper whereas the same is true for the value-weighted portfolio on few announcement days. This confirms the finding in the previous section that small firms have higher average returns on announcement days than large firms. The return on the equal-weighted portfolio reacts significantly to news about 6 macroeconomic variables whereas the return on the value-weighted portfolio reacts significantly news about 5 macroeconomic variables. Both the equal-weighted and the value-weighted portfolios react significantly to news about *Trade Balance of Goods and Services*, *Producer Price Index*, *Consumer Price Index*, and *Core Consumer Price Index*, whereas only the equal-weighted portfolio reacts significantly to news about *Consumer Credit* and *Exports* and only the value-weighted portfolio reacts significantly to news about *Employees on Nonfarm Payroll*. The coefficient estimates of those variables that either the equal-weighted portfolio or the value-weighted portfolio react significantly are as expected, except the coefficient estimate on the effect of news about *Employees on Nonfarm Payrolls*. Before we turn our attention to the effect of news about *Employees on Nonfarm Payrolls*, we should briefly discuss the coefficient estimates on other variables that aggregate portfolios react significantly to. Higher than expected realized values for Consumer Credit, Trade Balance and Exports suggest that the economy is performing better than expected, hence return on aggregate portfolios reacts positively to positive unanticipated news about these variables. On the other hand, higher than expected realized values for the price indexes suggest that the inflationary pressure on the economy is greater than previously expected, hence the market expects the future discount rates to be higher than previously expected and returns on aggregate portfolios react negatively. Previous studies (Boyd, Hu, and Jagannathan (2005), Flannery and Protopapadakis (2002) and Andersen, Bollerslev, Diebold, and Vega (2005)) about the effect of news about Employees on Nonfarm Payroll on aggregate market returns find similar results to ours. The reason for this negative reaction to positive news about employment is due to the fact that the information about interest rates revealed in the Employees on Nonfarm Payroll announcement dominates the information about the future corporate cash flows.

The reaction of the value-weighted aggregate portfolio is stronger (i.e. greater in absolute value) than the reaction of the the equal-weighted aggregate portfolio to news about 28 of the 42 different macroeconomic variables considered in this paper. Furthermore, for those macroeconomic variables that either the equal-weighted or the value-weighted portfolio significantly react to, the reaction of the value-weighted aggregate portfolio is always stronger than that of the equal-weighted portfolio. However, the coefficient estimates of the equal-weighted and the value-weighted aggregate portfolios is significantly different from each other for only news about *GDP Chain Price Index: Advance*, *Employees on Nonfarm Payroll*, and *Core Consumer Price Index* as suggested by the significant Wald statistics. These results suggest that large firms react generally stronger to news about macroeconomic variables than small firms.

### 3.3.3 Empirical Results on Five Size Sorted Portfolios

In this section, we present our empirical results on the effect of news about macroeconomic variables on firms with different market capitalizations. We estimate the empirical specification in Equation (3.2) as a system by running a seemingly unrelated regression (SUR) for five size sorted portfolios. Table 3.8 presents our empirical results.

Table 3.8: The Effect of Macroeconomic News on the Five Size Sorted Portfolios

| | Small | | | 2nd Qnt | | | 3rd Qnt | | | 4th Qnt | | | Large | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Announcement | $\beta_0$ | $\beta_1$ | $R^2$ | $\beta_0$ | $\beta_1$ | $R^2$ | $\beta_0$ | $\beta_1$ | $R^2$ | $\beta_0$ | $\beta_1$ | $R^2$ | $\beta_0$ | $\beta_1$ | $R^2$ | Wald Test |
| **Quarterly Announcements** | | | | | | | | | | | | | | | | |
| 1. Real GDP: Advance | -0.0050 | 0.0590 | 0.0063 | -0.0530 | 0.0591 | 0.0038 | -0.0089 | 0.0699 | 0.0052 | 0.0451 | 0.0465 | 0.0024 | 0.0320 | 0.0714 | 0.0041 | 0.0129 |
| 2. GDP Chain Price Index: Advance | -0.0040 | -0.0753 | 0.0096 | -0.0550 | -0.1055 | 0.0111 | -0.0212 | -0.1623 | 0.0260 | 0.0122 | -0.1866 | 0.0357 | -0.0426 | -0.2769 | 0.0561 | 2.9845 |
| 3. Real GDP: Preliminary | 0.1777 | 0.0848 | 0.0143 | 0.0881 | 0.1451 | 0.0334 | 0.0637 | 0.1630 | 0.0378 | 0.0287 | 0.1610 | 0.0373 | -0.1783 | 0.1113 | 0.0143 | 0.0788 |
| 4. GDP Chain Price Index: Preliminary | 0.1478 | 0.1000 | 0.0180 | 0.0414 | 0.0792 | 0.0093 | 0.0076 | 0.0967 | 0.0125 | -0.0287 | 0.1297 | 0.0229 | -0.2574* | 0.0755 | 0.0067 | 0.0586 |
| 5. Real GDP: Final | 0.2764* | -0.0766 | 0.0062 | 0.3616* | -0.0521 | 0.0023 | 0.2701* | -0.0097 | 0.0001 | 0.2247 | 0.0103 | 0.0001 | 0.0763 | 0.0070 | 0.0000 | 0.5229 |
| 6. GDP Chain Price Index: Final | 0.2977 | -0.0326 | 0.0010 | 0.4798** | -0.2503 | 0.0466 | 0.3659* | -0.2520 | 0.0581 | 0.2887* | -0.1648 | 0.0295 | 0.1142 | -0.1557 | 0.0228 | 0.9719 |
| **Monthly Announcements** | | | | | | | | | | | | | | | | |
| **Real Activity** | | | | | | | | | | | | | | | | |
| 7. Domestic Light Truck Sales | 0.0988 | -0.1322 | 0.0178 | 0.1036 | -0.1417 | 0.0129 | 0.1421 | -0.1597 | 0.0158 | 0.2012 | -0.1413 | 0.0134 | 0.2714* | -0.0930 | 0.0062 | 0.2318 |
| 8. Employees on Nonfarm Payrolls | 0.1082* | -0.0535 | 0.0045 | 0.0709 | -0.0708 | 0.0048 | 0.0707 | -0.1111 | 0.0107 | 0.0785 | -0.1563* | 0.0194 | 0.0241 | -0.2207** | 0.0339 | 10.5941** |
| 9. Unemployment Rate | 0.1446** | 0.0365 | 0.0021 | 0.1069 | 0.0226 | 0.0005 | 0.1003 | 0.0201 | 0.0004 | 0.1177 | 0.0607 | 0.0032 | 0.0733 | 0.0817 | 0.0050 | 1.0613 |
| 10. Hourly Earnings | 0.1218 | -0.1178 | 0.0176 | 0.0895 | -0.1586 | 0.0198 | 0.1076 | -0.1733* | 0.0216 | 0.1426 | -0.1576 | 0.0173 | 0.1103 | -0.1530 | 0.0166 | 0.3840 |
| 11. Manufacturing Payrolls | 0.2378 | 0.0151 | 0.0002 | 0.2285 | 0.0629 | 0.0018 | 0.3294 | 0.1239 | 0.0066 | 0.4104 | 0.1575 | 0.0102 | 0.2818 | 0.1200 | 0.0068 | 0.9218 |
| 12. Average Weekly Hours | 0.2651* | 0.0654 | 0.0037 | 0.2399 | 0.1346 | 0.0089 | 0.2916 | 0.1240 | 0.0070 | 0.3408 | 0.0896 | 0.0036 | 0.2901 | 0.1565 | 0.0123 | 0.7383 |
| 13. Retail Sales | 0.0755 | -0.0163 | 0.0005 | 0.0724 | -0.0097 | 0.0001 | 0.0911 | -0.0274 | 0.0008 | 0.0737 | -0.0451 | 0.0021 | 0.0712 | -0.0895 | 0.0070 | 3.2397 |
| 14. Retail Sales ex Motor Vehicles | 0.0711 | -0.0638 | 0.0060 | 0.0680 | -0.0405 | 0.0014 | 0.1116 | -0.0028 | 0.0000 | 0.0895 | -0.0347 | 0.0009 | 0.0969 | -0.0557 | 0.0021 | 0.0202 |
| 15. Industrial Production | -0.0036 | 0.0345 | 0.0017 | 0.0073 | 0.0506 | 0.0029 | 0.0039 | 0.0335 | 0.0012 | 0.0122 | 0.0652 | 0.0043 | 0.0541 | 0.1028 | 0.0093 | 2.8646 |
| 16. Capacity Utilization Rate | -0.0510 | 0.0726 | 0.0062 | -0.0261 | 0.0708 | 0.0047 | -0.0161 | 0.0546 | 0.0028 | 0.0009 | 0.0855 | 0.0065 | 0.0547 | 0.1464 | 0.0172 | 1.6622 |
| 17. Personal Income | 0.1316** | -0.0048 | 0.0000 | 0.1267* | -0.0081 | 0.0001 | 0.1342* | -0.0133 | 0.0002 | 0.1448* | -0.0310 | 0.0009 | 0.1060 | -0.0490 | 0.0022 | 0.9653 |
| 18. Consumer Credit | 0.0012 | 0.0923 | 0.0147 | -0.0223 | 0.1569* | 0.0284 | -0.0053 | 0.1479* | 0.0260 | -0.0182 | 0.1455* | 0.0277 | 0.0250 | 0.0937 | 0.0099 | 0.0008 |

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Table 3.8, Continued

| Announcement | Small $\beta_0$ | $\beta_1$ | $R^2$ | 2nd Qnt $\beta_0$ | $\beta_1$ | $R^2$ | 3rd Qnt $\beta_0$ | $\beta_1$ | $R^2$ | 4th Qnt $\beta_0$ | $\beta_1$ | $R^2$ | Large $\beta_0$ | $\beta_1$ | $R^2$ | Wald Test |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Consumption** | | | | | | | | | | | | | | | | |
| 19. Existing Home Sales | 0.1692 | -0.1047 | 0.0092 | 0.1707 | -0.0605 | 0.0022 | 0.1490 | -0.1547 | 0.0144 | 0.1611 | -0.0541 | 0.0018 | 0.0518 | 0.0109 | 0.0001 | 2.0369 |
| 20. New Home Sales | 0.1530** | 0.0079 | 0.0001 | 0.1719* | 0.0128 | 0.0002 | 0.1641* | 0.0119 | 0.0001 | 0.1428* | -0.0236 | 0.0006 | 0.0655 | -0.0478 | 0.0021 | 0.9033 |
| 21. PCE | 0.1475* | 0.0508 | 0.0032 | 0.1479* | 0.0077 | 0.0001 | 0.1521* | 0.0160 | 0.0002 | 0.1667* | 0.0058 | 0.0000 | 0.1128 | 0.0108 | 0.0001 | 0.6066 |
| **Investment** | | | | | | | | | | | | | | | | |
| 22. New Orders: Adv. Durables | 0.0900* | -0.0066 | 0.0001 | 0.1134* | -0.0198 | 0.0006 | 0.1367** | -0.0372 | 0.0019 | 0.1309** | -0.0571 | 0.0050 | 0.1109* | -0.0463 | 0.0026 | 0.9048 |
| 23. Construction Spending | 0.0775 | -0.0171 | 0.0004 | 0.1632* | -0.0390 | 0.0013 | 0.2326** | -0.0338 | 0.0010 | 0.2523** | -0.0537 | 0.0026 | 0.3164** | -0.0862 | 0.0063 | 1.3792 |
| 24. New Orders | 0.2181** | -0.0176 | 0.0005 | 0.1882** | -0.0353 | 0.0014 | 0.1609* | -0.0350 | 0.0013 | 0.1705* | -0.0362 | 0.0014 | 0.0986 | -0.0374 | 0.0015 | 0.1343 |
| 25. Business Inventories | -0.0334 | -0.0472 | 0.0022 | -0.0217 | -0.0506 | 0.0020 | -0.0204 | -0.0382 | 0.0012 | -0.0084 | -0.0190 | 0.0003 | 0.0252 | -0.0071 | 0.0000 | 0.4266 |
| **Government Purchases** | | | | | | | | | | | | | | | | |
| 26. Government Surplus/Deficit | -0.0901 | 0.1014 | 0.0163 | -0.1603* | 0.1103 | 0.0129 | -0.1611* | 0.0777 | 0.0069 | -0.1493* | 0.0855 | 0.0089 | -0.1357 | 0.0544 | 0.0029 | 0.8090 |
| **Net Exports** | | | | | | | | | | | | | | | | |
| 27. Trade Balance | -0.0052 | 0.0797 | 0.0102 | -0.0348 | 0.0866 | 0.0097 | -0.0398 | 0.1118* | 0.0152 | -0.0339 | 0.1329* | 0.0217 | -0.0191 | 0.1486* | 0.0202 | 1.9263 |
| 28. Exports | -0.0266 | 0.0761 | 0.0118 | -0.0874 | 0.1326* | 0.0243 | -0.0974 | 0.1469* | 0.0263 | -0.0845 | 0.1254* | 0.0191 | -0.0673 | 0.1025 | 0.0089 | 0.2026 |
| 29. Imports | -0.0259 | 0.0100 | 0.0002 | -0.0883 | 0.0407 | 0.0023 | -0.0917 | 0.0071 | 0.0001 | -0.0739 | -0.0380 | 0.0018 | -0.0530 | -0.0606 | 0.0031 | 1.4598 |
| **Prices** | | | | | | | | | | | | | | | | |
| 30. Import Price Index | -0.0123 | -0.1163 | 0.0105 | -0.0505 | -0.1311 | 0.0083 | -0.0370 | -0.0995 | 0.0049 | -0.0581 | -0.0328 | 0.0005 | -0.0689 | 0.0018 | 0.0000 | 0.9384 |
| 31. Export Price Index | -0.0059 | -0.2873* | 0.0639 | -0.0426 | -0.2859 | 0.0396 | -0.0309 | -0.2124 | 0.0224 | -0.0581 | -0.1831 | 0.0157 | -0.0717 | -0.1519 | 0.0115 | 1.2390 |
| 32. Producer Price Index | 0.1029* | -0.1210** | 0.0266 | 0.0650 | -0.1124* | 0.0157 | 0.0739 | -0.0955 | 0.0098 | 0.0607 | -0.1109 | 0.0116 | 0.0469 | -0.1267 | 0.0122 | 0.0161 |
| 33. Core PPI | 0.1204* | -0.0731 | 0.0089 | 0.0726 | -0.0944 | 0.0094 | 0.0960 | -0.0831 | 0.0062 | 0.0777 | -0.0904 | 0.0064 | 0.0773 | -0.1209 | 0.0098 | 0.5939 |
| 34. Consumer Price Index | 0.0176 | -0.1408** | 0.0322 | 0.0477 | -0.1189* | 0.0188 | 0.0482 | -0.1460** | 0.0266 | 0.0393 | -0.1561** | 0.0296 | 0.0575 | -0.1766** | 0.0302 | 0.7211 |

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Table 3.8, Continued

| | Small | | | 2nd Qnt | | | 3rd Qnt | | | 4th Qnt | | | Large | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Announcement | $\beta_0$ | $\beta_1$ | $R^2$ | $\beta_0$ | $\beta_1$ | $R^2$ | $\beta_0$ | $\beta_1$ | $R^2$ | $\beta_0$ | $\beta_1$ | $R^2$ | $\beta_0$ | $\beta_1$ | $R^2$ | Wald Test |
| 35. Core CPI | 0.0311 | -0.2398** | 0.0741 | 0.0516 | -0.2516** | 0.0671 | 0.0560 | -0.2662** | 0.0696 | 0.0330 | -0.2787** | 0.0763 | 0.0410 | -0.3174** | 0.0854 | 1.9990 |
| **Forward-looking** | | | | | | | | | | | | | | | | |
| 36. Phil Fed Bus. Cond. Index | 0.0617 | -0.0302 | 0.0009 | 0.0401 | -0.1124 | 0.0073 | 0.1457 | -0.1148 | 0.0078 | 0.1983 | -0.0203 | 0.0003 | 0.1684 | -0.1096 | 0.0075 | 0.5311 |
| 37. Consumer Confidence | 0.1840** | 0.1095 | 0.0187 | 0.2296** | 0.1486 | 0.0229 | 0.1833* | 0.1491 | 0.0208 | 0.1722* | 0.1182 | 0.0133 | 0.1538 | 0.0574 | 0.0031 | 0.7701 |
| 38. Chicago PMI | 0.5475** | 0.0735 | 0.0060 | 0.3938** | 0.0065 | 0.0000 | 0.3622** | 0.0066 | 0.0000 | 0.4115** | 0.0321 | 0.0010 | 0.1473 | -0.0386 | 0.0015 | 0.8967 |
| 39. ISM: Manuf. Index | 0.0468 | 0.0337 | 0.0014 | 0.0987 | 0.0200 | 0.0003 | 0.1563 | 0.0480 | 0.0018 | 0.1831* | 0.0551 | 0.0025 | 0.2754** | 0.0316 | 0.0008 | 0.0011 |
| 40. Housing Starts | 0.0093 | 0.0113 | 0.0001 | 0.0175 | 0.0309 | 0.0008 | 0.0404 | 0.0300 | 0.0008 | 0.0589 | 0.0470 | 0.0022 | 0.0967 | 0.1006 | 0.0086 | 1.8910 |
| 41. Composite Index of LI | 0.1702** | 0.0591 | 0.0056 | 0.2301** | 0.0431 | 0.0022 | 0.2368** | 0.0465 | 0.0027 | 0.2168** | 0.0493 | 0.0029 | 0.1340* | 0.0077 | 0.0001 | 1.4340 |
| **Weekly Announcements** | | | | | | | | | | | | | | | | |
| 42. Initial Claims | 0.0934** | 0.0423 | 0.0028 | 0.0533 | 0.0374 | 0.0014 | 0.0729 | 0.0112 | 0.0001 | 0.0683 | 0.0194 | 0.0004 | 0.0172 | -0.0146 | 0.0002 | 4.0892* |

Notes: $\beta_0$ and $\beta_1$ are the coefficient estimates of the regression model in Equation 3.2. The Wald Test is the Wald statistic testing the equality of $\beta_1$ for the portfolio of small firms and $\beta_1$ for the portfolio of large firms.

All five size sorted portfolios react significantly to news about *Consumer Price Index* and *Core Consumer Price Index*. The strength of the reaction (absolute value of the coefficient estimate, $\hat{\beta}_1$) increases monotonically with size for news about Core Consumer Price Index and almost monotonically for news about Consumer Price Index. These results were expected due to the findings in the previous section on the stronger reaction of the value-weighted portfolio which puts more weight on larger firms. Smallest firms ($1^{st}$ quintile) react significantly to news about prices, specifically, news about Export, Producer, Consumer and Core Consumer price indexes. On the other hand, largest firms ($5^{th}$ quintile) react significantly to news about Employees on Nonfarm Payroll, Trade Balance of Goods and Services, CPI and Core CPI. Mid-cap firms ($2^{nd}$, $3^{nrd}$ and $4^{th}$ quintiles) also react significantly to news about Hourly Earnings, Consumer Credit and Exports in addition to the above-mentioned announcements that smallest and largest firms react significantly to. The reaction of largest firms is stronger (i.e. greater in absolute value) than the reaction of smallest firms to news about 27 of the 42 different macroeconomic variables. However, the reaction is significantly different between small and large firms only for news about Employees on Nonfarm Payrolls and Initial Unemployment Claims as suggested by the Wald test statistics.

Several interesting facts emerge from these empirical results. First of all, small firms seem sensitive to news about price indexes which are more correlated with the market's discount rate whereas large firms seem sensitive to news about cash flow related news such as Trade Balance. However, when both small and large firms react significantly, large firms react stronger.

### 3.3.4 Empirical Results on Five Book-to-Market Ratio Sorted Portfolios

In this section, we present our empirical results on the effect of news about macroeconomic variables on firms with different book-to-market ratios. We estimate the empirical specification in Equation (3.2) as a system by running a seemingly unrelated regression (SUR) for five BM sorted portfolios. Table 3.9 presents our empirical results.

Table 3.9: The Effect of Macroeconomic News on the Five Book-to-Market Sorted Portfolios

| | Growth | | | 2nd Qnt | | | 3rd Qnt | | | 4th Qnt | | | Value | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Announcement | $\beta_0$ | $\beta_1$ | $R^2$ | $\beta_0$ | $\beta_1$ | $R^2$ | $\beta_0$ | $\beta_1$ | $R^2$ | $\beta_0$ | $\beta_1$ | $R^2$ | $\beta_0$ | $\beta_1$ | $R^2$ | Wald Test |
| **Quarterly Announcements** | | | | | | | | | | | | | | | | |
| 1. Real GDP: Advance | 0.0102 | 0.0645 | 0.0031 | 0.0720 | 0.0477 | 0.0020 | 0.0360 | 0.1273 | 0.0200 | 0.0548 | 0.0704 | 0.0079 | -0.0650 | 0.0600 | 0.0037 | 0.0022 |
| 2. GDP Chain Price Index: Advance | -0.0342 | -0.2452 | 0.0411 | -0.0033 | -0.2773 | 0.0634 | -0.0236 | -0.2393 | 0.0657 | 0.0079 | -0.1923 | 0.0542 | -0.0931 | -0.1988 | 0.0361 | 0.1965 |
| 3. Real GDP: Preliminary | -0.1234 | 0.0854 | 0.0075 | -0.1187 | 0.1070 | 0.0140 | -0.1243 | 0.1417 | 0.0264 | -0.0752 | 0.1258 | 0.0257 | 0.0393 | 0.1888 | 0.0531 | 1.7175 |
| 4. GDP Chain Price Index: Preliminary | -0.2175 | 0.1113 | 0.0137 | -0.1985 | 0.0623 | 0.0049 | -0.1741 | 0.0282 | 0.0010 | -0.1156 | 0.0655 | 0.0067 | 0.0022 | -0.0036 | 0.0000 | 2.1800 |
| 5. Real GDP: Final | 0.0815 | -0.0116 | 0.0001 | 0.1813 | 0.0291 | 0.0009 | 0.1254 | 0.0393 | 0.0021 | 0.2145* | 0.0108 | 0.0002 | 0.2203* | -0.0050 | 0.0000 | 0.0043 |
| 6. GDP Chain Price Index: Final | 0.1064 | -0.1714 | 0.0236 | 0.2412 | -0.2063 | 0.0409 | 0.2146 | -0.1959 | 0.0461 | 0.2785* | -0.1321 | 0.0253 | 0.3051* | -0.1859 | 0.0435 | 0.0187 |
| **Monthly Announcements** | | | | | | | | | | | | | | | | |
| **Real Activity** | | | | | | | | | | | | | | | | |
| 7. Domestic Light Truck Sales | 0.2553* | -0.0967 | 0.0056 | 0.2716** | -0.1422 | 0.0161 | 0.2739** | -0.1044 | 0.0101 | 0.2310** | -0.0891 | 0.0096 | 0.2343** | -0.1144 | 0.0133 | 0.0780 |
| 8. Employees on Nonfarm Payrolls | 0.0333 | -0.2206** | 0.0291 | 0.0488 | -0.1888** | 0.0301 | 0.0211 | -0.1510* | 0.0228 | 0.0129 | -0.1524* | 0.0255 | -0.0161 | -0.0918 | 0.0089 | 8.6019** |
| 9. Unemployment Rate | 0.0774 | 0.0762 | 0.0037 | 0.0999 | 0.0718 | 0.0045 | 0.0689 | 0.0491 | 0.0025 | 0.0617 | 0.0630 | 0.0047 | 0.0331 | 0.0412 | 0.0019 | 0.7980 |
| 10. Hourly Earnings | 0.1314 | -0.1596 | 0.0149 | 0.1201 | -0.1821* | 0.0277 | 0.0738 | -0.1188 | 0.0140 | 0.0598 | -0.1531* | 0.0258 | 0.0291 | -0.1578* | 0.0250 | 0.0010 |
| 11. Manufacturing Payrolls | 0.3381 | 0.1443 | 0.0078 | 0.2090 | 0.0173 | 0.0002 | 0.2082 | 0.1175 | 0.0098 | 0.1173 | 0.0166 | 0.0002 | 0.0714 | -0.0072 | 0.0000 | 1.6564 |
| 12. Average Weekly Hours | 0.3183 | 0.1667 | 0.0110 | 0.2924 | 0.1030 | 0.0068 | 0.2315 | 0.1633 | 0.0207 | 0.1666 | 0.1263 | 0.0141 | 0.1720 | 0.1428 | 0.0146 | 0.0436 |
| 13. Retail Sales | 0.0755 | -0.0921 | 0.0068 | 0.0580 | -0.0609 | 0.0036 | 0.0497 | -0.0609 | 0.0043 | 0.0690 | -0.0550 | 0.0038 | 0.0730 | -0.0366 | 0.0014 | 2.5008 |
| 14. Retail Sales ex Motor Vehicles | 0.1126 | -0.0758 | 0.0036 | 0.0837 | -0.0083 | 0.0001 | 0.0522 | -0.0351 | 0.0011 | 0.0671 | -0.0098 | 0.0001 | 0.0807 | -0.0258 | 0.0005 | 0.9518 |
| 15. Industrial Production | 0.0407 | 0.1039 | 0.0083 | 0.0450 | 0.0945 | 0.0084 | 0.0437 | 0.0521 | 0.0032 | 0.0565 | 0.0484 | 0.0029 | 0.0517 | 0.0910 | 0.0090 | 0.1232 |
| 16. Capacity Utilization Rate | 0.0443 | 0.1557 | 0.0170 | 0.0547 | 0.1169 | 0.0122 | 0.0378 | 0.0646 | 0.0046 | 0.0497 | 0.0722 | 0.0062 | 0.0365 | 0.1114 | 0.0118 | 0.8393 |
| 17. Personal Income | 0.1067 | -0.0373 | 0.0011 | 0.1149 | -0.0536 | 0.0027 | 0.1407* | -0.0321 | 0.0011 | 0.1334* | -0.0339 | 0.0015 | 0.1389* | -0.0456 | 0.0024 | 0.0447 |
| 18. Consumer Credit | 0.0432 | 0.1014 | 0.0098 | 0.0109 | 0.0987 | 0.0130 | -0.0164 | 0.1103 | 0.0176 | -0.0240 | 0.0917 | 0.0148 | -0.0194 | 0.0830 | 0.0096 | 0.1664 |

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Table 3.9, Continued

| Announcement | Growth $\beta_0$ | Growth $\beta_1$ | Growth $R^2$ | 2nd Qnt $\beta_0$ | 2nd Qnt $\beta_1$ | 2nd Qnt $R^2$ | 3rd Qnt $\beta_0$ | 3rd Qnt $\beta_1$ | 3rd Qnt $R^2$ | 4th Qnt $\beta_0$ | 4th Qnt $\beta_1$ | 4th Qnt $R^2$ | Value $\beta_0$ | Value $\beta_1$ | Value $R^2$ | Wald Test |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Consumption** | | | | | | | | | | | | | | | | |
| 19. Existing Home Sales | 0.0568 | 0.0053 | 0.0000 | 0.1151 | -0.0091 | 0.0001 | 0.0840 | -0.0484 | 0.0019 | 0.1022 | -0.0871 | 0.0074 | 0.0509 | 0.0445 | 0.0017 | 0.2225 |
| 20. New Home Sales | 0.0585 | -0.0142 | 0.0001 | 0.1160 | -0.0796 | 0.0073 | 0.1424* | -0.0494 | 0.0032 | 0.1510** | -0.1025 | 0.0156 | 0.1449* | -0.0839 | 0.0097 | 1.9431 |
| 21. PCE | 0.1005 | 0.0338 | 0.0008 | 0.1277 | 0.0108 | 0.0001 | 0.1608* | 0.0067 | 0.0000 | 0.1614** | 0.0056 | 0.0000 | 0.1531* | 0.0173 | 0.0003 | 0.1397 |
| **Investment** | | | | | | | | | | | | | | | | |
| 22. New Orders: Adv. Durables | 0.1169* | -0.0426 | 0.0019 | 0.1272** | -0.0550 | 0.0044 | 0.1003* | -0.0363 | 0.0020 | 0.1178** | -0.0304 | 0.0017 | 0.1297** | 0.0063 | 0.0001 | 1.7007 |
| 23. Construction Spending | 0.3054** | -0.0706 | 0.0033 | 0.3039** | -0.0494 | 0.0025 | 0.2748** | -0.1017 | 0.0129 | 0.2594** | -0.0492 | 0.0038 | 0.2946** | -0.0398 | 0.0021 | 0.3181 |
| 24. New Orders | 0.1150 | -0.0595 | 0.0030 | 0.1064 | -0.0195 | 0.0005 | 0.0975 | -0.0066 | 0.0001 | 0.0826 | 0.0128 | 0.0003 | 0.0514 | -0.0074 | 0.0001 | 1.1124 |
| 25. Business Inventories | 0.0097 | -0.0220 | 0.0003 | 0.0265 | -0.0071 | 0.0000 | 0.0259 | -0.0379 | 0.0012 | 0.0416 | -0.0251 | 0.0006 | 0.0598 | -0.0573 | 0.0025 | 0.4931 |
| **Government Purchases** | | | | | | | | | | | | | | | | |
| 26. Government Surplus/Deficit | -0.1386 | 0.0578 | 0.0026 | -0.1362* | 0.0545 | 0.0035 | -0.1301* | 0.0600 | 0.0055 | -0.0917 | 0.0714 | 0.0081 | -0.1028 | 0.1118 | 0.0177 | 1.0526 |
| **Net Exports** | | | | | | | | | | | | | | | | |
| 27. Trade Balance | -0.0173 | 0.1361* | 0.0143 | -0.0237 | 0.1287* | 0.0178 | -0.0233 | 0.0999* | 0.0135 | -0.0283 | 0.1238** | 0.0232 | -0.0573 | 0.1229** | 0.0228 | 0.1003 |
| 28. Exports | -0.0709 | 0.1221 | 0.0107 | -0.0748 | 0.0880 | 0.0083 | -0.0542 | 0.0607 | 0.0050 | -0.0608 | 0.0771 | 0.0092 | -0.1171* | 0.0609 | 0.0055 | 1.2751 |
| 29. Imports | -0.0578 | -0.0401 | 0.0012 | -0.0614 | -0.0555 | 0.0033 | -0.0475 | -0.0360 | 0.0018 | -0.0570 | -0.0200 | 0.0006 | -0.1160* | -0.0237 | 0.0008 | 0.0921 |
| **Prices** | | | | | | | | | | | | | | | | |
| 30. Import Price Index | -0.0806 | -0.0262 | 0.0003 | -0.0468 | 0.0101 | 0.0001 | 0.0361 | 0.0135 | 0.0001 | 0.0184 | 0.0246 | 0.0004 | -0.0259 | -0.0047 | 0.0000 | 0.0381 |
| 31. Export Price Index | -0.0809 | -0.1659 | 0.0122 | -0.0510 | -0.1792 | 0.0181 | 0.0316 | -0.1780 | 0.0198 | 0.0143 | -0.0939 | 0.0056 | -0.0277 | -0.1329 | 0.0085 | 0.0895 |
| 32. Producer Price Index | 0.0724 | -0.1284 | 0.0119 | 0.0370 | -0.1242 | 0.0125 | 0.0354 | -0.0925 | 0.0083 | 0.0600 | -0.0918 | 0.0096 | 0.0455 | -0.1217* | 0.0147 | 0.0373 |
| 33. Core PPI | 0.1001 | -0.1176 | 0.0087 | 0.0693 | -0.1108 | 0.0088 | 0.0596 | -0.1025 | 0.0089 | 0.0775 | -0.0893 | 0.0087 | 0.0478 | -0.0953 | 0.0077 | 0.2172 |
| 34. Consumer Price Index | 0.0474 | -0.1925** | 0.0303 | 0.0751 | -0.1633** | 0.0304 | 0.0555 | -0.1421** | 0.0288 | 0.0544 | -0.1500** | 0.0346 | 0.0790 | -0.1444** | 0.0292 | 1.7549 |

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Table 3.9, Continued

| Announcement | Growth $\beta_0$ | Growth $\beta_1$ | Growth $R^2$ | 2nd Qnt $\beta_0$ | 2nd Qnt $\beta_1$ | 2nd Qnt $R^2$ | 3rd Qnt $\beta_0$ | 3rd Qnt $\beta_1$ | 3rd Qnt $R^2$ | 4th Qnt $\beta_0$ | 4th Qnt $\beta_1$ | 4th Qnt $R^2$ | Value $\beta_0$ | Value $\beta_1$ | Value $R^2$ | Wald Test |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 35. Core CPI | 0.0427 | -0.3527** | 0.0864 | 0.0522 | -0.2802** | 0.0792 | 0.0367 | -0.2655** | 0.0920 | 0.0580 | -0.2297** | 0.0736 | 0.0959 | -0.2515** | 0.0776 | 3.8872* |
| **Forward-looking** | | | | | | | | | | | | | | | | |
| 36. Phil Fed Bus. Cond. Index | 0.1882 | -0.1736 | 0.0162 | 0.0629 | 0.0506 | 0.0017 | 0.1242 | 0.0321 | 0.0008 | 0.0861 | -0.0127 | 0.0002 | 0.1125 | 0.0529 | 0.0020 | 4.8235* |
| 37. Consumer Confidence | 0.1673 | 0.0938 | 0.0065 | 0.1766* | 0.0699 | 0.0059 | 0.1595* | 0.0385 | 0.0023 | 0.1754** | 0.0305 | 0.0017 | 0.1334* | 0.0255 | 0.0009 | 1.2000 |
| 38. Chicago PMI | 0.1174 | -0.0337 | 0.0010 | 0.2632* | -0.0237 | 0.0006 | 0.2729** | -0.0626 | 0.0059 | 0.3232** | -0.0194 | 0.0006 | 0.3700** | 0.0977 | 0.0131 | 1.6057 |
| 39. ISM: Manuf. Index | 0.2587** | 0.0586 | 0.0023 | 0.2542** | 0.0018 | 0.0000 | 0.2345** | -0.0067 | 0.0001 | 0.2432** | 0.0173 | 0.0004 | 0.2686** | 0.0534 | 0.0032 | 0.0101 |
| 40. Housing Starts | 0.0929 | 0.0801 | 0.0049 | 0.0429 | 0.1133* | 0.0137 | 0.0574 | 0.0890 | 0.0101 | 0.0725 | 0.0880 | 0.0099 | 0.0601 | 0.1092* | 0.0142 | 0.5089 |
| 41. Composite Index of LI | 0.1715** | 0.0217 | 0.0004 | 0.1486** | 0.0176 | 0.0004 | 0.1475** | 0.0130 | 0.0002 | 0.1715** | 0.0360 | 0.0022 | 0.1738** | 0.0388 | 0.0021 | 0.2126 |
| **Weekly Announcements** | | | | | | | | | | | | | | | | |
| 42. Initial Claims | 0.0338 | 0.0000 | 0.0000 | 0.0213 | -0.0145 | 0.0002 | 0.0211 | -0.0071 | 0.0001 | 0.0255 | 0.0108 | 0.0002 | 0.0148 | -0.0422 | 0.0020 | 2.2845 |

Notes: $\beta_0$ and $\beta_1$ are the coefficient estimates of the regression model in Equation 3.2. The Wald Test is the Wald statistic testing the equality of $\beta_1$ for the portfolio of growth firms and $\beta_1$ for the portfolio of value firms.

Although the empirical results for the five size sorted portfolios in the previous were somewhat anticipated from our empirical results on aggregate portfolios, the same is not true for the portfolios formed on BM ratio. All five BM ratio sorted portfolios react significantly to news about *Trade Balance of Goods and Services*, *CPI* and *Core CPI*. In addition to these three variables, firms with low BM ratio (growth) firms react significantly to news about Employees on Nonfarm Payrolls, whereas value firms react significantly to news about Hourly Earnings, Producer Price Index and Housing Starts. The reaction of growth (1$^{st}$ quintile) firms is stronger (i.e. greater in absolute value) than the reaction of value firms (5$^{th}$ quintile) to news about 30 of the 42 different macroeconomic variables. More importantly, for those variables that either growth or value firms react significantly to, the reaction of growth firms is stronger than that of value firms and the strength of the reaction decreases almost monotonically with respect to BM ratio. However, the difference between reactions of growth and value firms is significantly different from each other for only news about Employees Nonfarm Payrolls, Core CPI and Federal Reserve Bank of Philadelphia Current Business Condition Diffusion Index.

### 3.3.5 Robustness Checks

In this section, we discuss whether our empirical results in the previous section are due to outliers, lower liquidity of small and growth firms or the number of test portfolios used.

First, to test whether our empirical results are robust to different number of test portfolios, we use three and ten size sorted and book-to-market sorted and 25 equal-weighted and value-weighted size and BM sorted portfolios. We initially estimate the empirical specification in Equation (3.2) as a system for the 25 equal-weighted and value-weighted size and BM sorted portfolios.

Although, not presented here, our empirical results on the effect of news about macroeconomic variables on the 25 equal-weighted and value-weighted size and BM sorted portfolios are similar to our empirical results in the previous section. The news about macroeconomic variables that small, large, growth and value firms react significantly to are the same as in the previous section. Furthermore, the magnitude of reaction for large and growth firms is greater than that of small and value firms as in the previous section. Although not presented here, our results remain unchanged when we use three or ten size sorted and book-to-market sorted portfolios.

It is well known that small firms have less market liquidity than large firms. The lower market liquidity for small firms may result in smaller and insignificant news effects on announcement days, producing a more gradual adjustment to new information released by the announcement. Hence, smaller coefficient estimates for small firms in the previous section might be due to this gradual adjustment. If the reaction of small firms to news is gradual, we also should expect to observe a significant reaction after the announcement. In order to analyze whether there is any significant reaction to news after the announcement day, we run a regression of the following form:

$$r_{it+s} = \beta_{0,ij} + \beta_{1,ij} S_{j,t} + \varepsilon_{ij,t+s}, \quad s > 0 \tag{3.3}$$

The empirical specification is estimated for each macroeconomic variable separately using data only on announcement days for that macroeconomic variable. Table 3.10 presents empirical results from the estimation of the specification for $s = 1$.

Table 3.10: The Delayed Effect of Macroeconomic News on the Portfolios

| | Aggregate Portfolio | | 5 Portfolios Formed on Size | | | | | 5 Portfolios Formed on Book-to-Market Ratio | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Announcement | EW | VW | Small | $2^{nd}$ Quintile | $3^{rd}$ Quintile | $4^{th}$ Quintile | Large | Growth | $2^{nd}$ Quintile | $3^{rd}$ Quintile | $4^{th}$ Quintile | Value |
| **Quarterly Announcements** | | | | | | | | | | | | |
| 1. Real GDP: Advance | 0.1156 | 0.2217 | 0.0883 | 0.0903 | 0.1519 | 0.2113 | 0.2344 | 0.2429 | 0.2092 | 0.1279 | 0.1163 | 0.0812 |
| 2. GDP Chain Price Index: Advance | 0.0878 | 0.1321 | 0.0225 | 0.1302 | 0.1415 | 0.2171 | 0.1236 | 0.1071 | 0.1817 | 0.1134 | 0.0655 | 0.1446 |
| 3. Real GDP: Preliminary | -0.1110 | -0.1701 | -0.1477 | -0.2166 | -0.2035 | -0.1738 | -0.1653 | -0.2025 | -0.1768 | -0.1589 | -0.1044 | -0.1142 |
| 4. GDP Chain Price Index: Preliminary | 0.0771 | 0.0754 | 0.0592 | 0.1299 | 0.1429 | 0.0767 | 0.0620 | 0.0957 | 0.0382 | 0.0484 | -0.0358 | 0.0299 |
| 5. Real GDP: Final | 0.1333 | 0.0511 | 0.2532** | 0.1981 | 0.1376 | 0.1361 | -0.0018 | 0.0307 | 0.0477 | 0.0515 | 0.1156 | 0.1357 |
| 6. GDP Chain Price Index: Final | -0.0329 | -0.0244 | 0.0097 | 0.0348 | -0.0204 | -0.0630 | -0.0281 | -0.0477 | -0.0129 | -0.0524 | -0.0182 | 0.0365 |
| **Monthly Announcements** | | | | | | | | | | | | |
| **Real Activity** | | | | | | | | | | | | |
| 7. Domestic Light Truck Sales | 0.0240 | 0.1198 | 0.0766 | 0.0862 | 0.0954 | 0.1220 | 0.1391 | 0.1125 | 0.2064* | 0.1839* | 0.1633* | 0.2321* |
| 8. Employees on Nonfarm Payrolls | 0.0518 | 0.0880 | 0.0609 | 0.1133 | 0.0998 | 0.0676 | 0.0961 | 0.1154 | 0.1020 | 0.0641 | 0.0792 | 0.0881 |
| 9. Unemployment Rate | 0.0400 | 0.0023 | 0.0408 | 0.0152 | 0.0047 | 0.0178 | -0.0115 | 0.0141 | -0.0163 | -0.0026 | 0.0041 | 0.0199 |
| 10. Hourly Earnings | -0.0905 | -0.1248 | -0.0874 | -0.1191 | -0.1221 | -0.1290 | -0.1219 | -0.1499 | -0.1250 | -0.0639 | -0.1203* | -0.1233 |
| 11. Manufacturing Payrolls | 0.1116 | 0.1274 | 0.1069 | 0.1538 | 0.1202 | 0.1447 | 0.1137 | 0.1143 | 0.1259 | 0.0924 | 0.0365 | 0.0581 |
| 12. Average Weekly Hours | 0.1170 | 0.1867 | 0.1129 | 0.1923 | 0.2259 | 0.1966 | 0.1863 | 0.1801 | 0.2232 | 0.2058 | 0.1632 | 0.1881 |
| 13. Retail Sales | -0.0453 | -0.0255 | -0.0480 | -0.0640 | -0.0616 | -0.0516 | -0.0082 | -0.0149 | -0.0219 | -0.0488 | -0.0196 | 0.0181 |
| 14. Retail Sales ex Motor Vehicles | -0.1152 | -0.0575 | -0.1513* | -0.1292 | -0.0894 | -0.0961 | -0.0272 | -0.0160 | -0.0302 | -0.0677 | -0.0629 | -0.0326 |
| 15. Industrial Production | 0.0561 | 0.0497 | 0.0501 | 0.0906 | 0.0734 | 0.0794 | 0.0517 | 0.0991 | 0.0096 | 0.0205 | 0.0221 | 0.0054 |
| 16. Capacity Utilization Rate | 0.0317 | 0.0253 | 0.0280 | 0.0647 | 0.0482 | 0.0515 | 0.0134 | 0.0636 | 0.0042 | -0.0325 | -0.0176 | -0.0079 |
| 17. Personal Income | 0.0677 | 0.0848 | 0.0739 | 0.0727 | 0.0769 | 0.0596 | 0.1040 | 0.0870 | 0.0996 | 0.1002 | 0.0846 | 0.0889 |
| 18. Consumer Credit | 0.0739 | 0.0662 | 0.0779 | 0.0410 | 0.0678 | 0.0778 | 0.0542 | 0.0859 | 0.0009 | 0.0127 | 0.0034 | -0.0134 |

Continued on next page

Table 3.10, Continued

| | Aggregate Portfolio | | 5 Portfolios Formed on Size | | | | | 5 Portfolios Formed on Book-to-Market Ratio | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Announcement | EW | VW | Small | 2nd Quintile | 3rd Quintile | 4th Quintile | Large | Growth | 2nd Quintile | 3rd Quintile | 4th Quintile | Value |
| **Consumption** | | | | | | | | | | | | |
| 19. Existing Home Sales | -0.0459 | -0.0709 | -0.0867 | -0.0298 | -0.0385 | -0.0446 | -0.0925 | -0.0435 | -0.1624 | -0.1337 | -0.0775 | -0.2299** |
| 20. New Home Sales | -0.0184 | -0.0412 | 0.0040 | -0.0090 | -0.0583 | -0.0551 | -0.0321 | -0.0515 | 0.0161 | -0.0071 | 0.0045 | -0.0423 |
| 21. PCE | 0.0369 | 0.0135 | 0.0348 | 0.0460 | 0.0449 | 0.0022 | 0.0068 | 0.0374 | -0.0099 | 0.0027 | -0.0014 | 0.0026 |
| **Investment** | | | | | | | | | | | | |
| 22. New Orders: Advance Durable Goods | -0.0971* | -0.1543** | -0.1113* | -0.1387** | -0.1414** | -0.1403** | -0.1482** | -0.1545* | -0.1521** | -0.1281* | -0.0751 | -0.0793 |
| 23. Construction Spending | -0.0053 | -0.0065 | -0.0172 | 0.0128 | 0.0530 | 0.0116 | -0.0099 | -0.0169 | -0.0057 | 0.0322 | 0.0188 | 0.0388 |
| 24. New Orders | -0.0298 | -0.0312 | -0.0298 | -0.0248 | -0.0061 | -0.0246 | -0.0320 | -0.0219 | -0.0317 | -0.0215 | -0.0124 | 0.0052 |
| 25. Business Inventories | -0.0265 | -0.0729 | -0.0106 | -0.0686 | -0.0703 | -0.0281 | -0.0855 | -0.1109 | -0.0547 | -0.0380 | -0.0143 | -0.0350 |
| **Government Purchases** | | | | | | | | | | | | |
| 26. Government Surplus/Deficit | 0.0121 | -0.0125 | 0.0301 | 0.0342 | 0.0310 | 0.0086 | -0.0206 | -0.0119 | -0.0233 | -0.0244 | 0.0103 | -0.0057 |
| **Net Exports** | | | | | | | | | | | | |
| 27. Trade Balance: Goods & Services [BOP] | -0.0592 | -0.0567 | -0.1047* | -0.0961 | -0.0912 | -0.0856 | -0.0474 | -0.0626 | -0.0614 | -0.0738 | -0.1146* | -0.0884 |
| 28. Exports: Goods & Services [BOP] | 0.0145 | -0.0118 | -0.0426 | -0.0215 | -0.0179 | -0.0292 | -0.0138 | -0.0151 | -0.0097 | -0.0397 | -0.0840 | -0.0488 |
| 29. Imports: Goods & Services [BOP] | 0.0194 | 0.0151 | 0.0320 | 0.0309 | 0.0243 | 0.0192 | 0.0111 | 0.0062 | 0.0256 | 0.0177 | 0.0378 | 0.0445 |
| **Prices** | | | | | | | | | | | | |
| 30. Import Price Index | 0.1735 | 0.3357* | 0.1294 | 0.3191* | 0.3227* | 0.3554* | 0.3599* | 0.3740* | 0.3369* | 0.3193** | 0.2348* | 0.2447* |
| 31. Export Price Index | 0.1426 | 0.2756 | 0.0766 | 0.2124 | 0.2403 | 0.2428 | 0.2916 | 0.2745 | 0.2624 | 0.2725* | 0.2809* | 0.2580* |
| 32. Producer Price Index | -0.0682 | -0.0955 | -0.0615 | -0.0488 | -0.0697 | -0.0819 | -0.1004 | -0.1133 | -0.0926 | -0.0759 | -0.0650 | -0.0538 |
| 33. Core PPI | -0.0682 | -0.1177 | -0.0477 | -0.0655 | -0.1104 | -0.1280 | -0.1149 | -0.1276 | -0.1020 | -0.0797 | -0.0887 | -0.1169 |
| 34. Consumer Price Index | -0.0202 | 0.0186 | -0.0274 | -0.0203 | -0.0099 | -0.0169 | 0.0325 | 0.0364 | 0.0052 | 0.0100 | -0.0314 | -0.0039 |

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Table 3.10, Continued

| | Aggregate Portfolio | | 5 Portfolios Formed on Size | | | | | 5 Portfolios Formed on Book-to-Market Ratio | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Announcement | EW | VW | Small | $2^{nd}$ Quintile | $3^{rd}$ Quintile | $4^{th}$ Quintile | Large | Growth | $2^{nd}$ Quintile | $3^{rd}$ Quintile | $4^{th}$ Quintile | Value |
| 35. Core CPI | 0.0368 | 0.1047 | 0.0607 | 0.0889 | 0.0990 | 0.0695 | 0.1151 | 0.1271 | 0.0707 | 0.0922 | 0.0575 | 0.0605 |
| **Forward-looking** | | | | | | | | | | | | |
| 36. Phil Fed Current Bus. Cond. Diff. Index | -0.0754 | -0.1382 | -0.0482 | -0.0819 | -0.0991 | -0.1121 | -0.1423 | -0.1744 | -0.0824 | -0.1538 | -0.0277 | 0.0157 |
| 37. Consumer Confidence | 0.0191 | -0.0722 | 0.0415 | 0.0103 | -0.0396 | -0.0374 | -0.0948 | -0.1215 | -0.0419 | -0.0148 | -0.0406 | 0.0041 |
| 38. Chicago Purchasing Managers Index | -0.1160 | -0.0372 | -0.1309 | -0.1803 | -0.1581 | -0.1392 | -0.0098 | -0.0230 | -0.0343 | -0.0450 | -0.0629 | -0.0156 |
| 39. ISM: Manufacturing Composite Index | -0.0359 | -0.0273 | 0.0137 | 0.0097 | -0.0225 | -0.0214 | -0.0321 | -0.0550 | -0.0098 | 0.0017 | 0.0275 | 0.0318 |
| 40. Housing Starts | 0.0610 | 0.0856 | 0.0812 | 0.0997 | 0.0989 | 0.0876 | 0.0879 | 0.1214 | 0.0561 | 0.0672 | 0.0726 | 0.0813 |
| 41. Composite Index of Leading Indicators | 0.0091 | 0.0115 | 0.0077 | 0.0207 | 0.0047 | -0.0139 | 0.0116 | -0.0083 | -0.0093 | 0.0140 | 0.0379 | 0.0590 |
| **Weekly Announcements** | | | | | | | | | | | | |
| 42. Initial Claims | -0.0126 | 0.0008 | -0.0221 | -0.0168 | -0.0089 | 0.0057 | 0.0054 | 0.0028 | -0.0012 | 0.0107 | -0.0013 | -0.0045 |

Notes: This table presents the coefficient estimates of $\beta_1$ of the regression model in Equation 3.3. EW and VW denote the equal-weighted aggregate portfolio and the value-weighted aggregate portfolio, respectively.

Both the equal-weighted and the value-weighted aggregate portfolios react significantly to news about New Orders for Advance Durable Goods with a one day delay whereas the value-weighted aggregate portfolio also reacts significantly to news about Import Price Index with a one day delay. The delayed reaction to news about New Orders for Advance Durable Goods might be due to the fact that the data on orders for durable goods are extremely volatile and is subject to frequent revisions following its release. It might take some time for the market to analyze and understand the actual content of the announcement, hence the delayed reaction. Larger than expected monthly increase of increasing trend is generally considered inflationary, hence the negative reaction. The positive significant (delayed) reaction of the value-weighted aggregate portfolio to news about Import Price Index might be a correction to its initial negative reaction. Import Price Index is the first released announcement in the price indexes group, hence, it reveals preliminary information about the future inflation and is correlated with other announcements about prices. However, the market might initially react to news about Import Price Index and correct it one day after the announcement. More importantly, neither the equal-weighted or the value-weighted portfolios react significantly with a one day delay to news which they initially reacted significantly. Furthermore, small firms react significantly to news about Final Release for Real GDP, Retails Sales ex Motor Vehicles in addition to news about New Orders for Advance Durable Goods and Trade Balance with a one day delay, whereas large firms react significantly to news about New Orders for Advance Durable Goods and Import Price Index with a one day delay. As expected, small firms react significantly to more news with a one day delay possibly due to less market liquidity. This confirms our empirical finding that small firms are sensitive to more news than large firms. The delayed reaction is generally the opposite sign of the initial reaction suggesting that the market generally overreacts to those announcements initially and corrects itself after one day. Furthermore, small firms do not react significantly with a delay to news that they initially reacted significantly suggesting that our empirical finding on the difference in the magnitude of reaction between small and large firms is not due to a delayed reaction by small firms. Both growth and value firms react significantly to news about New Orders for Advance Durable Goods and Import Price Index with a one day delay like the value-weighted aggregate portfolio, whereas value firms additionally react significantly to news about Domestic Light Truck Sales, Existing Home Sales and Export Price Index with a one day lag. Neither growth nor value firms react significantly with a delay to news which they initially reacted suggesting that the stronger reaction of growth firms cannot be due to lower liquidity. We also estimate the empirical specification in Equation (3.3) for $s = 2, 3$. None of the portfolios considered reacts significantly to news two or three days after the announcement.

Finally, to test whether our empirical results in the previous section are due to outliers in our data set, we run a regression of the following form:

$$r_{it} = \beta_{0,ij} + \beta_{1,ij} S_{j,t} + \beta_{2,ij} S_{j,t}^2 + \varepsilon_{ij,t} \tag{3.4}$$

The empirical specification is estimated for each macroeconomic variable separately using data only on announcement days for that macroeconomic variable. We include the squared term ($S_{j,t}^2$) to our original empirical specification to analyze whether the news have an additional effect on announcement-day returns. If the coefficient estimates on the square term ($\hat{\beta}_{2,ij}$) are not statistically significant, then we can easily conclude that our empirical results in the previous section are not due to outliers in our data set. Table 3.11 reports the coefficient estimates for the parameters, $\beta_{2,ij}$:

Table 3.11: The Effect of Squared Macroeconomic News on the Portfolios

| | Aggregate Portfolio | | 5 Portfolios Formed on Size | | | | | 5 Portfolios Formed on Book-to-Market Ratio | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Announcement | EW | VW | Small | 2nd Quintile | 3rd Quintile | 4th Quintile | Large | Growth | 2nd Quintile | 3rd Quintile | 4th Quintile | Value |
| **Quarterly Announcements** | | | | | | | | | | | | |
| 1. Real GDP: Advance | -0.1650 | -0.1503 | -0.2042* | -0.2676* | -0.2226 | -0.1847 | -0.1307 | -0.1635 | -0.0664 | -0.1756 | -0.0937 | -0.1756 |
| 2. GDP Chain Price Index: Advance | 0.0243 | 0.0060 | 0.0237 | 0.0921 | 0.0861 | 0.0339 | -0.0039 | 0.0276 | -0.0646 | 0.0062 | -0.0129 | -0.0764 |
| 3. Real GDP: Preliminary | -0.0230 | -0.0735 | -0.0053 | -0.0658 | -0.0779* | -0.0885* | -0.0787 | -0.0975* | -0.0794 | -0.0522 | -0.0755* | -0.0502 |
| 4. GDP Chain Price Index: Preliminary | 0.0734 | 0.0917 | 0.0702 | 0.0582 | 0.0629 | 0.0785 | 0.0947 | 0.1072 | 0.1065 | 0.0923 | 0.0770 | 0.0462 |
| 5. Real GDP: Final | -0.0075 | 0.1096 | -0.0223 | 0.0059 | 0.0539 | 0.0677 | 0.1469 | 0.1609 | 0.1534 | 0.0789 | 0.0327 | 0.0764 |
| 6. GDP Chain Price Index: Final | 0.0783 | 0.2254* | 0.1126 | 0.1901 | 0.2430** | 0.1503 | 0.2501** | 0.2591* | 0.2283* | 0.2313** | 0.2114** | 0.1066 |
| **Quarterly Announcements** | | | | | | | | | | | | |
| **Real Activity** | | | | | | | | | | | | |
| 7. Domestic Light Truck Sales | 0.0533 | 0.0782 | 0.0424 | 0.0674 | 0.0745 | 0.0690 | 0.0749 | 0.0842 | 0.0660 | 0.0535 | 0.0487 | 0.0401 |
| 8. Employees on Nonfarm Payrolls | -0.0473 | -0.0677 | -0.0601 | -0.0545 | -0.0538 | -0.0727 | -0.0732 | -0.0666 | -0.0812 | -0.0726 | -0.0666 | -0.0678 |
| 9. Unemployment Rate | 0.0191 | 0.0210 | 0.0265 | 0.0234 | 0.0156 | 0.0148 | 0.0234 | 0.0220 | 0.0318 | 0.0262 | 0.0201 | 0.0170 |
| 10. Hourly Earnings | -0.0634 | -0.1234 | -0.0847 | -0.0822 | -0.1019 | -0.1103 | -0.1281 | -0.1490 | -0.0953 | -0.0908 | -0.0850 | -0.0827 |
| 11. Manufacturing Payrolls | -0.0865 | -0.1887 | -0.0885 | -0.1251 | -0.1141 | -0.1678 | -0.1882 | -0.2059 | -0.1465 | -0.1011 | -0.0453 | -0.1501 |
| 12. Average Weekly Hours | -0.0711 | -0.0992 | -0.0755 | -0.1327 | -0.1460 | -0.1514 | -0.0846 | -0.0869 | -0.0808 | -0.1077 | -0.1212 | -0.1395 |
| 13. Retail Sales | 0.0126 | 0.0121 | 0.0114 | 0.0254 | 0.0121 | 0.0107 | 0.0153 | 0.0171 | 0.0111 | 0.0146 | 0.0119 | 0.0217 |
| 14. Retail Sales ex Motor Vehicles | -0.0097 | -0.0054 | -0.0105 | 0.0100 | -0.0005 | 0.0061 | -0.0063 | -0.0060 | 0.0073 | 0.0070 | 0.0062 | -0.0028 |
| 15. Industrial Production | 0.0013 | -0.0287 | 0.0078 | -0.0001 | -0.0025 | -0.0099 | -0.0300 | -0.0307 | -0.0262 | -0.0116 | -0.0221 | -0.0316 |
| 16. Capacity Utilization Rate | -0.0100 | -0.0269 | -0.0134 | 0.0027 | -0.0037 | -0.0217 | -0.0316 | -0.0149 | -0.0218 | -0.0239 | -0.0412 | -0.0614 |
| 17. Personal Income | -0.0032 | -0.0027 | -0.0023 | -0.0008 | -0.0002 | -0.0023 | -0.0033 | -0.0005 | 0.0001 | -0.0044 | -0.0059 | -0.0072 |
| 18. Consumer Credit | -0.0262 | -0.0261 | -0.0358 | -0.0307 | -0.0307 | -0.0323 | -0.0250 | -0.0335 | -0.0150 | -0.0208 | -0.0155 | -0.0005 |

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Table 3.11, Continued

| | Aggregate Portfolio | | 5 Portfolios Formed on Size | | | | | 5 Portfolios Formed on Book-to-Market Ratio | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Announcement | EW | VW | Small | 2nd Quintile | 3rd Quintile | 4th Quintile | Large | Growth | 2nd Quintile | 3rd Quintile | 4th Quintile | Value |
| **Consumption** | | | | | | | | | | | | |
| 19. Existing Home Sales | -0.0015 | 0.0136 | -0.0046 | -0.0126 | 0.0310 | -0.0059 | 0.0183 | -0.0014 | 0.0431 | 0.0482 | 0.0216 | 0.0114 |
| 20. New Home Sales | 0.0210 | 0.0360 | 0.0186 | 0.0282 | 0.0333 | 0.0396 | 0.0343 | 0.0476 | 0.0218 | 0.0151 | 0.0112 | 0.0189 |
| 21. PCE | -0.0184 | 0.0138 | -0.0247 | -0.0068 | 0.0007 | 0.0048 | 0.0229 | 0.0200 | 0.0074 | 0.0087 | 0.0247 | 0.0026 |
| **Investment** | | | | | | | | | | | | |
| 22. New Orders: Advance Durable Goods | -0.0160 | -0.0143 | -0.0100 | -0.0121 | -0.0188 | -0.0305 | -0.0053 | -0.0137 | -0.0082 | 0.0186 | 0.0115 | -0.0004 |
| 23. Construction Spending | -0.0457 | -0.0799 | -0.0220 | -0.0499 | -0.0696 | -0.0545 | -0.0813 | -0.0995 | -0.0562 | -0.0295 | -0.0266 | -0.0488 |
| 24. New Orders | 0.0089 | 0.0090 | 0.0081 | 0.0123 | 0.0133 | 0.0133 | 0.0055 | 0.0112 | 0.0076 | 0.0065 | -0.0052 | 0.0013 |
| 25. Business Inventories | 0.0239 | 0.0183 | 0.0313 | 0.0178 | 0.0224 | 0.0233 | 0.0101 | 0.0106 | -0.0014 | 0.0018 | 0.0244 | 0.0048 |
| **Government Purchases** | | | | | | | | | | | | |
| 26. Government Surplus/Deficit | 0.0029 | 0.0008 | 0.0067 | 0.0071 | 0.0065 | 0.0031 | 0.0005 | 0.0014 | 0.0014 | 0.0009 | 0.0043 | 0.0035 |
| **Net Exports** | | | | | | | | | | | | |
| 27. Trade Balance: Goods & Services [BOP] | 0.0402 | 0.0458 | 0.0277 | 0.0206 | 0.0305 | 0.0385 | 0.0414 | 0.0488 | 0.0274 | 0.0243 | 0.0224 | 0.0076 |
| 28. Exports: Goods & Services [BOP] | -0.0234 | 0.0134 | -0.0167 | -0.0264 | -0.0104 | -0.0114 | 0.0230 | 0.0209 | 0.0138 | 0.0113 | 0.0126 | 0.0124 |
| 29. Imports: Goods & Services [BOP] | -0.0171 | -0.0116 | -0.0232 | -0.0338 | -0.0234 | -0.0172 | -0.0105 | -0.0104 | -0.0102 | -0.0183 | -0.0050 | -0.0251 |
| **Prices** | | | | | | | | | | | | |
| 30. Import Price Index | 0.0062 | 0.0053 | -0.0340 | -0.0716 | -0.0323 | -0.0535 | 0.0388 | 0.0057 | 0.0430 | 0.0379 | 0.0619 | 0.0568 |
| 31. Export Price Index | -0.0502 | -0.0504 | -0.0449 | -0.0397 | -0.0339 | -0.0567 | -0.0568 | -0.0602 | -0.0549 | -0.0634 | -0.0454 | -0.0128 |
| 32. Producer Price Index | -0.0104 | -0.0168 | -0.0142 | -0.0272 | -0.0165 | -0.0042 | -0.0161 | -0.0189 | -0.0150 | -0.0063 | 0.0134 | -0.0116 |
| 33. Core PPI | -0.0223 | -0.0343 | -0.0217 | -0.0279 | -0.0290 | -0.0230 | -0.0328 | -0.0375 | -0.0234 | -0.0219 | -0.0061 | -0.0302 |
| 34. Consumer Price Index | -0.0316 | -0.0178 | -0.0281 | -0.0218 | -0.0316 | -0.0272 | -0.0042 | -0.0081 | -0.0066 | -0.0124 | -0.0044 | -0.0260 |

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Table 3.11, Continued

| | Aggregate Portfolio | | 5 Portfolios Formed on Size | | | | | 5 Portfolios Formed on Book-to-Market Ratio | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Announcement | EW | VW | Small | 2nd Quintile | 3rd Quintile | 4th Quintile | Large | Growth | 2nd Quintile | 3rd Quintile | 4th Quintile | Value |
| 35. Core CPI | 0.0117 | 0.0073 | 0.0021 | -0.0094 | 0.0111 | 0.0077 | 0.0044 | 0.0115 | 0.0000 | 0.0027 | -0.0142 | -0.0273 |
| **Forward-looking** | | | | | | | | | | | | |
| 36. Phil Fed Current Bus. Cond. Diff. Index | 0.1522* | 0.1755 | 0.0924 | 0.1546 | 0.1482 | 0.1549 | 0.1801 | 0.2084 | 0.0982 | 0.0589 | 0.0941 | 0.1357 |
| 37. Consumer Confidence | 0.0353 | 0.0596 | 0.0338 | 0.0513 | 0.0393 | 0.0429 | 0.0637 | 0.0887 | 0.0359 | 0.0143 | 0.0201 | 0.0263 |
| 38. Chicago Purchasing Managers Index | -0.0624 | -0.0237 | -0.0809 | -0.0729 | -0.0588 | -0.0664 | -0.0146 | -0.0316 | -0.0172 | -0.0184 | -0.0197 | -0.0480 |
| 39. ISM: Manufacturing Composite Index | 0.0640 | 0.0369 | 0.0675 | 0.0838 | 0.0562 | 0.0496 | 0.0302 | 0.0381 | 0.0117 | 0.0495 | 0.0837 | 0.0339 |
| 40. Housing Starts | 0.0307 | 0.0234 | 0.0378 | 0.0356 | 0.0431 | 0.0336 | 0.0169 | 0.0132 | 0.0183 | 0.0244 | 0.0242 | 0.0305 |
| 41. Composite Index of Leading Indicators | 0.0077 | 0.0112 | 0.0101 | 0.0110 | 0.0110 | 0.0154 | 0.0184 | 0.0307 | 0.0140 | 0.0077 | 0.0128 | 0.0175 |
| **Quarterly Announcements** | | | | | | | | | | | | |
| 42. Initial Claims | 0.0210 | 0.0066 | 0.0150 | 0.0187 | 0.0187 | 0.0106 | 0.0054 | 0.0028 | 0.0091 | 0.0074 | 0.0150 | 0.0178 |

Notes: This table presents the coefficient estimates of $\beta_2$ of the regression model in Equation 3.4. EW and VW denote the equal-weighted aggregate portfolio and the value-weighted aggregate portfolio, respectively.

The coefficient estimates are statistically significant for only news about GDP numbers. However, for those announcements that portfolios react significantly to, the coefficient estimates of $\beta_{2,ij}$ are not statistically significant suggesting that our empirical results on the effect of news on stock returns are not due to outliers in our data set.

### 3.3.6 Announcement Timing

In this section, we analyze whether the macroeconomic variables released earlier in any given month have greater effects on stock returns than those released later. In order to analyze the effect of release sequence within the same category of macroeconomic variables, following Andersen, Bollerslev, Diebold, and Vega (2003), we group the macroeconomic variables into seven categories: the GDP announcements, the real activity announcements, the consumption announcements, the investment announcements, the net exports announcements, the prices announcements, the forward-looking announcements. Within each category, we order the macroeconomic variables with respect to the sequence of release in any given month. Table 3.3 summarizes the order within each category along with the numbering used in Figure 3.1. Smaller announcement number in a given category corresponds to an earlier release date in a given month.[2] Figure 3.1 presents the $R^2$ of Equation (3.2) estimated for each macroeconomic variable separately using data only on announcement days for that macroeconomic variable.

[2] We arbitrarily order the announcements that are released on the same day in a given month.

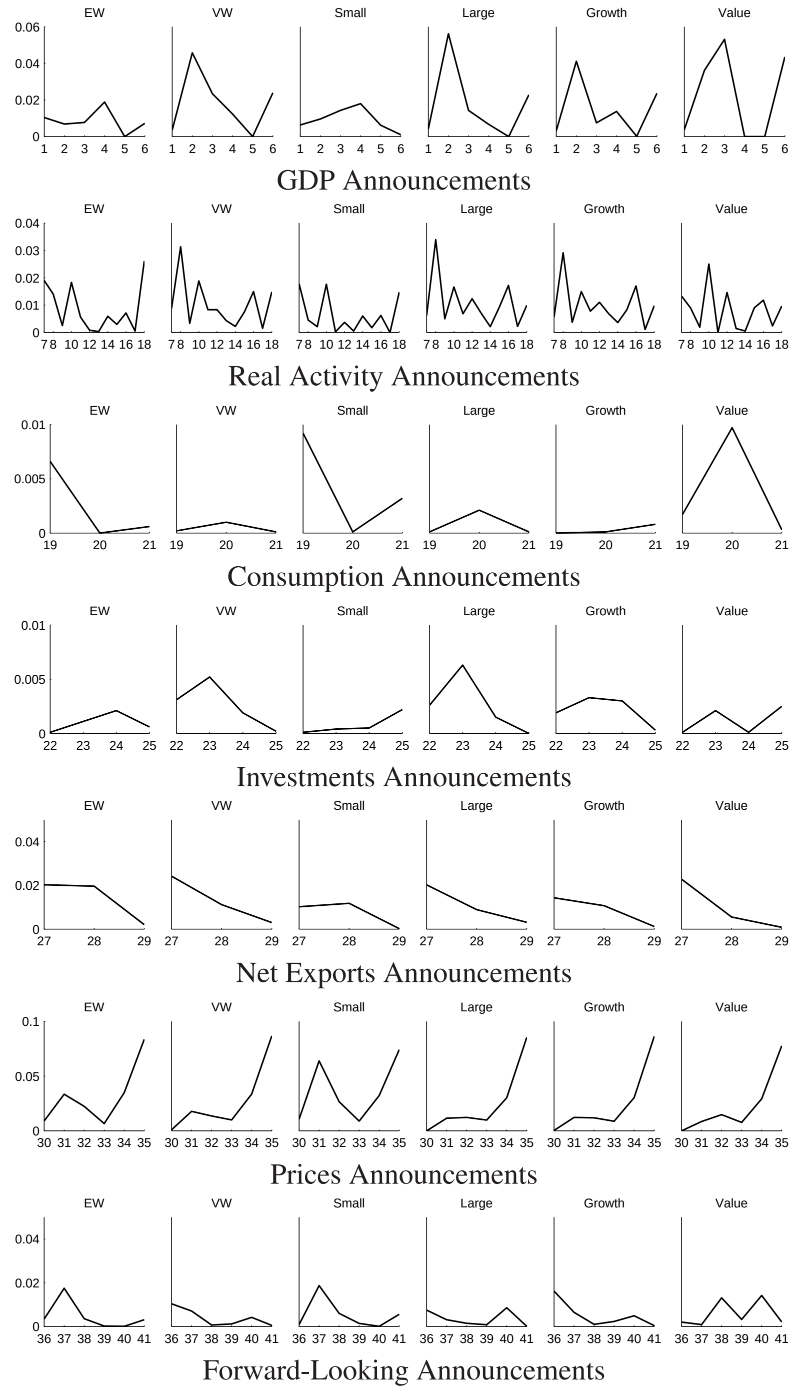


Figure 3.1: The Effect of Timing of Announcements

Notes: EW and VW denote the equal-weighted aggregate portfolio and the value-weighted aggregate portfolio, respectively. The y-axis is the $R^2$ whereas the x-axis is the announcement number in order of release in a given month as described in Section 3.3.6 and in Table 3.3

First of all, we do not find any clear evidence for the conjecture that the macroeconomic variables released earlier in any given month have greater effects on stock returns than those released later. The GDP and real activity announcements have more explanatory power, higher $R^2$, for the value-weighted aggregate portfolio and large firms than for the equal-weighted aggregate portfolio and small firms. However, overall, there is no such clear comparison between the value-weighted and the equal-weighted aggregate portfolio or between large and small firms or growth and value firms. This can be easily seen both from Figure 3.1 and Tables 3.7, 3.8 and 3.9. 23 of the 42 macroeconomic variables considered have higher explanatory power for the value-weighted portfolio than the equal-weighted portfolio on the corresponding announcement days.

## 3.4 Sources of Asymmetries in the Reaction of Stock Prices to Macroeconomic News

Our empirical results presented in Section 3.3 suggest that stock returns with different characteristics react differently to same unanticipated news about the same macroeconomic factor. Having documented these asymmetries in the reaction of stock prices, in this section, we analyze possible sources and explanations for these asymmetries. An unanticipated news about a macroeconomic variable can affect stock returns through three different channels: its direct effect on stock returns, its effect through the market's discount rate news and its effect through the market's cash flow news. To analyze possible sources of asymmetries in the reaction of stock returns, we employ the two-beta model of Campbell and Vuolteenaho (2004). Our approach of decomposing the effect of news on stock returns is closest to that of Bernanke and Kuttner (2005). Campbell and Vuolteenaho (2004) show that the market return contains two components, one reflecting news about the market's future cash flows and the other reflecting news about the market's discount rates. They show that different types of stocks have different betas with the two components of the market return. Following Bernanke and Kuttner (2005) and Campbell and Vuolteenaho (2004), we decompose the market return into news about future cash flows and future discount rates using the approach of Campbell (1991) and Campbell and Shiller (1988a).

Using the decomposition and the two-beta model of Campbell and Vuolteenaho (2004), we analyze the effect of unanticipated news on stock returns with different characteristics through these two components of the market return and its direct effect on returns. The approach can be briefly summarized as follows.[3] Campbell and Shiller's decomposition is a dynamic generalization of the Gordon growth model and employs a log-linear approximation of returns. Specifically, let $r_t^*$ denote the log market return in period $t$, defined as $r_t^* \equiv \log(1 + r_t)$ where $r_t$ is the percentage market return. By definition, the log return can be expressed as follows:

$$\begin{aligned} r_t^* &= \log(P_t + D_t) - \log(P_{t-1}) \\ &= p_t - p_{t-1} + \log(1 + \exp(d_t - p_t)) \end{aligned} \tag{3.5}$$

where $p_t$ is the log price and $d_t$ is the log dividend paid by the stock. The last term on the right-hand side of Equation (3.5) is a nonlinear function of the log dividend-price ratio. Using a first-order Taylor expansion, we obtain an approximation for log returns:

$$r_t^* \approx \theta + \rho p_t + (1 - \rho) d_t - p_{t-1} \tag{3.6}$$

where $\theta$ and $\rho$ are parameters of linearization defined by $\rho \equiv 1/(1 + \exp(\overline{d - p}))$ and $\theta \equiv -\log(\rho) - (1 - rho)\log(1/\rho - 1)$. $(\overline{d - p})$ is the average log dividend-price ratio. Imposing the transversality condition, we can express asset returns as linear combinations of revisions in expected future dividends and returns as follows:

$$\begin{aligned} \eta_t \equiv r_t^* - E_{t-1}[r_t^*] &= E_t\Big[\sum_{j=0}^{\infty} \rho^j \Delta d_{t+j}\Big] - E_{t-1}\Big[\sum_{j=0}^{\infty} \rho^j \Delta d_{t+j}\Big] \\ &\quad - \left(E_t\Big[\sum_{j=1}^{\infty} \rho^j r_{t+j}^*\Big] - E_{t-1}\Big[\sum_{j=1}^{\infty} \rho^j r_{t+j}^*\Big]\right) \\ &\equiv \eta_{d,t} - \eta_{r,t} \end{aligned} \tag{3.7}$$

where $\Delta$ denotes the first-order difference operator, i.e. one period change and $E_t$ denotes the expectation operator given the information set in period $t$. $\eta_{d,t}$ denotes news about the market's future cash flow and $\eta_{r,t}$ denotes news about the market's future discount rate. $\rho$ is a discount coefficient that is usually assumed to be the average log price dividend ratio. This equation has the following economic interpretation. If the unexpected return, $\eta_t$, is positive, then either expected future dividend (or consumption) growth $\eta_{d,t}$ must be higher than previously expected, or the excess future returns $\eta_{r,t}$ must be lower than expected, or any combination of these two must hold true. However, one should note that this is not a behavioral model but rather a simple

[3] The reader is referred to Campbell (1991) and Campbell and Shiller (1988a) for further details

accounting identity.

Empirically, one can employ a forecasting model, specifically a vector autoregression (VAR) model, to obtain proxies for the relevant expectations in the log-linear approximation. Following the literature, we decompose market returns using a one lag VAR model involving the variable of interest, the excess market (log) return, and variables that can forecast market returns. This VAR approach first estimates the current expected return and the change in discounted sum of future expected returns and then backs out the change in discounted sum of future cash flows or cash flow news from the identity in Equation (3.7). We model the dynamics of the market return as a component of the following VAR(1) model:

$$\mathbf{z}_t \equiv \begin{bmatrix} r_t^* \\ \mathbf{x}_t \end{bmatrix} = \mathbf{A_0} + \mathbf{A_1}\mathbf{z}_{t-1} + \boldsymbol{\xi}_t \tag{3.8}$$

where $\mathbf{z}_t$ is an n $\times$ 1 vector process whose first element is the market excess (log) return and $\mathbf{x}_t$ is an n $-$ 1 $\times$ 1 vector process whose elements have forecasting power for the market excess return. Using the VAR model in Equation (3.8) and the log-linearization in Equation (3.7), one can obtain estimates of the cash flow news, $\eta_{d,t}$, and the discount rate news, $\eta_{r,t}$. Specifically, let " $\hat{\cdot}$ " denote the estimated values, e.g. $\hat{\boldsymbol{\xi}}_t$ denote the residuals (or equivalently, the one-period forecast errors) from the VAR estimation. By definition, $\hat{\eta}_{r,t}$ can be expressed as follows:

$$\hat{\eta}_{r,t} = \mathbf{e}_1' \sum_{j=1}^{\infty} \hat{\rho}^j \hat{\mathbf{A}}_1^j \hat{\boldsymbol{\xi}}_t = \mathbf{e}_1' \hat{\rho} \hat{\mathbf{A}}_1 (\mathbf{I} - \hat{\rho}\hat{\mathbf{A}}_1)^{-1} \hat{\boldsymbol{\xi}}_t \tag{3.9}$$

From Equation (3.7) the revision in the expectation of future dividends, $\hat{\eta}_{d,t}$ can be treated as a residual:

$$\hat{\eta}_{d,t} = (r_t^* - \hat{E}_{t-1}[r_t^*]) + \hat{\eta}_{r,t} = \mathbf{e}_1'(\mathbf{I} + \hat{\rho}\hat{\mathbf{A}}_1(\mathbf{I} - \hat{\rho}\hat{\mathbf{A}}_1)^{-1})\hat{\boldsymbol{\xi}}_t \tag{3.10}$$

The return can be decomposed into its components as follows: $r_t^* = \hat{E}_{t-1}[r_t^*] + \hat{\eta}_{d,t} - \hat{\eta}_{r,t}$. The discount coefficient is not estimated from the VAR model but rather is set to the average log price dividend ratio.

### 3.4.1 The VAR Estimation

Different from the previous literature, we need to decompose market returns at daily frequency rather than monthly or annual frequency. Hence, we need to include state variables that have forecasting power for the market return at the daily level in our VAR specification. The real interest rate, the relative bill rate, the change in the bill rate, the dividend price ratio, the term structure premium, the junk bond premium, the price earnings ratio and the small-stock value spread are among those variables that have been used in the previous literature to decompose monthly or annual stock returns. However, most of these variables are not available either at daily frequency or for our whole sample period.

We employ a parsimonious one lag VAR with the 3-month bill rate, the term structure premium and the daily dividend price ratio as state variables. We use the secondary market rate of the 3-month US Government Treasury bills ($TB_t$) as a proxy for the daily risk free rate since it is the only short term rate available for our whole sample period. The daily 3-month bill rate is available from the Federal Reserve's H.15 release of daily interest rates. The term structure premium ($TS_t$) is the yield spread between the 10-year constant-maturity US Treasury bond and the 3-month US Treasury bill in annualized percentage points. The daily dividend price ratio is the return on income item in CRSP files for either the equal-weighted ($DP_{EW,t}$) or the value-weighted ($DP_{VW,t}$) portfolio of all stocks traded on NYSE, NASDAQ and AMEX. The choice of one-lag VAR model is not restrictive, since a higher-order VAR can always be stacked into a first-order form. Previous literature (see Flannery and Protopapadakis (2002)) has shown that these state variables have some forecasting power for the daily excess market returns. The literature usually employs return on the value-weighted CRSP index as the market return. In this paper, we decompose the market return into cash flow and discount rate news by employing both the value-weighted ($r^e_{VW,t}$) and the equal-weighted ($r^e_{EW,t}$) CRSP index as the market index. When estimating the VAR model to decompose market returns using either the value-weighted or the equal-weighted portfolios, we use the same state variables except the dividend price ratios. We use the dividend price ratio of the equal-weighted portfolio while decomposing returns on the equal-weighted portfolio and similarly for the value-weighted portfolio. As expected, the empirical results depend strongly on which index used as the market index. In line with the previous literature, we find that the value-weighted index provides more reasonable results than the equal-weighted portfolio. The excess market log return is calculated as the difference between the daily log return on all stocks in CRSP files and the daily risk-free rates.[4] Tables 3.12 and 3.13 present descriptive statistics and correlations for state variables used in the VAR models.

[4] Daily log returns are calculated as $\log(1+r_t/100)$ where $r_t$ is the percentage return on all stocks from the CRSP and the daily log risk-free rates are calculated as $\log((1 + r^f_t/100)^{(1/360)})$ where $r^f_t$ is the annualized percentage rate of the 3-month US Government Treasury bills obtained from the Federal Reserve's H.15 daily releases. Excess returns are calculated as the difference between $\log(1 + r_t/100)$ and $\log((1 + r^f_t/100)^{(1/360)})$.

Table 3.12: Summary Statistics for the State Variables

| | $r^e_{VW,t}$ | $r^e_{EW,t}$ | $TB_t$ | $TS_t$ | $DP_{VW,t}$ | $DP_{EW,t}$ |
|---|---|---|---|---|---|---|
| Mean | 0.0325 | 0.0775 | 5.9994 | 1.8663 | 0.0114 | 0.0071 |
| Median | 0.0632 | 0.1349 | 5.4900 | 2.0700 | 0.0055 | 0.0043 |
| Maximum | 8.2924 | 6.6608 | 17.1400 | 5.4100 | 0.2141 | 0.0664 |
| Minimum | -18.791 | -10.996 | 0.800 | -3.730 | 0.000 | -0.003 |
| Std. Dev. | 0.9765 | 0.7375 | 3.2343 | 1.2958 | 0.0156 | 0.0078 |
| Skewness | -1.3778 | -1.5119 | 0.8564 | -0.7673 | 3.2834 | 2.5561 |
| Kurtosis | 29.8027 | 22.5633 | 3.8900 | 3.7585 | 20.5941 | 11.6960 |

Notes: $r^e_{VW,t}$ and $r^e_{EW,t}$ are the excess return on the value-weighted and the equal-weighted aggregate portfolios, respectively. $TB_t$ is 3-month bill rate and $TS_t$ is the term structure premium. $DP_{VW,t}$ and $DP_{EW,t}$ are the dividend price ratios for the value-weighted and the equal-weighted aggregate portfolios, respectively. Std. Dev. denotes standard deviation.

Table 3.13: Correlations between the State Variables

| | $r^e_{VW,t}$ | $r^e_{EW,t}$ | $TB_t$ | $TS_t$ | $DP_{VW,t}$ | $DP_{EW,t}$ |
|---|---|---|---|---|---|---|
| $r^e_{VW,t}$ | 1.0000 | 0.8380 | -0.0201 | 0.0109 | 0.0017 | -0.0092 |
| $r^e_{EW,t}$ | 0.8380 | 1.0000 | -0.0684 | 0.0379 | -0.0356 | -0.0496 |
| $TB_t$ | -0.0201 | -0.0684 | 1.0000 | -0.4952 | 0.2388 | 0.1679 |
| $TS_t$ | 0.0109 | 0.0379 | -0.4952 | 1.0000 | 0.0066 | -0.0638 |
| $DP_{VW,t}$ | 0.0017 | -0.0356 | 0.2388 | 0.0066 | 1.0000 | 0.6820 |
| $DP_{EW,t}$ | -0.0092 | -0.0496 | 0.1679 | -0.0638 | 0.6820 | 1.0000 |
| $r^e_{VW,t-1}$ | 0.0784 | 0.2705 | -0.0195 | 0.0100 | -0.0050 | -0.0200 |
| $r^e_{EW,t-1}$ | 0.0350 | 0.2695 | -0.0670 | 0.0367 | 0.0025 | -0.0081 |
| $TB_{t-1}$ | -0.0175 | -0.0666 | 0.9994 | -0.4940 | 0.2383 | 0.1675 |
| $TS_{t-1}$ | 0.0143 | 0.0388 | -0.4943 | 0.9972 | 0.0072 | -0.0632 |
| $DP_{VW,t-1}$ | 0.0098 | -0.0133 | 0.2392 | 0.0066 | 0.2215 | 0.0911 |
| $DP_{EW,t-1}$ | 0.0148 | -0.0169 | 0.1682 | -0.0642 | 0.0819 | 0.0861 |

Notes: $r^e_{VW,t}$ and $r^e_{EW,t}$ are the excess return on the value-weighted and the equal-weighted aggregate portfolios, respectively. $TB_t$ is 3-month bill rate and $TS_t$ is the term structure premium. $DP_{VW,t}$ and $DP_{EW,t}$ are the dividend price ratios for the value-weighted and the equal-weighted aggregate portfolios, respectively. Std. Dev. denotes standard deviation.

The results are similar to those in Campbell and Vuolteenaho (2004) for the state variables analyzed in both studies. However, one should note that their analysis is at monthly frequency whereas ours is at daily frequency. The correlations between lagged state variables and the excess value-weighted portfolio return are smaller than those between lagged state variables and excess equal-weighted portfolio. These weak correlations suggest that the predictive powers of state variables at daily frequency will be somewhat weak, especially for the value-weighted portfolio.

As mentioned before, we estimate the VAR model in Equation (3.8) for daily returns on value-weighted and equal-weighted portfolios separately. The VAR models are estimated using either ordinary least squares (OLS) or generalized method of moments (GMM). The parameter estimates from OLS and GMM are identical, but GMM delivers a heteroskedasticity-consistent variance-covariance matrix. Before estimating the VAR model, we demean both the returns and the state variables, hence our estimates of $\mathbf{A}_0$ is a matrix of zeros. Tables 3.14 and 3.15 present the VAR estimation results for the value-weighted and the equal-weighted portfolios, respectively.

Table 3.14: VAR Estimation Results for the Value-Weighted Portfolio

| | $r^e_{VW,t}$ | $TB_t$ | $TS_t$ | $DP_{VW,t}$ |
|---|---|---|---|---|
| $r^e_{VW,t-1}$ | 0.0779 | 0.0021 | -0.0012 | 0.0000 |
| | (0.0126) | (0.0014) | (0.0012) | (0.0002) |
| | (0.0150) | (0.0023) | (0.0013) | (0.0002) |
| $TB_{t-1}$ | -0.0050 | 0.9995 | -0.0001 | 0.0013 |
| | (0.0045) | (0.0005) | (0.0004) | (0.0001) |
| | (0.0047) | (0.0006) | (0.0006) | (0.0001) |
| $TS_{t-1}$ | 0.0039 | 0.0019 | 0.9966 | 0.0017 |
| | (0.0110) | (0.0013) | (0.0011) | (0.0002) |
| | (0.0122) | (0.0022) | (0.0016) | (0.0002) |
| $DP_{VW,t-1}$ | 0.8557 | 0.1083 | -0.0007 | 0.1560 |
| | (0.8194) | (0.0934) | (0.0810) | (0.0124) |
| | (0.6554) | (0.1346) | (0.1032) | (0.0175) |
| $R^2$ | 0.66% | 99.88% | 99.45% | 10.00% |
| $\bar{R}^2$ | 0.61% | 99.88% | 99.45% | 9.96% |
| F Statistic | 1.398E+01 | 1.786E+06 | 3.794E+05 | 2.337E+02 |

Notes: $r^e_{VW,t}$ is the excess return on the value-weighted aggregate portfolio. $TB_t$ is 3-month bill rate and $TS_t$ is the term structure premium. $DP_{VW,t}$ is the dividend price ratio for the value-weighted aggregate portfolios. $\bar{R}^2$ denotes the adjusted $R^2$.

Table 3.15: VAR Estimation Results for the Equal-Weighted Portfolio

| | $r^e_{EW,t}$ | $TB_t$ | $TS_t$ | $DP_{EW,t}$ |
|---|---|---|---|---|
| $r^e_{EW,t-1}$ | 0.2662 | 0.0058 | -0.0021 | 0.0001 |
| | (0.0121) | (0.0019) | (0.0016) | (0.0001) |
| | (0.0173) | (0.0031) | (0.0020) | (0.0001) |
| $TB_{t-1}$ | -0.0105 | 0.9996 | -0.0001 | 0.0004 |
| | (0.0032) | (0.0005) | (0.0004) | (0.0000) |
| | (0.0042) | (0.0006) | (0.0005) | (0.0000) |
| $TS_{t-1}$ | 0.0035 | 0.0021 | 0.9966 | 0.0001 |
| | (0.0079) | (0.0012) | (0.0011) | (0.0001) |
| | (0.0116) | (0.0023) | (0.0016) | (0.0001) |
| $DP_{EW,t-1}$ | 0.4155 | 0.2202 | -0.1055 | 0.0594 |
| | (1.1644) | (0.1819) | (0.1578) | (0.0126) |
| | (1.0102) | (0.2364) | (0.1973) | (0.0105) |
| $R^2$ | 7.50% | 99.88% | 99.45% | 3.20% |
| $\bar{R}^2$ | 7.46% | 99.88% | 99.45% | 3.15% |
| F Statistic | 1.704E+02 | 1.788E+06 | 3.794E+05 | 6.949E+01 |

Notes: $r^e_{EW,t}$ is the excess return on the equal-weighted aggregate portfolio. $TB_t$ is 3-month bill rate and $TS_t$ is the term structure premium. $DP_{EW,t}$ is the dividend price ratio for the equal-weighted aggregate portfolios. $\bar{R}^2$ denotes the adjusted $R^2$.

Each column of Tables 3.14 and 3.15 corresponds to a different equation of the VAR model. The first column is the predictive equation for the excess market return. The first row for each predictive variable is the coefficient estimate, the first number in parenthesis under the coefficient estimate is the usual OLS standard error whereas the second number in parenthesis is the heteroskedasticity-consistent GMM standard error. As expected, the state variables do not have predictive power for the value-weighted portfolio suggested by insignificant parameter estimates and low $R^2$. On the other hand, for the equal-weighted portfolio, the 3-month T-bill rate has predictive power and a significant coefficient estimate whereas the other coefficient estimates are insignificant. The predictive equations for the value-weighted and the equal-weighted portfolios (the first columns in Tables 3.14 and 3.15) have $R^2$ of 0.66% and 7.50%, respectively, suggesting a reasonable degree of predictability for the value-weighted portfolio and a good degree of predictability for the equal-weighted portfolio at daily frequency.[5] One should note that the predictability of the value-weighted portfolio is mostly due to the predictive power of its own lagged return whereas the predictability of the equal-weighted portfolio is mostly due to the predictive power of its own lagged return and the 3-month T-bill rate. Both the value-weighted and the equal-weighted portfolios display some degree of momentum as suggested by the significant coefficient estimates of own lagged returns. The return of the equal-weighted portfolio displays a higher degree of momentum (0.2662 with a standard error of 0.0121) than the return of the value-weighted portfolio (0.0779 with a standard error of 0.0126) as suggested previously by the higher serial correlation of the equal-weighted portfolio.

Both signs and magnitudes of the coefficient estimates from the VAR model for daily returns are similar to those reported in the previous literature for either daily returns or monthly returns. The 3-month T-bill rate has a negative coefficient estimate consistent with the findings of Flannery and Protopapadakis (2002). The term structure premium and the dividend price ratio positively predict the excess market return consistent with findings of Campbell and Vuolteenaho (2004).[6]

The other columns present empirical results for the other state variables. Both the 3-month T-bill rate and the term structure premium are highly persistent with near-unit roots and

[5] Campbell and Vuolteenaho (2004) report an $R^2$ of 2.57% for monthly returns which suggests that an $R^2$ of 0.66% is a reasonable degree of predictability for daily returns.

[6] Campbell and Vuolteenaho (2004) employ the price earnings ratio of S&P 500 in their VAR analysis rather than the dividend price ratio used in our empirical analysis. They find that the smoothed price earnings ratio negatively predicts excess market return. Our empirical findings are consistent with findings of Campbell and Vuolteenaho (2004) since the price earnings ratio is negatively correlated with the dividend price ratio. Furthermore, the coefficient estimate of the term structure premium is consistent with Campbell and Vuolteenaho (2004) but not with Flannery and Protopapadakis (2002). Unfortunately, we have no explanation for this discrepancy.

the coefficient estimates except their own lags are insignificant. Both of them along with the lagged dividend price ratio positively predict the dividend price ratio of the value-weighted and the equal-weighted portfolios with $R^2$ of 10% and 3.19%.

### 3.4.2 Cash Flow and Discount Rate News and Variance Decomposition

Having estimated the VAR model, we decompose the excess market return into the cash flow and the discount rate components by plugging the residuals from the VAR estimation into Equation (3.7). Following Campbell and Vuolteenaho (2004), we set the discount coefficient, $\rho = 0.95^{1/252}$ assuming that there are 252 trading days in a year. One should note that $\rho$ is related to the long-term average of the log dividend price ratio which has an annualized value of 0.95. Table 3.16 presents covariances between the excess return on the value-weighted portfolio, its unexpected components and the cash flow and the discount rate news obtained by decomposing the excess market return as discussed above. Table 3.17 presents the corresponding covariances for the equal-weighted portfolio.

Table 3.16: Covariances and Variances of the Value-Weighted Excess Market Return, the Cash Flow News and the Discount Rate News

| | $r^e_{VW,t}$ | $r^e_{VW,t} - E_{t-1}[r^e_{VW,t}]$ | $\eta^{VW}_{d,t}$ | $\eta^{VW}_{r,t}$ |
|---|---|---|---|---|
| $r^e_{VW,t}$ | 0.9531 | 0.9468 | 1.0764 | 0.1296 |
| $r^e_{VW,t} - E_{t-1}[r^e_{VW,t}]$ | 0.9468 | 0.9468 | 1.0764 | 0.1296 |
| $\eta^{VW}_{d,t}$ | 1.0764 | 1.0764 | 1.6308 | 0.5544 |
| $\eta^{VW}_{r,t}$ | 0.1296 | 0.1296 | 0.5544 | 0.4248 |

Notes: $r^e_{VW,t}$ is the excess return on the value-weighted aggregate portfolio. $E_{t-1}[r^e_{VW,t}]$ is the expected return on the value-weighted aggregate portfolio where the expectation is based on the previous day's information set. $\eta^{VW}_{d,t}$ and $\eta^{VW}_{r,t}$ are the cash flow and the discount rate component of the value-weighted aggregate market portfolio.

Table 3.17: Covariances and Variances of the Equal-Weighted Excess Market Return, the Cash Flow News and the Discount Rate News

| | $r^e_{EW,t}$ | $r^e_{EW,t} - E_{t-1}[r^e_{EW,t}]$ | $\eta^{EW}_{d,t}$ | $\eta^{EW}_{r,t}$ |
|---|---|---|---|---|
| $r^e_{EW,t}$ | 0.5436 | 0.5028 | 0.7211 | 0.2183 |
| $r^e_{EW,t} - E_{t-1}[r^e_{VW,t}]$ | 0.5028 | 0.5028 | 0.7211 | 0.2183 |
| $\eta^{EW}_{d,t}$ | 0.7211 | 0.7211 | 5.1867 | 4.4656 |
| $\eta^{EW}_{r,t}$ | 0.2183 | 0.2183 | 4.4656 | 4.2473 |

Notes: $r^e_{EW,t}$ is the excess return on the equal-weighted aggregate portfolio. $E_{t-1}[r^e_{EW,t}]$ is the expected return on the equal-weighted aggregate portfolio where the expectation is based on the previous day's information set. $\eta^{EW}_{d,t}$ and $\eta^{EW}_{r,t}$ are the cash flow and the discount rate component of the equal-weighted aggregate market portfolio.

The variances and covariances are for the log percentage returns and the news. The cash flow news have a higher daily standard deviation (1.28% for the value-weighted portfolio and 2.28% for the equal-weighted portfolio) than the discount rate news (0.65% for the value-weighted portfolio and 2.06% for the equal-weighted portfolio). These results suggest that the cash flow component is dominant in determining the daily market returns. Our empirical findings are different than that of Campbell (1991) and Campbell and Vuolteenaho (2004). Unlike our empirical findings, these studies find that discount rate news has a higher standard deviation than cash flow news at monthly frequency. This discrepancy between our empirical findings and those of the previous literature might be due to different frequencies of data used in these studies. Tables 3.18 and 3.19 present correlations between the excess return on the value-weighted portfolio, its unexpected components and the cash flow and the discount rate news.

Table 3.18: Correlations between the Value-Weighted Excess Market Return, the Cash Flow News and the Discount Rate News

| | $r^e_{VW,t}$ | $r^e_{VW,t} - E_{t-1}[r^e_{VW,t}]$ | $\eta^{VW}_{d,t}$ | $\eta^{VW}_{r,t}$ |
|---|---|---|---|---|
| $r^e_{VW,t}$ | 1.0000 | 0.9967 | 0.8634 | 0.2036 |
| $r^e_{VW,t} - E_{t-1}[r^e_{VW,t}]$ | 0.9967 | 1.0000 | 0.8663 | 0.2043 |
| $\eta^{VW}_{d,t}$ | 0.8634 | 0.8663 | 1.0000 | 0.6661 |
| $\eta^{VW}_{r,t}$ | 0.2036 | 0.2043 | 0.6661 | 1.0000 |

Notes: $r^e_{VW,t}$ is the excess return on the value-weighted aggregate portfolio whereas $E_{t-1}[r^e_{VW,t}]$ is the expected return given the information set at time $t-1$ constructed from the estimated VAR model. $\eta^{VW}_{d,t}$ is the cash flow component of the value-weighted market return whereas $\eta^{VW}_{r,t}$ is the discount rate component at time $t$.

Table 3.19: Correlations between the Equal-Weighted Excess Market Return, the Cash Flow and the Discount Rate News

| | $r^e_{EW,t}$ | $r^e_{EW,t} - E_{t-1}[r^e_{EW,t}]$ | $\eta^{EW}_{d,t}$ | $\eta^{EW}_{r,t}$ |
|---|---|---|---|---|
| $r^e_{EW,t}$ | 1.0000 | 0.9618 | 0.4295 | 0.1437 |
| $r^e_{EW,t} - E_{t-1}[r^e_{EW,t}]$ | 0.9618 | 1.0000 | 0.4465 | 0.1494 |
| $\eta^{EW}_{d,t}$ | 0.4295 | 0.4465 | 1.0000 | 0.9514 |
| $\eta^{EW}_{r,t}$ | 0.1437 | 0.1494 | 0.9514 | 1.0000 |

Notes: $r^e_{EW,t}$ is the excess return on the equal-weighted aggregate portfolio whereas $E_{t-1}[r^e_{EW,t}]$ is the expected return given the information set at time $t-1$ constructed from the estimated VAR model. $\eta^{EW}_{d,t}$ is the cash flow component of the equal-weighted market return whereas $\eta^{EW}_{r,t}$ is the discount rate component at time $t$.

The correlations between the cash flow news and the discount rate news are 66.61% and 95.14% for the value-weighted and the equal-weighted portfolios, respectively. The correlation reported in Campbell and Vuolteenaho (2004) is 11.4%, smaller than the one reported in this study. They also note that the correlation of 11.4% is relatively smaller to those reported in the previous literature. They also note that this finding is due to a richer forecasting model used in their study. The correlation between the excess return and the cash flow news (86.34% for the value-weighted portfolio and 42.95% for the equal-weighted portfolio) is higher than the correlation between the excess return and the discount rate news (20.36% for the value-weighted portfolio and 14.37% for the equal-weighted portfolio) confirming that the most important component for explaining excess market return is the cash flow news. Due to the high correlation between the cash flow and the discount rate news for the equal-weighted portfolio, we choose to use the decomposition of the excess returns on the value-weighted portfolio rather than the equal-weighted portfolio to avoid the problem of multi-collinearity in the estimation of the two-beta model. Furthermore, the previous literature also uses the value-weighted portfolio as the market portfolio. Tables 3.20 and 3.21 present correlations between residuals from the VAR estimation and the cash flow and the discount rate news.

Table 3.20: Correlations between the VAR Residuals and the Value-Weighted Cash Flow and Discount Rate News

| | $\eta_{d,t}^{VW}$ | $\eta_{r,t}^{VW}$ |
|---|---|---|
| $r_{VW,t}^{e}$ | 0.8663 | 0.2043 |
| $TB_{t-1}$ | -0.5358 | -0.9531 |
| $TS_{t-1}$ | 0.1852 | 0.4440 |
| $DP_{VW,t-1}$ | -0.0055 | -0.0152 |

Notes: $r_{VW,t}^{e}$ is the excess return on the value-weighted aggregate portfolio. $\eta_{d,t}^{VW}$ is the cash flow component of the value-weighted market return whereas $\eta_{r,t}^{VW}$ is the discount rate component at time $t$. $TB_t$ is 3-month bill rate and $TS_t$ is the term structure premium. $DP_{VW,t}$ is the dividend price ratio for the value-weighted aggregate portfolios.

Table 3.21: Correlations between the VAR Residuals and the Equal-Weighted Cash Flow and Discount Rate News

| | $\eta_{d,t}^{EW}$ | $\eta_{r,t}^{EW}$ |
|---|---|---|
| $r_{EW,t}^{e}$ | 0.4465 | 0.1494 |
| $TB_{t-1}$ | -0.8235 | -0.8923 |
| $TS_{t-1}$ | 0.2517 | 0.2839 |
| $DP_{EW,t-1}$ | -0.0469 | -0.0373 |

Notes: $r_{EW,t}^{e}$ is the excess return on the equal-weighted aggregate portfolio. $\eta_{d,t}^{EW}$ is the cash flow component of the equal-weighted market return whereas $\eta_{r,t}^{EW}$ is the discount rate component at time $t$. $TB_t$ is 3-month bill rate and $TS_t$ is the term structure premium. $DP_{EW,t}$ is the dividend price ratio for the equal-weighted aggregate portfolios.

Furthermore, the daily variance of returns can be decomposed into three components using Equation (3.7) as follows:

$$\text{var}(r_t^e) = \text{var}(\eta_{d,t}) + \text{var}(\eta_{r,t}) - 2\text{cov}(\eta_{d,t}, \eta_{r,t}) \tag{3.11}$$

where $\text{var}(\eta_{d,t})$ and $\text{var}(\eta_{r,t})$ are daily variances of the cash flow news and the discount rate news and $\text{cov}(\eta_{d,t}, \eta_{r,t})$ is the covariance between the cash flow and the discount rate news. This variance decomposition summarizes the relative contribution of different components to the daily variance of market returns. Table 3.22 presents the results of the variance decomposition for daily returns on the value-weighted and the equal-weighted portfolio.

Table 3.22: The Variance Decomposition of Market Returns

| | VW | EW |
|---|---|---|
| $\text{var}(\eta_{d,t})$ | 1.630797 | 5.186702 |
| $\text{var}(\eta_{r,t})$ | 0.424793 | 4.247251 |
| $-2\text{cov}(\eta_{d,t}, \eta_{r,t})$ | -1.10875 | -8.93113 |
| $\text{var}(r_t^e)$ | 0.946839 | 0.502824 |

Notes: EW and VW denote the equal-weighted aggregate portfolio and the value-weighted aggregate portfolio, respectively. $\eta_{d,t}$ is the cash flow component of the value-weighted market return whereas $\eta_{r,t}$ is the discount rate component at time $t$. $r_t^e$ is the excess return on the value-weighted market portfolio.

For the variance decomposition of the value-weighted portfolio, the most important component is the variance of the cash flow news whereas the most important component for the equal-weighted portfolio is the covariance term.

### 3.4.3 Explaining the Sources of Reaction to Macroeconomic News

Having decomposed the excess market return into the cash flow news and the discount rate news, we can analyze the sources of the reaction of returns to macroeconomic news. Unexpected information about macroeconomic news may affect a stock return through three channels, its effect on the market's cash flow and the discount rate news, its direct effect that is not captured by either cash flow or discount rate news. To distinguish between different effects, we employ the two-beta model of Campbell and Vuolteenaho (2004). Specifically, we estimate the following system of three equations:

$$r_{it} = \beta_{0i} + \beta_{DR,i}\eta_{r,t} + \beta_{CF,i}\eta_{d,t} + \beta^{*}_{1,ij}S_{jt} + \epsilon_{it} \quad (3.12)$$

$$\eta_{r,t} = \alpha_{DR,0} + \alpha_{DR,j}S_{jt} + \nu_{DR,t} \quad (3.13)$$

$$\eta_{d,t} = \alpha_{CF,0} + \alpha_{CF,j}S_{jt} + \nu_{CF,t} \quad (3.14)$$

where $i = 1, 2, \ldots, 5$ for the 5 size sorted or 5 book-to-market ratio sorted portfolios and $i = 1, 2, \ldots, 25$ for either value-weighted and equal-weighted 25 size and book-to-market sorted portfolios. The system of equations is estimated separately for each macroeconomic news variable using the whole data sample rather than using only the announcement days since we need to estimate the cash flow and the discount rate betas over the whole sample rather than only on announcement days. Estimating betas only on announcement days might result in false estimates of betas and incorrect interpretation for the sources of the reaction. The system is estimated via SUR to obtain heteroskedasticity consistent standard errors.

The effect of a macroeconomic news on returns of a portfolio can be easily decomposed into its effect through the market's discount rate, its effect through the market's cash flow and its direct effect. Specifically, the effect of macroeconomic news variable $j$ on the return on portfolio $i$, $\beta_{1,ij}$, from Equation (3.2) can be decomposed as follows:

$$\beta_{1,ij} = \alpha_{DR,j}\beta_{DR,i} + \alpha_{CF,j}\beta_{CF,i} + \beta^{*}_{1,ij} \quad (3.15)$$

where the first term on the right hand side of Equation (3.15) is the effect of macroeconomic news variable $j$ through the market's discount rate, the second term is the its effect through the market's cash flow and the last term is its direct effect. If there is a significant reaction to a certain macroeconomic news variable, using Equation (3.15), we can analyze which of these three channels reacts significantly and causes the overall reaction of the return. We should note the equality in Equation (3.15) holds as an identity in the population. Decomposing the effect in the sample requires the estimation of Equation (3.2) over the whole sample rather than estimating only on announcement days as in Section 3.3.1. As mentioned previously, estimates and standard errors of $\beta_{1,ij}$ are almost identical whether the empirical specification is estimated using only announcement days or the whole data set. For completeness, we also present estimates of $\beta_{1,ij}$ over the whole sample. We first estimate Equations (3.13) and (3.14) to analyze the effect of macroeconomic news on the market's cash flow and discount rate components. Based on the reaction of cash flow and discount rate components, one can easily classify macroeconomic variables into two broad categories, ones that reveal information about the cash flow and ones that reveal information about the discount rate. Specifically, say for macroeconomic variable $j$, the coefficient estimate of $\alpha_{CF}$ is significant but not the coefficient estimate of $\alpha_{DR}$, then one can consider macroeconomic variable $j$ as a variable that reveal unexpected information about the market's cash flow component. Similarly, one can classify a macroeconomic variable as a discount rate variable if the opposite is true. If both cash flow and discount rate components react significantly to a macroeconomic variable, then that variable is both a discount rate and a cash flow variable. Table 3.23 presents the reaction of the market's cash flow and discount rate components to macroeconomic news.

Table 3.23: The Reaction of Market's Cash Flow and Discount Rate News to Macroeconomic News

| | Estimated using data only on announcement days | | | | Estimated using the whole sample | | | |
|---|---|---|---|---|---|---|---|---|
| | Cash Flow News | | Discount Rate News | | Cash Flow News | | Discount Rate News | |
| Announcement | $\alpha_{CF}$ | $R^2$ | $\alpha_{DR}$ | $R^2$ | $\alpha_{CF}$ | $R^2$ | $\alpha_{DR}$ | $R^2$ |
| **Quarterly Announcements** | | | | | | | | |
| Real GDP: Advance, Q/Q %Chg at an Annual Rate, (SAAR, %) | 0.0080 | 0.0000 | -0.0461 | 0.0177 | 0.0173 | 0.0000 | -0.0249 | 0.0000 |
| GDP Chain Price Index: Advance, Q/Q %Chg, (SAAR, %) | -0.2342 | 0.0325 | 0.0105 | 0.0009 | -0.2178 | 0.0003 | -0.0092 | 0.0000 |
| Real GDP: Preliminary, Q/Q %Chg at an Annual Rate, (SAAR, %) | 0.0664 | 0.0047 | -0.0676* | 0.0704 | 0.0560 | 0.0000 | -0.0628 | 0.0001 |
| GDP Chain Price Index: Prelim, Q/Q %Chg at an Ann Rate, (SA, %) | 0.1035 | 0.0119 | 0.0137 | 0.0032 | 0.0785 | 0.0000 | 0.0191 | 0.0000 |
| Real GDP: Final, Q/Q %Chg at an Annual Rate, (SAAR, %) | -0.0198 | 0.0004 | 0.0095 | 0.0005 | -0.0066 | 0.0000 | 0.0164 | 0.0000 |
| GDP Chain Price Index: Final, Q/Q %Chg, (SAAR, %) | -0.3192 | 0.0820 | -0.1453* | 0.1107 | -0.2403 | 0.0003 | -0.1072 | 0.0003 |
| **Monthly Announcements** | | | | | | | | |
| **Real Activity** | | | | | | | | |
| Domestic Light Truck Sales, (SAAR, Mil.Units) | -0.1236 | 0.0102 | 0.0030 | 0.0001 | -0.0829 | 0.0001 | 0.0022 | 0.0000 |
| Employees on Nonfarm Payrolls, M/M Change, (SA, Thous) | -0.5377** | 0.1445 | -0.3327** | 0.3303 | -0.5359** | 0.0067 | -0.3310** | 0.0098 |
| Unemployment Rate, (SA, %) | 0.2540** | 0.0284 | 0.1939** | 0.0549 | 0.2247** | 0.0016 | 0.1748** | 0.0037 |
| Hourly Earnings, M/M %Change, (SA, %) | -0.2172 | 0.0261 | -0.0669 | 0.0193 | -0.2140 | 0.0008 | -0.0661 | 0.0003 |
| Manufacturing Payrolls, Month/Month Change, (SA, Thous) | 0.0499 | 0.0011 | -0.0787 | 0.0467 | -0.0700 | 0.0001 | -0.0723 | 0.0002 |
| Average Weekly Hours, (SA, Hours) | 0.1098 | 0.0057 | -0.0085 | 0.0006 | 0.0258 | 0.0000 | -0.0162 | 0.0000 |
| Retail Sales, M/M %Chg, (SA, %) | -0.2426** | 0.0392 | -0.1715** | 0.0795 | -0.2437** | 0.0017 | -0.1721** | 0.0033 |
| Retail Sales ex Motor Vehicles, M/M %Chg, (SA, %) | -0.1110 | 0.0082 | -0.0657* | 0.0285 | -0.1189 | 0.0003 | -0.0699 | 0.0003 |
| Industrial Production, M/M %Chg, (SA, %) | -0.0323 | 0.0007 | -0.1204** | 0.0394 | -0.0324 | 0.0000 | -0.1206** | 0.0016 |
| Capacity Utilization Rate: Total Industry, (SA, %) | 0.0521 | 0.0020 | -0.0891** | 0.0514 | 0.0512 | 0.0001 | -0.0875 | 0.0006 |

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Table 3.23, Continued

| | Estimated using data only on announcement days | | | | Estimated using the whole sample | | | |
|---|---|---|---|---|---|---|---|---|
| | Cash Flow News | | Discount Rate News | | Cash Flow News | | Discount Rate News | |
| Announcement | $\alpha_{CF}$ | $R^2$ | $\alpha_{DR}$ | $R^2$ | $\alpha_{CF}$ | $R^2$ | $\alpha_{DR}$ | $R^2$ |
| Personal Income, M/M %Chg, (SAAR, %) | -0.0725 | 0.0037 | -0.0339 | 0.0048 | -0.0695 | 0.0001 | -0.0340 | 0.0001 |
| Consumer Credit, Month/Month Change, (SA, Bil.$) | 0.0971 | 0.0084 | -0.0011 | 0.0000 | 0.0911 | 0.0002 | -0.0022 | 0.0000 |
| **Consumption** | | | | | | | | |
| Existing Home Sales, (SAAR, Mil) | -0.0375 | 0.0008 | -0.0407 | 0.0276 | -0.0380 | 0.0000 | -0.0515 | 0.0001 |
| New Home Sales, (SAAR, Thous) | -0.1065 | 0.0098 | -0.0832** | 0.0770 | -0.0977 | 0.0002 | -0.0786 | 0.0005 |
| PCE, M/M %Chg, (SAAR, %) | -0.0316 | 0.0008 | -0.0492* | 0.0217 | -0.0219 | 0.0000 | -0.0493 | 0.0002 |
| **Investment** | | | | | | | | |
| New Orders: Advance Durable Goods, M/M %Chg, (SA, %) | -0.1429* | 0.0143 | -0.0992* | 0.0208 | -0.1407 | 0.0006 | -0.0982** | 0.0011 |
| Construction Spending, M/M %Chg, (SAAR, %) | -0.0670* | 0.0031 | 0.0062 | 0.0003 | -0.0418 | 0.0000 | 0.0048 | 0.0000 |
| New Orders, M/M %Chg, (SA, %) | -0.0625 | 0.0035 | -0.0264 | 0.0064 | -0.0552 | 0.0001 | -0.0244 | 0.0000 |
| Business Inventories, M/M %Chg, (SA, %) | -0.0044 | 0.0000 | 0.0170 | 0.0019 | -0.0103 | 0.0000 | 0.0218 | 0.0000 |
| **Government Purchases** | | | | | | | | |
| Government Surplus/Deficit, (NSA, Bil.$) | 0.0886* | 0.0071 | 0.0246 | 0.0067 | 0.0726 | 0.0001 | 0.0219 | 0.0000 |
| **Net Exports** | | | | | | | | |
| Trade Balance: Goods & Services [BOP], (SA, Bil.$) | 0.1421 | 0.0128 | -0.0003 | 0.0000 | 0.1579 | 0.0007 | 0.0030 | 0.0000 |
| Exports: Goods & Services [BOP], (SA, Bil.$) | 0.1086 | 0.0090 | 0.0045 | 0.0002 | 0.1008 | 0.0002 | 0.0059 | 0.0000 |
| Imports: Goods & Services [BOP], (SA, Bil.$) | -0.0790 | 0.0048 | -0.0290 | 0.0089 | -0.0935 | 0.0002 | -0.0254 | 0.0000 |
| **Prices** | | | | | | | | |
| Import Price Index, M/M %Chg, (NSA, %) | -0.0326 | 0.0006 | 0.0160 | 0.0014 | -0.0246 | 0.0000 | 0.0119 | 0.0000 |

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Table 3.23, Continued

| | Estimated using data only on announcement days | | | | Estimated using the whole sample | | | |
|---|---|---|---|---|---|---|---|---|
| | Cash Flow News | | Discount Rate News | | Cash Flow News | | Discount Rate News | |
| Announcement | $\alpha_{CF}$ | $R^2$ | $\alpha_{DR}$ | $R^2$ | $\alpha_{CF}$ | $R^2$ | $\alpha_{DR}$ | $R^2$ |
| Export Price Index, M/M %Chg, (NSA, %) | -0.1909 | 0.0205 | 0.0058 | 0.0002 | -0.1895 | 0.0003 | 0.0051 | 0.0000 |
| Producer Price Index, M/M %Chg, (SA, %) | -0.2121** | 0.0244 | -0.0871* | 0.0141 | -0.2214** | 0.0015 | -0.0950* | 0.0010 |
| Core PPI, Month/Month Change, (SA, %) | -0.1462 | 0.0150 | -0.0373 | 0.0105 | -0.1579 | 0.0005 | -0.0455 | 0.0001 |
| Consumer Price Index, M/M %Chg, (SA, %) | -0.2787** | 0.0506 | -0.1170** | 0.0459 | -0.2811** | 0.0023 | -0.1195** | 0.0016 |
| Core CPI, M/M %Chg, (SA, %) | -0.3977** | 0.1089 | -0.0954** | 0.0716 | -0.3965** | 0.0028 | -0.0935 | 0.0006 |
| **Forward-looking** | | | | | | | | |
| Phil Fed Current Business Cond Diffusion Indx, (SA, %) | -0.2256 | 0.0295 | -0.0968** | 0.0936 | -0.2250 | 0.0004 | -0.0966 | 0.0003 |
| Consumer Confidence, (SA, 1985=100) | 0.0024 | 0.0000 | -0.0797** | 0.0809 | 0.0069 | 0.0000 | -0.0800 | 0.0004 |
| Chicago Purchasing Managers Index, (SA, 50+=Econ Growth) | -0.1258* | 0.0161 | -0.0955** | 0.1559 | -0.1118 | 0.0001 | -0.0914 | 0.0002 |
| ISM: Mfg Composite Index, (SA, 50+ = Econ Expand) | -0.0936* | 0.0067 | -0.1288** | 0.1409 | -0.0996 | 0.0002 | -0.1280** | 0.0011 |
| Housing Starts, (SAAR, Thous) | 0.0832 | 0.0036 | 0.0198 | 0.0007 | 0.0938 | 0.0003 | 0.0256 | 0.0001 |
| Composite Index of Leading Indicators, M/M %Chg, (%) | 0.0570 | 0.0023 | 0.0400 | 0.0042 | 0.0603 | 0.0001 | 0.0407 | 0.0002 |
| **Weekly Announcements** | | | | | | | | |
| Initial Claims, (Thous) | 0.0445 | 0.0017 | 0.0502** | 0.0258 | 0.0440 | 0.0001 | 0.0491* | 0.0006 |

Notes: $\alpha_{DR}$ and $\alpha_{CF}$ are the effects of news about the corresponding macroeconomic variable on the market's discount rate news and the market's cash flow components, i.e. the coefficient estimates of regression parameters in Equation 3.13 and 3.14. First four columns present coefficient estimates using data only on the corresponding announcement days whereas next four columns present coefficient estimates using the whole sample.

The first four columns of Table 3.23 present estimation results using data only on announcement days whereas the last four columns present estimation results using the whole sample. As previously mentioned, the coefficient estimates of $\alpha_{DR}$ and $\alpha_{CF}$ are similar whether or not the whole sample is used. However, we should note that the significance of coefficient estimates differ depending on the data set used. Although, we present results for both data sets, we will focus on the estimation results using the whole sample since we also need to estimate the reaction in Equation (3.12) using the whole sample. According to our estimation results using the whole data sample, news about Industrial Production, New Orders, ISM Manufacturing Composite Index and Initial Claims can be classified as discount rate variables, whereas only Core CPI (surprisingly) can be classified as cash flow variable. News about Employees of Nonfarm Payrolls, Unemployment Rate, Retail Sales, PPI and CPI reveal unexpected information about both the cash flow component and discount rate component. Unfortunately, from this simple classification of macroeconomic variables into cash flow or discount rate variables, one cannot provide a simple interpretation to why returns on different portfolios react differently to same news. Hence, we estimate the system of equations to analyze the source (or sources) of asymmetric reaction between portfolios with different characteristics. Since it is not possible to present the analysis for each macroeconomic variable considered in this paper, we only present the results for those macroeconomic variables which either 5 size sorted or 5 book-to-market sorted portfolios react significantly. We estimate the system in Equations (3.12)-(3.14) separately for news about 7 macroeconomic variables which have significant effects on stock returns, Industrial Production, Consumer Price Index, Core Consumer Price Index, Producer Price Index, Employees on Nonfarm Payrolls, Hourly Earnings and Trade Balance. Tables 3.24 and 3.25 present decomposition of the reaction of 5 size sorted and 5 BM sorted portfolios to news about these 7 macroeconomic variables, respectively.

Table 3.24: The Decomposition of the Reaction of the Five Size Sorted Portfolios to Selected Macroeconomics News

| | Two-Beta Model | | | | Decomposition of Reaction | | | Total Reaction |
|---|---|---|---|---|---|---|---|---|
| | $\beta_{CF}$ | $\beta_{DR}$ | $\beta_1^*$ | $R^2$ | $\beta_{CF}\alpha_{CF}$ | $\beta_{DR}\alpha_{DR}$ | $\beta_1^*$ | $\beta_1$ |
| **Industrial Production** | | | | | | | | |
| Small | 0.6225** | -0.6477** | -0.0231 | 0.5714 | -0.0202 | 0.0781** | -0.0231 | 0.0349 |
| | (0.0069) | (0.0135) | (0.0303) | | (0.0460) | (0.0245) | (0.0303) | (0.0462) |
| Quintile 2 | 0.8144** | -0.8578** | -0.0261 | 0.7057 | -0.0264 | 0.1035** | -0.0261 | 0.0509 |
| | (0.0067) | (0.0132) | (0.0295) | | (0.0602) | (0.0324) | (0.0295) | (0.0543) |
| Quintile 3 | 0.8822** | -0.9166** | -0.0481 | 0.8019 | -0.0286 | 0.1106** | -0.0481 | 0.0339 |
| | (0.0056) | (0.0110) | (0.0246) | | (0.0653) | (0.0346) | (0.0246) | (0.0553) |
| Quintile 4 | 0.9291** | -0.9348** | -0.0172 | 0.8791 | -0.0301 | 0.1128** | -0.0172 | 0.0655 |
| | (0.0044) | (0.0087) | (0.0194) | | (0.0687) | (0.0353) | (0.0194) | (0.0558) |
| Large | 1.0507** | -1.0276** | 0.0130 | 0.9686 | -0.0341 | 0.1240** | 0.0130 | 0.1028 |
| | (0.0024) | (0.0048) | (0.0107) | | (0.0777) | (0.0388) | (0.0107) | (0.0604) |
| Wald Stat. | 2557.68 | 523.4899 | 0.9420 | | 0.1922 | 10.0289 | 0.9420 | 2.3346 |
| P | 0.0000 | 0.0000 | 0.3318 | | 0.6611 | 0.0015 | 0.3318 | 0.1265 |
| **Consumer Price Index** | | | | | | | | |
| Small | 0.6220** | -0.6474** | -0.0412 | 0.5715 | -0.1749** | 0.0774** | -0.0412 | -0.1387** |
| | (0.0069) | (0.0135) | (0.0302) | | (0.0459) | (0.0244) | (0.0302) | (0.0461) |
| Quintile 2 | 0.8142** | -0.8572** | 0.0079 | 0.7056 | -0.2289** | 0.1025** | 0.0079 | -0.1185* |
| | (0.0067) | (0.0132) | (0.0294) | | (0.0601) | (0.0323) | (0.0294) | (0.0542) |
| Quintile 3 | 0.8819** | -0.9156** | -0.0071 | 0.8018 | -0.2479** | 0.1094** | -0.0071 | -0.1456** |
| | (0.0056) | (0.0110) | (0.0246) | | (0.0651) | (0.0345) | (0.0246) | (0.0551) |
| Quintile 4 | 0.9290** | -0.9344** | -0.0054 | 0.8791 | -0.2612** | 0.1117** | -0.0054 | -0.1549** |
| | (0.0044) | (0.0087) | (0.0194) | | (0.0685) | (0.0352) | (0.0194) | (0.0557) |
| Large | 1.0507** | -1.0279** | -0.0043 | 0.9686 | -0.2954** | 0.1229** | -0.0043 | -0.1768** |
| | (0.0024) | (0.0048) | (0.0107) | | (0.0775) | (0.0387) | (0.0107) | (0.0602) |
| Wald Stat. | 2563.38 | 526.3855 | 0.9914 | | 14.4499 | 9.8868 | 0.9914 | 0.7371 |
| P | 0.0000 | 0.0000 | 0.3194 | | 0.0001 | 0.0017 | 0.3194 | 0.3906 |
| **Core Consumer Price Index** | | | | | | | | |
| Small | 0.6218** | -0.6469** | -0.0547 | 0.5715 | -0.2465** | 0.0605 | -0.0547 | -0.2407** |
| | (0.0069) | (0.0135) | (0.0385) | | (0.0585) | (0.0311) | (0.0385) | (0.0586) |
| Quintile 2 | 0.8141** | -0.8572** | -0.0092 | 0.7056 | -0.3228** | 0.0802 | -0.0092 | -0.2517** |
| | (0.0067) | (0.0132) | (0.0375) | | (0.0765) | (0.0412) | (0.0375) | (0.0689) |
| Quintile 3 | 0.8819** | -0.9156** | -0.0021 | 0.8018 | -0.3497** | 0.0856 | -0.0021 | -0.2661** |
| | (0.0056) | (0.0110) | (0.0313) | | (0.0829) | (0.0440) | (0.0313) | (0.0702) |
| Quintile 4 | 0.9290** | -0.9344** | 0.0011 | 0.8791 | -0.3683** | 0.0874 | 0.0011 | -0.2798** |
| | (0.0044) | (0.0087) | (0.0247) | | (0.0873) | (0.0448) | (0.0247) | (0.0709) |
| Large | 1.0508** | -1.0279** | 0.0024 | 0.9686 | -0.4166** | 0.0962 | 0.0024 | -0.3180** |
| | (0.0024) | (0.0048) | (0.0136) | | (0.0987) | (0.0493) | (0.0136) | (0.0767) |

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Table 3.24, Continued

| | Two-Beta Model | | | | Decomposition of Reaction | | | Total Reaction |
|---|---|---|---|---|---|---|---|---|
| | $\beta_{CF}$ | $\beta_{DR}$ | $\beta_1^*$ | $R^2$ | $\beta_{CF}\alpha_{CF}$ | $\beta_{DR}\alpha_{DR}$ | $\beta_1^*$ | $\beta_1$ |
| Wald Stat. | 2562.59 | 527.6720 | 1.4638 | | 17.6973 | 3.7726 | 1.4638 | 1.8657 |
| P | 0.0000 | 0.0000 | 0.2263 | | 0.0000 | 0.0521 | 0.2263 | 0.1720 |
| | | | | **Producer Price Index** | | | | |
| Small | 0.6220** | -0.6474** | -0.0537 | 0.5716 | -0.1377** | 0.0615* | -0.0537 | -0.1299** |
| | (0.0069) | (0.0135) | (0.0298) | | (0.0454) | (0.0241) | (0.0298) | (0.0455) |
| Quintile 2 | 0.8141** | -0.8573** | -0.0156 | 0.7056 | -0.1802** | 0.0815* | -0.0156 | -0.1145* |
| | (0.0067) | (0.0132) | (0.0291) | | (0.0594) | (0.0319) | (0.0291) | (0.0535) |
| Quintile 3 | 0.8820** | -0.9155** | 0.0095 | 0.8018 | -0.1952** | 0.0870* | 0.0095 | -0.0988 |
| | (0.0056) | (0.0110) | (0.0243) | | (0.0643) | (0.0341) | (0.0243) | (0.0545) |
| Quintile 4 | 0.9290** | -0.9344** | 0.0054 | 0.8791 | -0.2057** | 0.0888* | 0.0054 | -0.1115* |
| | (0.0044) | (0.0087) | (0.0191) | | (0.0677) | (0.0348) | (0.0191) | (0.0550) |
| Large | 1.0508** | -1.0278** | 0.0094 | 0.9686 | -0.2326** | 0.0977* | 0.0094 | -0.1256* |
| | (0.0024) | (0.0048) | (0.0106) | | (0.0766) | (0.0382) | (0.0106) | (0.0595) |
| Wald Stat. | 2566.03 | 526.3506 | 2.9720 | | 9.1914 | 6.4412 | 2.9720 | 0.0097 |
| P | 0.0000 | 0.0000 | 0.0847 | | 0.0024 | 0.0112 | 0.0847 | 0.9217 |
| | | | | **Employees on Nonfarm Payrolls** | | | | |
| Small | 0.6226** | -0.6457** | 0.0630 | 0.5716 | -0.3336** | 0.2137** | 0.0630 | -0.0569 |
| | (0.0069) | (0.0135) | (0.0339) | | (0.0514) | (0.0275) | (0.0339) | (0.0516) |
| Quintile 2 | 0.8145** | -0.8553** | 0.0816* | 0.7059 | -0.4365** | 0.2831** | 0.0816* | -0.0718 |
| | (0.0067) | (0.0132) | (0.0330) | | (0.0672) | (0.0362) | (0.0330) | (0.0606) |
| Quintile 3 | 0.8822** | -0.9142** | 0.0580* | 0.8019 | -0.4727** | 0.3026** | 0.0580* | -0.1121 |
| | (0.0056) | (0.0110) | (0.0276) | | (0.0727) | (0.0385) | (0.0276) | (0.0617) |
| Quintile 4 | 0.9291** | -0.9337** | 0.0313 | 0.8791 | -0.4979** | 0.3090** | 0.0313 | -0.1576* |
| | (0.0044) | (0.0087) | (0.0218) | | (0.0766) | (0.0393) | (0.0218) | (0.0623) |
| Large | 1.0508** | -1.0277** | 0.0040 | 0.9686 | -0.5631** | 0.3402** | 0.0040 | -0.2190** |
| | (0.0024) | (0.0048) | (0.0120) | | (0.0866) | (0.0432) | (0.0120) | (0.0674) |
| Wald Stat. | 2558.78 | 529.0291 | 2.0090 | | 41.6414 | 55.6531 | 2.0090 | 10.6396 |
| P | 0.0000 | 0.0000 | 0.1564 | | 0.0000 | 0.0000 | 0.1564 | 0.0011 |
| | | | | **Hourly Earnings** | | | | |
| Small | 0.6222** | -0.6471** | -0.0251 | 0.5714 | -0.1332* | 0.0428 | -0.0251 | -0.1155 |
| | (0.0069) | (0.0135) | (0.0393) | | (0.0599) | (0.0318) | (0.0393) | (0.0600) |
| Quintile 2 | 0.8140** | -0.8572** | -0.0398 | 0.7057 | -0.1742* | 0.0566 | -0.0398 | -0.1574* |
| | (0.0067) | (0.0132) | (0.0383) | | (0.0783) | (0.0421) | (0.0383) | (0.0706) |
| Quintile 3 | 0.8818** | -0.9156** | -0.0433 | 0.8019 | -0.1887* | 0.0605 | -0.0433 | -0.1715* |
| | (0.0056) | (0.0110) | (0.0320) | | (0.0848) | (0.0450) | (0.0320) | (0.0718) |
| Quintile 4 | 0.9289** | -0.9344** | -0.0178 | 0.8791 | -0.1988* | 0.0617 | -0.0178 | -0.1548* |
| | (0.0044) | (0.0087) | (0.0252) | | (0.0893) | (0.0459) | (0.0252) | (0.0726) |
| Large | 1.0508** | -1.0278** | 0.0058 | 0.9686 | -0.2249* | 0.0679 | 0.0058 | -0.1512 |

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Table 3.24, Continued

| | Two-Beta Model | | | | Decomposition of Reaction | | | Total Reaction |
|---|---|---|---|---|---|---|---|---|
| | $\beta_{CF}$ | $\beta_{DR}$ | $\beta_1^*$ | $R^2$ | $\beta_{CF}\alpha_{CF}$ | $\beta_{DR}\alpha_{DR}$ | $\beta_1^*$ | $\beta_1$ |
| | (0.0024) | (0.0048) | (0.0139) | | (0.1011) | (0.0505) | (0.0139) | (0.0785) |
| Wald Stat. | 2562.52 | 526.9531 | 0.4093 | | 4.9427 | 1.8047 | 0.4093 | 0.3801 |
| P | 0.0000 | 0.0000 | 0.5223 | | 0.0262 | 0.1791 | 0.5223 | 0.5376 |
| **Trade Balance** | | | | | | | | |
| Small | 0.6224** | -0.6472** | -0.0080 | 0.5714 | 0.0983* | -0.0019 | -0.0080 | 0.0884 |
| | (0.0069) | (0.0135) | (0.0300) | | (0.0456) | (0.0242) | (0.0300) | (0.0457) |
| Quintile 2 | 0.8144** | -0.8575** | -0.0259 | 0.7057 | 0.1286* | -0.0025 | -0.0259 | 0.1001 |
| | (0.0067) | (0.0132) | (0.0292) | | (0.0597) | (0.0321) | (0.0292) | (0.0537) |
| Quintile 3 | 0.8820** | -0.9157** | -0.0102 | 0.8018 | 0.1393* | -0.0027 | -0.0102 | 0.1263* |
| | (0.0056) | (0.0110) | (0.0244) | | (0.0646) | (0.0342) | (0.0244) | (0.0547) |
| Quintile 4 | 0.9290** | -0.9344** | 0.0031 | 0.8791 | 0.1467* | -0.0028 | 0.0031 | 0.1470** |
| | (0.0044) | (0.0087) | (0.0192) | | (0.0680) | (0.0349) | (0.0192) | (0.0552) |
| Large | 1.0508** | -1.0279** | -0.0029 | 0.9686 | 0.1660* | -0.0031 | -0.0029 | 0.1599** |
| | (0.0024) | (0.0048) | (0.0106) | | (0.0770) | (0.0384) | (0.0106) | (0.0598) |
| Wald Stat. | 2558.47 | 526.4347 | 0.0190 | | 4.6427 | 0.0063 | 0.0190 | 2.6390 |
| P | 0.0000 | 0.0000 | 0.8905 | | 0.0312 | 0.9367 | 0.8905 | 0.1043 |

Notes: $\beta_{CF}$ and $\beta_{DR}$ are the estimates of the cash flow and the discount rate betas from the regression model in Equation 3.12, respectively. $\beta_1^*$ is the estimate of the news variable's direct effect on portfolio returns from the regression in Equation 3.12. $\beta_{CF}\alpha_{CF}$ and $\beta_{DR}\alpha_{DR}$ are the effect of news variable through the market's cash flow component and the market's discount rate component as discussed in Equation 3.15, respectively. $\beta_1$ is the estimate of the overall effect of the news variable on portfolio returns obtained by estimating the regression in Equation 3.2 over the whole sample.

Table 3.25: The Decomposition of Reaction of the Five Book-to-Market Sorted Portfolios to Selected Macroeconomics News

| | Two-Beta Model | | | | Decomposition of Reaction | | | Total Reaction |
|---|---|---|---|---|---|---|---|---|
| | $\beta_{CF}$ | $\beta_{DR}$ | $\beta_1^*$ | $R^2$ | $\beta_{CF}\alpha_{CF}$ | $\beta_{DR}\alpha_{DR}$ | $\beta_1^*$ | $\beta_1$ |
| **Industrial Production** | | | | | | | | |
| Growth | 1.1236** | -1.1197** | 0.0054 | 0.9435 | -0.0364 | 0.1351** | 0.0054 | 0.1040 |
| | (0.0035) | (0.0069) | (0.0155) | | (0.0831) | (0.0422) | (0.0155) | (0.0652) |
| Quintile 2 | 0.9564** | -0.9464** | 0.0114 | 0.9001 | -0.0310 | 0.1142** | 0.0114 | 0.0946 |
| | (0.0041) | (0.0080) | (0.0180) | | (0.0708) | (0.0357) | (0.0180) | (0.0569) |
| Quintile 3 | 0.8666** | -0.8584** | -0.0232 | 0.8589 | -0.0281 | 0.1035** | -0.0232 | 0.0522 |
| | (0.0045) | (0.0089) | (0.0198) | | (0.0641) | (0.0324) | (0.0198) | (0.0528) |
| Quintile 4 | 0.7814** | -0.7218** | -0.0133 | 0.8109 | -0.0253 | 0.0871** | -0.0133 | 0.0485 |
| | (0.0049) | (0.0096) | (0.0215) | | (0.0578) | (0.0273) | (0.0215) | (0.0495) |
| Value | 0.7932** | -0.7538** | 0.0259 | 0.7605 | -0.0257 | 0.0909** | 0.0259 | 0.0911 |
| | (0.0058) | (0.0113) | (0.0253) | | (0.0587) | (0.0285) | (0.0253) | (0.0516) |
| Wald Stat. | 1846.10 | 588.9942 | 0.3708 | | 0.1922 | 10.0503 | 0.3708 | 0.1126 |
| P | 0.0000 | 0.0000 | 0.5425 | | 0.6611 | 0.0015 | 0.5425 | 0.7372 |
| **Consumer Price Index** | | | | | | | | |
| Growth | 1.1235** | -1.1199** | -0.0102 | 0.9435 | -0.3159** | 0.1338** | -0.0102 | -0.1922** |
| | (0.0035) | (0.0069) | (0.0155) | | (0.0829) | (0.0422) | (0.0155) | (0.0651) |
| Quintile 2 | 0.9564** | -0.9467** | -0.0087 | 0.9001 | -0.2689** | 0.1131** | -0.0087 | -0.1645** |
| | (0.0041) | (0.0080) | (0.0180) | | (0.0705) | (0.0357) | (0.0180) | (0.0568) |
| Quintile 3 | 0.8664** | -0.8578** | -0.0010 | 0.8589 | -0.2436** | 0.1025** | -0.0010 | -0.1421** |
| | (0.0045) | (0.0089) | (0.0198) | | (0.0639) | (0.0323) | (0.0198) | (0.0527) |
| Quintile 4 | 0.7812** | -0.7216** | -0.0163 | 0.8109 | -0.2196** | 0.0862** | -0.0163 | -0.1497** |
| | (0.0049) | (0.0096) | (0.0215) | | (0.0576) | (0.0272) | (0.0215) | (0.0494) |
| Value | 0.7932** | -0.7544** | -0.0124 | 0.7605 | -0.2230** | 0.0902** | -0.0124 | -0.1453** |
| | (0.0058) | (0.0113) | (0.0253) | | (0.0585) | (0.0284) | (0.0253) | (0.0515) |
| Wald Stat. | 1844.65 | 588.8247 | 0.0042 | | 14.4183 | 9.9066 | 0.0042 | 1.5045 |
| P | 0.0000 | 0.0000 | 0.9482 | | 0.0001 | 0.0016 | 0.9482 | 0.2200 |
| **Core Consumer Price Index** | | | | | | | | |
| Growth | 1.1235** | -1.1198** | -0.0124 | 0.9435 | -0.4455** | 0.1048 | -0.0124 | -0.3531** |
| | (0.0035) | (0.0069) | (0.0197) | | (0.1055) | (0.0537) | (0.0197) | (0.0829) |
| Quintile 2 | 0.9566** | -0.9467** | 0.0103 | 0.9001 | -0.3793** | 0.0886 | 0.0103 | -0.2804** |
| | (0.0041) | (0.0080) | (0.0229) | | (0.0899) | (0.0454) | (0.0229) | (0.0723) |
| Quintile 3 | 0.8664** | -0.8578** | -0.0031 | 0.8589 | -0.3435** | 0.0802 | -0.0031 | -0.2663** |
| | (0.0045) | (0.0089) | (0.0252) | | (0.0814) | (0.0412) | (0.0252) | (0.0670) |
| Quintile 4 | 0.7814** | -0.7215** | 0.0126 | 0.8109 | -0.3098** | 0.0675 | 0.0126 | -0.2297** |
| | (0.0049) | (0.0096) | (0.0274) | | (0.0734) | (0.0346) | (0.0274) | (0.0629) |
| Value | 0.7933** | -0.7543** | -0.0062 | 0.7605 | -0.3145** | 0.0706 | -0.0062 | -0.2502** |
| | (0.0058) | (0.0113) | (0.0322) | | (0.0745) | (0.0362) | (0.0322) | (0.0656) |

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Table 3.25, Continued

| | Two-Beta Model | | | | Decomposition of Reaction | | | Total Reaction |
|---|---|---|---|---|---|---|---|---|
| | $\beta_{CF}$ | $\beta_{DR}$ | $\beta_1^*$ | $R^2$ | $\beta_{CF}\alpha_{CF}$ | $\beta_{DR}\alpha_{DR}$ | $\beta_1^*$ | $\beta_1$ |
| Wald Stat. | 1840.91 | 588.7020 | 0.0209 | | 17.6495 | 3.7754 | 0.0209 | 4.4500 |
| P | 0.0000 | 0.0000 | 0.8851 | | 0.0000 | 0.0520 | 0.8851 | 0.0349 |
| **Producer Price Index** | | | | | | | | |
| Growth | 1.1236** | -1.1198** | 0.0104 | 0.9435 | -0.2487** | 0.1064* | 0.0104 | -0.1320* |
| | (0.0035) | (0.0069) | (0.0153) | | (0.0819) | (0.0417) | (0.0153) | (0.0643) |
| Quintile 2 | 0.9565** | -0.9466** | 0.0007 | 0.9001 | -0.2117** | 0.0899* | 0.0007 | -0.1211* |
| | (0.0041) | (0.0080) | (0.0177) | | (0.0697) | (0.0352) | (0.0177) | (0.0561) |
| Quintile 3 | 0.8666** | -0.8578** | 0.0211 | 0.8589 | -0.1918** | 0.0815* | 0.0211 | -0.0892 |
| | (0.0045) | (0.0089) | (0.0196) | | (0.0632) | (0.0319) | (0.0196) | (0.0520) |
| Quintile 4 | 0.7814** | -0.7214** | 0.0125 | 0.8109 | -0.1730** | 0.0685* | 0.0125 | -0.0920 |
| | (0.0049) | (0.0096) | (0.0212) | | (0.0570) | (0.0269) | (0.0212) | (0.0488) |
| Value | 0.7933** | -0.7544** | -0.0145 | 0.7605 | -0.1756** | 0.0717* | -0.0145 | -0.1184* |
| | (0.0058) | (0.0113) | (0.0249) | | (0.0578) | (0.0281) | (0.0249) | (0.0509) |
| Wald Stat. | 1846.67 | 588.6054 | 0.5598 | | 9.1786 | 6.4495 | 0.5598 | 0.1285 |
| P | 0.0000 | 0.0000 | 0.4543 | | 0.0024 | 0.0111 | 0.4543 | 0.7200 |
| **Employees on Nonfarm Payrolls** | | | | | | | | |
| Growth | 1.1236** | -1.1195** | 0.0121 | 0.9435 | -0.6021** | 0.3706** | 0.0121 | -0.2195** |
| | (0.0035) | (0.0069) | (0.0174) | | (0.0926) | (0.0470) | (0.0174) | (0.0728) |
| Quintile 2 | 0.9565** | -0.9464** | 0.0110 | 0.9001 | -0.5126** | 0.3132** | 0.0110 | -0.1884** |
| | (0.0041) | (0.0081) | (0.0202) | | (0.0788) | (0.0398) | (0.0202) | (0.0635) |
| Quintile 3 | 0.8666** | -0.8571** | 0.0317 | 0.8589 | -0.4644** | 0.2837** | 0.0317 | -0.1490* |
| | (0.0045) | (0.0089) | (0.0223) | | (0.0714) | (0.0361) | (0.0223) | (0.0589) |
| Quintile 4 | 0.7815** | -0.7207** | 0.0305 | 0.8109 | -0.4188** | 0.2386** | 0.0305 | -0.1497** |
| | (0.0049) | (0.0096) | (0.0242) | | (0.0644) | (0.0304) | (0.0242) | (0.0553) |
| Value | 0.7937** | -0.7522** | 0.0894** | 0.7608 | -0.4253** | 0.2490** | 0.0894** | -0.0869 |
| | (0.0058) | (0.0113) | (0.0284) | | (0.0654) | (0.0318) | (0.0284) | (0.0577) |
| Wald Stat. | 1842.64 | 593.1487 | 4.1813 | | 41.3797 | 56.2933 | 4.1813 | 9.5683 |
| P | 0.0000 | 0.0000 | 0.0409 | | 0.0000 | 0.0000 | 0.0409 | 0.0020 |
| **Hourly Earnings** | | | | | | | | |
| Growth | 1.1236** | -1.1198** | 0.0095 | 0.9435 | -0.2405* | 0.0740 | 0.0095 | -0.1570 |
| | (0.0035) | (0.0069) | (0.0202) | | (0.1081) | (0.0550) | (0.0202) | (0.0848) |
| Quintile 2 | 0.9563** | -0.9466** | -0.0379 | 0.9001 | -0.2047* | 0.0625 | -0.0379 | -0.1800* |
| | (0.0041) | (0.0080) | (0.0234) | | (0.0920) | (0.0465) | (0.0234) | (0.0740) |
| Quintile 3 | 0.8665** | -0.8579** | 0.0105 | 0.8589 | -0.1854* | 0.0567 | 0.0105 | -0.1182 |
| | (0.0045) | (0.0089) | (0.0258) | | (0.0833) | (0.0421) | (0.0258) | (0.0686) |
| Quintile 4 | 0.7812** | -0.7215** | -0.0335 | 0.8109 | -0.1672* | 0.0477 | -0.0335 | -0.1531* |
| | (0.0049) | (0.0096) | (0.0280) | | (0.0751) | (0.0354) | (0.0280) | (0.0643) |
| Value | 0.7932** | -0.7543** | -0.0391 | 0.7605 | -0.1697* | 0.0498 | -0.0391 | -0.1590* |

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Table 3.25, Continued

| | Two-Beta Model | | | | Decomposition of Reaction | | | Total Reaction |
|---|---|---|---|---|---|---|---|---|
| | $\beta_{CF}$ | $\beta_{DR}$ | $\beta_1^*$ | $R^2$ | $\beta_{CF}\alpha_{CF}$ | $\beta_{DR}\alpha_{DR}$ | $\beta_1^*$ | $\beta_1$ |
| | (0.0058) | (0.0113) | (0.0329) | | (0.0763) | (0.0370) | (0.0329) | (0.0672) |
| Wald Stat. | 1847.57 | 589.1617 | 1.2317 | | 4.9390 | 1.8054 | 1.2317 | 0.0017 |
| P | 0.0000 | 0.0000 | 0.2671 | | 0.0263 | 0.1791 | 0.2671 | 0.9667 |
| | | | | **Trade Balance** | | | | |
| Growth | 1.1238** | -1.1201** | -0.0273 | 0.9435 | 0.1775* | -0.0033 | -0.0273 | 0.1468* |
| | (0.0035) | (0.0069) | (0.0154) | | (0.0823) | (0.0419) | (0.0154) | (0.0646) |
| Quintile 2 | 0.9566** | -0.9467** | -0.0072 | 0.9001 | 0.1511* | -0.0028 | -0.0072 | 0.1410* |
| | (0.0041) | (0.0080) | (0.0178) | | (0.0701) | (0.0354) | (0.0178) | (0.0563) |
| Quintile 3 | 0.8666** | -0.8581** | -0.0223 | 0.8589 | 0.1369* | -0.0025 | -0.0223 | 0.1120* |
| | (0.0045) | (0.0089) | (0.0196) | | (0.0635) | (0.0321) | (0.0196) | (0.0523) |
| Quintile 4 | 0.7812** | -0.7213** | 0.0161 | 0.8109 | 0.1234* | -0.0021 | 0.0161 | 0.1373** |
| | (0.0049) | (0.0096) | (0.0213) | | (0.0572) | (0.0270) | (0.0213) | (0.0490) |
| Value | 0.7932** | -0.7541** | 0.0188 | 0.7605 | 0.1253* | -0.0022 | 0.0188 | 0.1418** |
| | (0.0058) | (0.0113) | (0.0251) | | (0.0581) | (0.0282) | (0.0251) | (0.0511) |
| Wald Stat. | 1848.44 | 590.3315 | 1.9084 | | 4.6395 | 0.0063 | 1.9084 | 0.0172 |
| P | 0.0000 | 0.0000 | 0.1671 | | 0.0312 | 0.9367 | 0.1671 | 0.8955 |

Notes: $\beta_{CF}$ and $\beta_{DR}$ are the estimates of the cash flow and the discount rate betas from the regression model in Equation 3.12, respectively. $\beta_1^*$ is the estimate of the news variable's direct effect on portfolio returns from the regression in Equation 3.12. $\beta_{CF}\alpha_{CF}$ and $\beta_{DR}\alpha_{DR}$ are the effect of news variable through the market's cash flow component and the market's discount rate component as discussed in Equation 3.15, respectively. $\beta_1$ is the estimate of the overall effect of the news variable on portfolio returns obtained by estimating the regression in Equation 3.2 over the whole sample.

Each row presents estimation results for different portfolios, either size sorted or BM sorted. The two columns denoted $\beta_{CF}$ and $\beta_{DR}$ under the heading "Two-Beta Model" reports estimates of the cash flow and the discount rate betas in Equation (3.12) for different portfolios. The third column denoted $\beta_1^*$ reports the reaction to news about the macroeconomic variable when one controls for the cash flow news and the discount rate news. The last column denoted "$R^2$" reports $R^2$'s of regressions for different portfolios. The next three columns under the heading "Decomposition of Reaction" reports the decomposition of the total reaction that is reported in the last column denoted "Total Reaction". As mentioned before, the column denoted $\beta_{CF}\alpha_{CF}$ reports the effect of news on returns through its effect on the market's cash flow component whereas $\beta_{DR}\alpha_{DR}$ reports its effect through the market's discount rate component. The heteroskedasticity-consistent standard errors are reported in parenthesis under the coefficient estimates. The standard errors for $\beta_{CF}\alpha_{CF}$ and $\beta_{DR}\alpha_{DR}$ are calculated using the delta method. The last two rows report Wald statistics testing the equality of coefficient estimates for small (growth) and large (value) portfolios and the corresponding p-value of the Chi-square distribution, respectively.

First of all, as expected, cash flow betas are positive whereas discount rate betas are negative. The magnitudes of both the cash flow and the discount rate betas increase monotonically with size and decrease monotonically with book-to-market ratio suggesting that returns on large and growth are more sensitive to both cash flow and discount rate news than returns on small and value firms. The Wald statistics testing the equality of cash flow and discount rate betas between small (growth) and large (value) firms are highly significant confirming the above observation. The explanatory power of the two beta model for daily returns also increases with high market capitalization and low book-to-market ratio as suggest by higher $R^2$s for growth and large firms. For most macroeconomic news variables which returns react significantly to, the direct effect of news becomes insignificant when one controls for the other two channels. This can be easily be seen from insignificant coefficient estimates of the direct effect, $\beta_1^*$, suggesting that news variables usually affect returns via its effect on market's cash flow and discount rate components.

We first focus on the decomposition of the effect of news about Industrial Production. Although news about Industrial Production does not have any significant on returns, it has a significant effect on the market's discount rates and is one of the variables that is classified as a discount rate variable in Table 3.23. As expected, the effect of news about Industrial Production on returns is only through its effect on the market's discount rate. However, this significant effect through the discount rate is dominated by the opposite direct effect and the opposite effect through the cash flow component and results in an insignificant effect. We then focus on the effect of news about Consumer Price Index which we classified as a discount rate and also a cash flow variable. As expected, both its effects on returns through both the market's cash flow and the market's discount rate are significant. However, the differential reaction between small (growth) and large (value) firms is due to differential reaction through the market's cash flow not the market's discount rate. The same result is true for the news about Core Consumer Price Index which does not have any effect on the returns through the discount rate channel. On the other hand, the news about Employees on Nonfarm Payrolls affect stock returns significantly through both the discount rate channel and the cash flow channel. However, the overall effect of news about Employees on Nonfarm Payrolls on small and value firms is insignificant due to its direct significant effect on these firms that cancels the significant reaction of the two other channels.

## 3.5 Conclusion

In this paper, we analyze the asymmetries in the reaction of returns on portfolios with different characteristics to the same macroeconomic news. The first empirical question addressed in this paper is "Do the effects of macroeconomic news on stock returns differ across assets?". More specifically, we analyze whether stock returns on a portfolio of firms with high market capitalization and/or high book equity-to-market equity ratio react differently than stock returns on a portfolio of firms with low market capitalization and/or low book equity-to-market equity. We find that returns on a portfolio of firms with high market capitalization (large firms) and book-to-market ratio (value firms) react stronger (in magnitude) to macroeconomic news than returns on a portfolio of firms with low market capitalization (small firms) and book-to-market ratio (growth firms). We also find that firms with high market capitalization and low book-to-market ratio are sensitive to fewer macroeconomic variables than firms with low market capitalization and high book-to-market ratio. Having documented these asymmetries in the reaction of firms with different characteristics, we analyze the possible sources of these asymmetries by decomposing the effect of news into three parts, its effect through the market's discount rate component, its effect through the market's cash flow component and its direct effect. First of all, we find that the news does not have any direct effect on stock returns when one controls for the market's discount rate and cash flow components suggesting that the reaction is generally captured by the two market components. Furthermore, we find that the differential reaction across firms with different characteristics is generally due to the differential sensitivity to the market's cash flow component.

# Appendix A

# Appendix for Chapter 1

## A.1 Proof of Propositions and Corollaries

*Proof of Proposition 1.1.* Before proceeding to the proof of Proposition 1.1, we describe the transition probability matrix for $\tilde{S}_t$. Let $Pr_{ij}^{(z)}$ denote the transition probabilities of the $z_t$ process, i.e. $Pr_{ij}^{(z)} = \Pr(z_{t+1} = i | z_t = j)$ for $i, j = 0, 1$, then the transition probability matrix $\mathbf{\Pi}$ for the expanded state space $\tilde{S}_t$ can be written in detail as follows:

$$\mathbf{\Pi} = \begin{pmatrix} \pi_1(1)Pr_{11}^{(z)} & \pi_1(0)Pr_{10}^{(z)} & (1-\pi_0(1))Pr_{11}^{(z)} & (1-\pi_0(0))Pr_{10}^{(z)} \\ \pi_1(1)Pr_{01}^{(z)} & \pi_1(0)Pr_{00}^{(z)} & (1-\pi_0(1))Pr_{01}^{(z)} & (1-\pi_0(0))Pr_{00}^{(z)} \\ (1-\pi_1(1))Pr_{11}^{(z)} & (1-\pi_1(0))Pr_{10}^{(z)} & \pi_0(1)Pr_{11}^{(z)} & \pi_0(0)Pr_{10}^{(z)} \\ (1-\pi_1(1))Pr_{01}^{(z)} & (1-\pi_1(0))Pr_{00}^{(z)} & \pi_0(1)Pr_{01}^{(z)} & \pi_0(0)Pr_{00}^{(z)} \end{pmatrix}$$

where $\mathbf{\Pi}_{ij}$ denotes the probability of switching from State $j$ to State $i$ for $i, j = \{(1, 1), (1, -1), (0, 1), (0, -1)\}$.

Rewriting the first order condition where $U'(C_t) = C_t^{\gamma}$ and assuming that in equilibrium $D_t = C_t$ for all $t$ and rearranging, we get

$$P_t C_t^{\gamma} = \beta E_t [P_{t+1} C_{t+1}^{\gamma} + C_{t+1}^{1+\gamma}]$$

Conjecturing a solution of the form in Equation (1.7) and substituting this into the FOC and rearranging,

$$\rho(S_t, z_t) = \beta E_t \left[ \frac{C_{t+1}^{1+\gamma}}{C_t^{1+\gamma}} (\rho(S_{t+1}, z_{t+1}) + 1) \right]$$

Note that from the law of motion for log-consumption in Equation (1.3), we have

$$\left(\frac{C_{t+1}}{C_t}\right)^{1+\gamma} = \exp\left((1+\gamma)(\mu_{S_{t+1}} + \sigma_{S_{t+1}}\varepsilon_{t+1})\right)$$

Substituting the law of motion for $\left(\frac{C_{t+1}}{C_t}\right)^{1+\gamma}$ into the FOC,

$$\rho(S_t, z_t) = \beta E_t\left[\exp((1+\gamma)(\mu_{S_{t+1}} + \sigma_{S_{t+1}}\varepsilon_{t+1}))(\rho(S_{t+1}, z_{t+1}) + 1)\right] \tag{A.1}$$

Since $\rho(S_t, z_t)$ can take only $4$ possible, the expectation on the right hand side of the above equation can be written as a finite sum given the current state variable $\tilde{S}_t$, e.g. for $\rho(1,1)$ the above equality becomes

$$\begin{aligned}\rho(1,1) =& \beta E_t\left[\exp((1+\gamma)(\mu_1 + \sigma_1\varepsilon_{t+1}))(\rho(1,1)+1)\right]\mathbf{\Pi}_{11} + \\ & \beta E_t\left[\exp((1+\gamma)(\mu_1 + \sigma_1\varepsilon_{t+1}))(\rho(1,-1)+1)\right]\mathbf{\Pi}_{21} + \\ & \beta E_t\left[\exp((1+\gamma)(\mu_0 + \sigma_0\varepsilon_{t+1}))(\rho(0,1)+1)\right]\mathbf{\Pi}_{31} + \\ & \beta E_t\left[\exp((1+\gamma)(\mu_0 + \sigma_0\varepsilon_{t+1}))(\rho(0,-1)+1)\right]\mathbf{\Pi}_{41}\end{aligned} \tag{A.2}$$

Note that

$$\begin{aligned}& E_t\left[\exp((1+\gamma)(\mu_i + \sigma_i\varepsilon_{t+1}))(\rho(j,k)+1)\right] = \\ & \exp((1+\gamma)\mu_i + (1+\gamma)^2\sigma_i^2/2)(\rho(j,k)+1)\end{aligned}$$

for $i, j = 0, 1$ and $k = -1, 1$ since $\varepsilon_{t+1} \sim iiN(0,1)$ and independent of $\tilde{S}_s$ for all $s$ and $E_t[\exp\{\mu + \sigma\varepsilon_{t+1}\}] = \exp\{\mu + \sigma^2/2\}$.

To reduce notation, define constants $c_1, c_0$ as $c_1 = \beta\exp((1+\gamma)\mu_1 + (1+\gamma)^2\sigma_1^2/2)$, and $c_0 = \beta\exp((1+\gamma)\mu_0 + (1+\gamma)^2\sigma_0^2/2)$, respectively, and the $(4\times 4)$ matrix of constants $\mathbf{M}$ as follows:

$$\mathbf{M} = \begin{pmatrix} c_1\mathbf{\Pi}_{11} & c_1\mathbf{\Pi}_{21} & c_0\mathbf{\Pi}_{31} & c_0\mathbf{\Pi}_{41} \\ c_1\mathbf{\Pi}_{12} & c_1\mathbf{\Pi}_{22} & c_0\mathbf{\Pi}_{32} & c_0\mathbf{\Pi}_{42} \\ c_1\mathbf{\Pi}_{13} & c_1\mathbf{\Pi}_{23} & c_0\mathbf{\Pi}_{33} & c_0\mathbf{\Pi}_{43} \\ c_1\mathbf{\Pi}_{14} & c_1\mathbf{\Pi}_{24} & c_0\mathbf{\Pi}_{34} & c_0\mathbf{\Pi}_{44} \end{pmatrix} \tag{A.3}$$

The FOC in Equation (A.1) can be written compactly in vector form as

$$\rho = \mathbf{M}(\rho + \iota) \tag{A.4}$$

where $\rho$ is defined as in Proposition (1.1).

Assuming that $(\mathbf{I}_4 - \mathbf{M})$ is non-singular, the solution to this system of equations can be written as

$$\rho = (\mathbf{I}_4 - \mathbf{M})^{-1}\mathbf{M}\iota \tag{A.5}$$

Equation (1.9) follows immediately. □

*Proof of Corollary 1.1.* Let $r_{t+1} = \frac{P_{t+1}-P_t}{P_t}$ denote next period's return as defined in Corollary 1.1, then $r_{t+1}$ can also be written as

$$\begin{aligned} r_{t+1} &= \frac{P_{t+1}/C_{t+1}}{P_t/C_t}\frac{C_{t+1}}{C_t} - 1 \\ &= \frac{\rho(S_{t+1}, z_{t+1})}{\rho(S_t, z_t)} \exp(\mu_{S_{t+1}} + \sigma_{S_{t+1}}\varepsilon_{t+1}) - 1 \end{aligned}$$

Furthermore, the expected one-period return is

$$E_t[r_{t+1}] = E_t\left[\rho(S_{t+1}, z_{t+1})\exp(\mu_{S_{t+1}} + \sigma_{S_{t+1}}\varepsilon_{t+1})\right]\frac{1}{\rho(S_t, z_t)} - 1$$

Since the investor observes both $S_t$ and $z_t$, then the expectation can be written as a finite sum of as in the proof of Proposition 1.1, e.g. for $S_t = z_t = 1$,

$$\begin{aligned} E_t[r_{t+1}|S_t = z_t = 1] =&(\rho(1,1)\exp(\mu_1 + \sigma_1^2/2)\mathbf{\Pi}_{11} + \\ &\rho(1,-1)\exp(\mu_1 + \sigma_1^2/2)\mathbf{\Pi}_{21} + \\ &\rho(0,1)\exp(\mu_0 + \sigma_0^2/2)\mathbf{\Pi}_{31} + \\ &\rho(0,-1)\exp(\mu_0 + \sigma_0^2/2)\mathbf{\Pi}_{41})\frac{1}{\rho(1,1)} - 1 \end{aligned}$$

Define $\tilde{c}_1$, $\tilde{c}_0$ as $\tilde{c}_1 = \exp\{\mu_1 + \sigma_1^2/2\}$, and $\tilde{c}_0 = \exp\{\mu_0 + \sigma_0^2/2\}$, respectively and the $(4 \times 4)$ matrix of constants $\tilde{\mathbf{M}}$ as follows:

$$\tilde{\mathbf{M}} = \begin{pmatrix} \tilde{c}_1\mathbf{\Pi}_{11} & \tilde{c}_1\mathbf{\Pi}_{21} & \tilde{c}_0\mathbf{\Pi}_{31} & \tilde{c}_0\mathbf{\Pi}_{41} \\ \tilde{c}_1\mathbf{\Pi}_{12} & \tilde{c}_1\mathbf{\Pi}_{22} & \tilde{c}_0\mathbf{\Pi}_{32} & \tilde{c}_0\mathbf{\Pi}_{42} \\ \tilde{c}_1\mathbf{\Pi}_{13} & \tilde{c}_1\mathbf{\Pi}_{23} & \tilde{c}_0\mathbf{\Pi}_{33} & \tilde{c}_0\mathbf{\Pi}_{43} \\ \tilde{c}_1\mathbf{\Pi}_{14} & \tilde{c}_1\mathbf{\Pi}_{24} & \tilde{c}_0\mathbf{\Pi}_{34} & \tilde{c}_0\mathbf{\Pi}_{44} \end{pmatrix} \tag{A.6}$$

Therefore, the expected returns can be written compactly in a vector form as follows

$$\mathbf{r_{t+1|t}} = E_t[\frac{\mathbf{P}_{t+1} - \mathbf{P}_t}{\mathbf{P}_t}] = \frac{\tilde{\mathbf{M}}\rho}{\rho} - \iota = \frac{\tilde{\mathbf{M}}(\mathbf{I}_4 - \mathbf{M})^{-1}\mathbf{M}\iota}{(\mathbf{I}_4 - \mathbf{M})^{-1}\mathbf{M}\iota} - \iota \tag{A.7}$$

Furthermore, let $R_{t+1}$ to be the gross asset return defined as

$$R_{t+1} = \frac{P_{t+1} + C_{t+1}}{P_t}$$

then, the gross return can be written as

$$R_{t+1} = \frac{\rho(S_{t+1}, z_{t+1}) + 1}{\rho(S_t, z_t)} \exp(\mu_{S_{t+1}} + \sigma_{S_{t+1}}\varepsilon_{t+1})$$

The expected one-period gross return can be written compactly in vector form as follows:

$$\mathbf{R_{t+1|t}} = \frac{\tilde{\mathbf{M}}(\rho + \iota)}{\rho}$$

□

*Proof of Proposition 1.2.* The proof of Proposition 1.2 is straight forward. Note that the true state of the economy, $S_t$ is in the investor's information set, i.e. $S_t \in \mathcal{F}_t$ where $\mathcal{F}_t$ is the investor's information set at time $t$.

$$E_t[r_{t+1}|z_t = 1] = E_t[r_{t+1}|S_t = i, z_t = 1] = \begin{cases} (\mathbf{r_{t+1|t}})_{11} & \text{if } i = 1 \\ (\mathbf{r_{t+1|t}})_{31} & \text{if } i = 0 \end{cases}$$

$$E_t[r_{t+1}|z_t = -1] = E_t[r_{t+1}|S_t = i, z_t = -1] = \begin{cases} (\mathbf{r_{t+1|t}})_{21} & \text{if } i = 1 \\ (\mathbf{r_{t+1|t}})_{41} & \text{if } i = 0 \end{cases}$$

Therefore, Equations (1.13) and (1.14) simultaneously holding implies $E_t[r_{t+1}|z_t = 1] > E_t[r_{t+1}|z_t = -1]$, the definition of underreaction in Definition 1.1. □

## A.2 Algorithm

The conditional likelihood can be calculated recursively similar to GARCH estimation. In this algorithm, the focus is on the conditional probability of observing a state rather than the switching probabilities between states. The conditional probability of observing a state is the weight on the mixture components. First, note that, the log-consumption growth process can be written as

$$\Delta c_t = \begin{cases} N(\mu_0, \sigma_0^2) & \text{if } S_t = 0 \\ N(\mu_1, \sigma_1^2) & \text{if } S_t = 1 \end{cases}$$

Let $f(\cdot|\mathcal{G}_t)$ denote the conditional distribution of $(\cdot)$ process where $\mathcal{G}_t = \sigma(z_t, z_{t-1}, \ldots, \Delta c_t, \Delta c_{t-1}, \ldots)$, then

$$\begin{aligned} f(\Delta c_t|\mathcal{G}_{t-1}) &= \sum_{i=0}^{1} f(\Delta c_t, S_t = i|\mathcal{G}_{t-1}) \\ &= \sum_{i=0}^{1} f(\Delta c_t, S_t = i|\mathcal{G}_{t-1}) \Pr(S_t = i|\mathcal{G}_{t-1}) \\ &= \sum_{i=0}^{1} f(\Delta c_t, S_t = i|\mathcal{G}_{t-1}) p_{it} \end{aligned}$$

where $p_{it} = \Pr(S_t = i|\mathcal{G}_{t-1})$. Therefore, the distribution of $\Delta c_t$ conditional on last period's information set, $\mathcal{G}_{t-1}$, can be written as

$$\Delta c_t|\mathcal{G}_{t-1} \sim \begin{cases} f(\Delta c_t, S_t = 0|\mathcal{G}_{t-1}) & \text{with probability } p_{0t} \\ f(\Delta c_t, S_t = 1|\mathcal{G}_{t-1}) & \text{with probability } p_{1t} \end{cases}$$

where

$$f(\Delta c_t|S_t = i, \mathcal{G}_{t-1}) = \frac{1}{\sqrt{2\pi\sigma_i^2}} \exp\left(\frac{-(\Delta c_t - \mu_i)^2}{2\sigma_i^2}\right)$$

Note that

$$\Pr(S_{t-1}=i|\mathcal{G}_{t-1}) = \Pr(S_{t-1}=i|\Delta c_{t-1}, z_{t-1}, \mathcal{G}_{t-2}) \tag{A.8}$$

$$= \frac{f(S_{t-1}=i, \Delta c_{t-1}, z_{t-1}|\mathcal{G}_{t-2})}{f(\Delta c_{t-1}, z_{t-1}|\mathcal{G}_{t-2})} \tag{A.9}$$

$$= \frac{f(\Delta c_{t-1}, z_{t-1}|S_{t-1}=i, \mathcal{G}_{t-2}) \Pr(S_{t-1}=i|\mathcal{G}_{t-2})}{\sum_{k=0}^{1} f(\Delta c_{t-1}, z_{t-1}|S_{t-1}=k, \mathcal{G}_{t-2}) \Pr(S_{t-1}=k|\mathcal{G}_{t-2})} \tag{A.10}$$

$$= \frac{f(\Delta c_{t-1}|S_{t-1}=i, \mathcal{G}_{t-2})}{\sum_{k=0}^{1} f(\Delta c_{t-1}|S_{t-1}=k, \mathcal{G}_{t-2})} \cdots$$

$$\cdots \frac{\Pr(z_{t-1}=j|S_{t-1}=i, \mathcal{G}_{t-2}) \Pr(S_{t-1}=i|\mathcal{G}_{t-2})}{\Pr(z_{t-1}=j|S_{t-1}=i, \mathcal{G}_{t-2}) \Pr(S_{t-1}=k|\mathcal{G}_{t-2})} \tag{A.11}$$

$$= \frac{f(\Delta c_{t-1}|S_{t-1}=i, \mathcal{G}_{t-2}) \Pr(S_{t-1}=i|\mathcal{G}_{t-2})}{\sum_{k=0}^{1} f(\Delta c_{t-1}|S_{t-1}=k, \mathcal{G}_{t-2}) \Pr(S_{t-1}=k|\mathcal{G}_{t-2})} \tag{A.12}$$

$$= \frac{f(\Delta c_{t-1}|S_{t-1}=i, \mathcal{G}_{t-2}) p_{i,t-1}}{\sum_{k=0}^{1} f(\Delta c_{t-1}|S_{t-1}=k, \mathcal{G}_{t-2}) p_{k,t-1}} \tag{A.13}$$

for $j = -1, 1$ where Equation (A.8) follows from the definition of $\mathcal{G}_{t-1}$, Equations (A.9) and (A.10) follow from Bayes' rule. Equation (A.11) follows from the fact that given the current state the log-consumption process is independent of the current $z$. Equation (A.12) follows from the independence assumption of $S$ and $z$ discussed in Section 1.3. Equation (A.13) follows from the definition of $p_{it}$. Therefore, $p_{0t} = \Pr(S_t = 0|\mathcal{G}_{t-1})$ can be written recursively as

$$p_{0t} = \Pr(S_t = 0|\mathcal{G}_{t-1}) = \sum_{i=0}^{1} \Pr(S_t = 0|S_{t-1}=i, \mathcal{G}_{t-1}) \Pr(S_{t-1}=i|\mathcal{G}_{t-1}) \tag{A.14}$$

where $\Pr(S_{t-1}=i|\mathcal{G}_{t-1})$ is derived in Equation (A.13).

Note that $p_{0t} = 1 - p_{1t}$. Therefore, $p_{0t}$ and $p_{1t}$ can be written recursively with an initial condition where the initial condition is given by

$$p_{0,1} = \frac{1 - \pi_0(z_0)}{2 - \pi_1(z_0) - \pi_0(z_0)} \tag{A.15}$$

where $\pi_1(z_0)$ and $\pi_0(z_0)$ are as in Section 1.3.

Having specified the conditional mean and conditional variances and the dynamics of switching between regimes, the log-likelihood function can be written as follows:

$$\mathcal{L} = \sum_{t=1}^{T} \log[p_{0t} \frac{1}{\sqrt{2\pi\sigma_0^2}} \exp\{-\frac{(\Delta c_t - \mu_0)^2}{2\sigma_0^2}\} + (1-p_{0t}) \frac{1}{\sqrt{2\pi\sigma_1^2}} \exp\{-\frac{(\Delta c_t - \mu_1)^2}{2\sigma_1^2}\}] \quad \text{(A.16)}$$

The log-likelihood is maximized with respect to the model parameters using GAUSS® CML module. Different initialization for parameters were employed, and the global maximum has been chosen.

## A.3 Evaluation of Probability Forecasts

In this paper, we use several methods to evaluate the performance of different models in predicting the NBER recessions. Following Diebold and Lopez (1996), the in-sample probability forecasts are evaluated based on their accuracy and calibration. Accuracy refers to the predicted probability ($p_{0t}$) closeness, on average to observed realization ($I_t$), as measured by a zero-one dummy variable. $I_t$ is one if $t$ is an NBER recession quarter, zero otherwise. The accuracy can be measured by the quadratic probability score (QPS) and log probability score (LPS), analogs of a mean squared error measure.

$$QPS = \frac{1}{T}\sum_{t=1}^{T} 2(p_{0t} - I_t)^2 \quad \text{(A.17)}$$

$$LPS = -\frac{1}{T}\sum_{t=1}^{T}[(1-I_t)\ln(1-p_{0t}) + I_t \ln(p_{0t})] \quad \text{(A.18)}$$

QPS ranges from 0 to 2; 0 corresponds to perfect accuracy. The LPS ranges from 0 to infinity; 0 corresponds to perfect accuracy. The difference between QPS and LPS is the implicit loss function; the former is quadratic and latter is logarithmic. Another difference between those scorings is that larger mistakes are less taken into account by the LPS.

Calibration refers to the closeness of forecast probabilities to observed relative frequencies. It is measured by the global squared bias:

$$GSB = 2(\overline{p_0} - \overline{I})^2 \quad \text{(A.19)}$$

where $\overline{p_0} = \frac{1}{T}\sum_{t=1}^{T} p_{0t}$ and $\overline{I} = \frac{1}{T}\sum_{t=1}^{T} I_t$. Calibration compares the mean forecasted probability to the observed relative frequencies. Please refer to Diebold and Lopez (1996) for more detailed discussion.

# Appendix B

# Appendix for Chapter 2

## B.1 Proofs

*Proof of Lemma 2.1.* In this proof, for convenience, we refer to the time period between the previous announcement and the upcoming announcement as the current "quarter". Investors form their beliefs about the current state of the economy by observing two sources of information, the previous announcement about the state of the economy in the previous quarter and dividend realizations.

Case 1. ($t = T_{n-1}$): Note that on the (n-1)$^{\text{th}}$ announcement day, $T_{n-1}$, the only relevant variable about the state of the economy in the upcoming quarter in investors' information set is the (n-1)$^{\text{th}}$ announcement which reveals the true state of the economy in the previous quarter. Having observed the announcement, investors form their prior beliefs about the current state of the economy based on the law of motion of the state variable, $z_n$. If the (n-1)$^{\text{th}}$ reveals that economy has been in state $j$, i.e. $z_{n-1} = j$, the probability of switching to state $i$ is given by $q_{ji}$, the ji$^{\text{th}}$ element of the transition probability matrix of $z_n$, $\mathbf{Q}$. On the announcement day, investors prior beliefs about the current state of the economy solely depends on the previous announcement. Hence, the equation in the first case is a function of only the previous announcement not dividend realizations.

Case 2. ($T_{n-1} < t < T_n$): Having observed the previous announcement at time $T_{n-1}$, investors update their beliefs through dividend realizations according to Bayes' rule. Recall that the probability of being in state $i$, $\pi_{it} = \Pr(z_n = i|\mathcal{F}_t)$.

$$\begin{aligned}
\pi_{it} &= \Pr(z_n = i|\Delta d_t, \mathcal{F}_{t-1}) && \text{(B.1)} \\
&= \frac{\Pr(\Delta d_t|z_n = i, \mathcal{F}_{t-1}) \Pr(z_n = i|\mathcal{F}_{t-1})}{\Pr(\Delta d_t|\mathcal{F}_{t-1})} && \text{(B.2)} \\
&= \frac{\Pr(\Delta d_t|z_n = i, \mathcal{F}_{t-1}) \Pr(z_n = i|\mathcal{F}_{t-1})}{\sum_{j=1}^{N} \Pr(\Delta d_t|z_n = j, \mathcal{F}_{t-1}) \Pr(z_n = j|\mathcal{F}_{t-1})} && \text{(B.3)} \\
&= \frac{\phi(\frac{\Delta d_t - \mu_i}{\sigma_i})\pi_{i,t-1}}{\sum_{j=1}^{N} \phi(\frac{\Delta d_t - \mu_j}{\sigma_j})\pi_{j,t-1}} && \text{(B.4)}
\end{aligned}$$

where $\phi(\cdot)$ is the standard normal density function. Equation (B.1) follows from the definition of $\mathcal{F}_t$. Equation (B.2) and (B.3) follow from Bayes' rule and law of total probability, respectively[1]. Note that, by definition, $\pi_{j,t-1} = \Pr(z_n = j|\mathcal{F}_{t-1})$. Equation (B.4) follows from the law of motion for dividend growth in Equation (2.2).

Case 2. ($t = T_n$): On the announcement day, $T_n$, investors observe the true growth of the economy. Therefore, the probability of being in state $i$ is either 1 or 0 depending on the announcement, hence the indicator function. This completes the proof. □

*Proof of Lemma 2.2.* By recursive substitution of future prices into Euler equation in (2.7), the price of the risky asset can be expressed as a discounted sum of expected future dividends where the discount factor is the intertemporal marginal rate of substitution:

$$P_t = E_t\left[\sum_{\tau=1}^{\infty} \beta^{\tau} \frac{U'(C_{t+\tau})}{U'(C_t)} D_{t+\tau}\right] \tag{B.5}$$

Imposing the equilibrium condition, $C_t = D_t$, substituting the functional form for the utility function and rearranging the terms, the price-dividend ratio at time $t$ can be expressed as follows:

$$\frac{P_t}{D_t} = E_t\left[\sum_{\tau=1}^{\infty} \beta^{\tau} \left(\frac{D_{t+\tau}}{D_t}\right)^{1-\gamma}\right] \tag{B.6}$$

The infinite sum in Equation (B.6) can be expressed as a sum of two terms, sum of discounted future dividends until the upcoming announcement day and sum of discounted future dividends after the upcoming announcement day. The price-dividend ratio can be expressed as follows:

$$\frac{P_t}{D_t} = \sum_{\tau=1}^{T_n - t} \beta^{\tau} E_t\left[\left(\frac{D_{t+\tau}}{D_t}\right)^{1-\gamma}\right] + \beta^{T_n - t} E_t\left[\left(\frac{D_{T_n}}{D_t}\right)^{1-\gamma} \frac{P_{T_n}}{D_{T_n}}\right] \tag{B.7}$$

[1] Recall that Bayes' rule is $\Pr(A|B,C) = \frac{\Pr(B|A,C)\Pr(A|C)}{\Pr(A|C)}$

Conditioning on the current state, the following holds:

$$\frac{P_t}{D_t} = \sum_{j=1}^{N}\sum_{\tau=1}^{T_n-t}\beta^{\tau}E_t\left[\left(\frac{D_{t+\tau}}{D_t}\right)^{1-\gamma}\middle|z_n=j\right]\pi_{jt} + \sum_{j=1}^{N}\beta^{T_n-t}E_t\left[\left(\frac{D_{T_n}}{D_t}\right)^{1-\gamma}\middle|z_n=j\right]E_t\left[\frac{P_{T_n}}{D_{T_n}}\middle|z_n=j\right]\pi_{jt} \quad \text{(B.8)}$$

where Equation (B.8) follows from law of total probability and conditional independence of $\frac{D_{T_n}}{D_t}$ and $\frac{P_{T_n}}{D_{T_n}}$ when the conditioning information is the current state variable. Note that for any $t \in [T_{n-1}, T_n]$ and $\tau \in [1, T_n - t]$, we have

$$E_t\left[\left(\frac{D_{t+\tau}}{D_t}\right)^{1-\gamma}\middle|z_n=j\right] = E_t[\exp((1-\gamma)\mu_j\tau + (1-\gamma)\sigma_j\sum_{l=1}^{\tau}\varepsilon_{t+l})] \quad \text{(B.9)}$$

$$= \exp((1-\gamma)\mu_j + (1-\gamma)^2\sigma_j^2/2)^{\tau} \quad \text{(B.10)}$$

$$\equiv (e^{a_j})^{\tau} \quad \text{(B.11)}$$

where $a_j \equiv (1-\gamma)\mu_j + (1-\gamma)^2\sigma_j^2/2$. Equation (B.9) follows from the law of motion for the dividend growth rate. Equation (B.10) follows from the formula for the expectation of a lognormal variable where the mean and variance of the normal variable are $(1-\gamma)\mu_j\tau$ and $(1-\gamma)^2\sigma_j^2\tau$, respectively. The price-dividend ratio can be expressed as:

$$\frac{P_t}{D_t} = \sum_{j=1}^{N}\sum_{\tau=1}^{T_n-t}(\beta e^{a_j})^{\tau}\pi_{jt} + \sum_{j=1}^{N}(\beta e^{a_j})^{T_n-t}E_t\left[\frac{P_{T_n}}{D_{T_n}}\middle|z_n=j\right]\pi_{jt}$$

$$= \sum_{j=1}^{N}\left(\frac{(\beta e^{a_j})^{T_n-t+1}-1}{\beta e^{a_j}-1}-1\right)\pi_{jt} + \sum_{j=1}^{N}(\beta e^{a_j})^{T_n-t}E_t\left[\frac{P_{T_n}}{D_{T_n}}\middle|z_n=j\right]\pi_{jt} \quad \text{(B.12)}$$

The price-dividend ratio on the (n-1)th announcement day can be expressed as follows by setting $t = T_{n-1}$:

$$\frac{P_{T_{n-1}}}{D_{T_{n-1}}} = \sum_{j=1}^{N}\left(\frac{(\beta e^{a_j})^{T+1}-1}{\beta e^{a_j}-1}-1\right)q_{z_{n-1},j} + \sum_{j=1}^{N}(\beta e^{a_j})^{T}E_t\left[\frac{P_{T_n}}{D_{T_n}}\middle|z_n=j\right]q_{z_{n-1},j} \quad \text{(B.13)}$$

Equation (B.13) follows from the fact that $\pi_{j,T_{n-1}} = \sum_{l=1}^{N} q_{lj}1_{\{z_{n-1}=l\}} = q_{z_{n-1},j}$ and $T_n - T_{n-1} = T$.

In order to solve the difference equation in (B.13), we conjecture a solution for the price-dividend ratio on announcement days of the following form:

$$\frac{P_{T_n}}{D_{T_n}} = \lambda_{z_n} \text{ for } n = 1, 2, \dots \text{ and } z_n = 1, 2, \dots, N \tag{B.14}$$

Plugging in the conjecture in Equation (B.14), we obtain the following system of $N$ linear equations in $N$ variables, $(\lambda_1, \dots, \lambda_N)$:

$$\lambda_i = \sum_{j=1}^{N} \left( \frac{(\beta e^{a_j})^{T+1} - 1}{\beta e^{a_j} - 1} - 1 \right) q_{ij} + \sum_{j=1}^{N} (\beta e^{a_j})^T \lambda_j q_{ij} \tag{B.15}$$

for $i = 1, 2, \dots, N$. To reduce notation, we define a $N \times 1$ vector, $\mathbf{G}$, whose $j^{\text{th}}$ element, $g_j$, is given by $g_j = \frac{(\beta e^{a_j})^{T+1}-1}{\beta e^{a_j}-1} - 1$ and a $N \times N$ diagonal matrix, $\mathbf{H}$, whose $i^{\text{th}}$ diagonal element, $h_i$, is given by $h_i = (\beta e^{a_i})^T$. The system of equations in (B.15) can be expressed as follows:

$$\lambda = \mathbf{QG} + \mathbf{HQ}\lambda \tag{B.16}$$

Solving for the vector $\lambda$, we obtain the price-dividend ratio on announcement days in Lemma 2.2. This completes the proof. □

*Proof of Proposition 2.1.* Proof of Proposition follows from Equation (B.12). Note that $E_t[\frac{P_{T_n}}{D_{T_n}} | z_n = j] = \lambda_j$ from the result in Lemma 2.2. Plugging in, we obtain Equation (2.9) for the price-dividend ratio on non-announcement days. □

*Proof of Corollary 2.1.* Rearranging terms in the basic return equation, we obtain the following:

$$r_t = \frac{P_t + D_t - P_{t-1}}{P_{t-1}} = \frac{P_t/D_t + 1}{P_{t-1}/D_{t-1}} \frac{D_t}{D_{t-1}} - 1 \tag{B.17}$$

Plugging in the law of motion for the dividend growth in Equation (2.2) and the closed from solutions for the price-dividend ratio in Equation (2.9), we obtain the formula in Corollary 2.1. □

*Proof of Proposition 2.2.* Equation (2.14) follows immediately from the definition of returns and price-dividend ratio in Equation (2.9). The price-dividend ratio takes one of the two values depending on the state of the economy revealed on the announcement day. In other words, if the announcement reveals a high growth state for the economy, the price-dividend ratio on the announcement day, $P_{T^*}/D_{T^*}$ is equal $k_1$. Otherwise, it is equal $k_2$. The return on the announcement day can be expressed as:

$$r_{T^*} = \frac{(k_1 1_{\{z_{T^*}=1\}} + k_2 1_{\{z_{T^*}=2\}} + 1)e^{\mu_{z_{T^*}} + \sigma\varepsilon_{T^*}}}{k_1\pi_{T^*-1} + k_2(1-\pi_{T^*-1})} - 1 \tag{B.18}$$

Expected return on the announcement day can be expressed as follows:

$$\begin{aligned} E_{T^*-1}[r_{T^*}] &= E_{T^*-1}\left[\frac{(k_1 1_{\{z_{T^*}=1\}} + k_2 1_{\{z_{T^*}=2\}} + 1)e^{\mu_{z_{T^*}} + \sigma\varepsilon_{T^*}}}{k_1\pi_{T^*-1} + k_2(1-\pi_{T^*-1})} - 1\right] \\ &= \sum_{i=1}^{2} \frac{k_i + 1}{k_1\pi_{T^*-1} + k_2(1-\pi_{T^*-1})} E_{T^*-1}[e^{\mu_i + \sigma\varepsilon_{T^*}}] \Pr(z_{T^*} = i|\mathcal{F}_{T^*-1}) - 1 \end{aligned}$$

It is straightforward to obtain Equation (2.15) in Proposition 2.2 by plugging $E_{T^*-1}[e^{\mu_i+\sigma\varepsilon_{T^*}}] = e^{\mu_i+\sigma^2/2}$. On the other hand, the conditional volatility of returns on announcement days can be written as $var_{T^*-1}[r_{T^*}] = E_{T^*-1}[r^2_{T^*}] - (E_{T^*-1}[r_{T^*}])^2$. Plugging in the values for the conditional expectations, we obtain Equation (2.16). □

*Proof of Proposition 2.3.*

1. This follows directly from Proposition 2.2 and the definition of unanticipated news. Plugging in the definition and rearranging, we obtain return on announcement day as a function of unanticipated news.

2. When $\mu_1 > \mu_2$, it is relatively easy to show that $\gamma > 1$ implies that $k_2 - k_1 > 0$. Hence, the multiplicative factor in front of unanticipated news is positive when the announcement is positive, i.e. $z_{T^*} = 1$. Since return on announcement day is inversely related to unanticipated news, a positive coefficient on unanticipated news implies a negative relation between returns and unanticipated news. A similar argument holds for the case of negative announcement, i.e. $z_{T^*} = 2$. The reserve inequality holds when $\gamma < 1$, i.e. $k_2 - k_1 < 0$. Hence the opposite holds. In other words, a positive unanticipated news has a positive effect on returns on announcement days.

3. It follows directly from the return equation in the first implication. If $(k_1 + 1)e^{\mu_1} > (k_2 + 1)e^{\mu_2}$, then $r_{T*}$ is greater for the same magnitude of unanticipated news when the announcement reveals positive news (i.e. $z_{T*} = 1$). In other words, if the inequality holds, the absolute effect of a positive unanticipated news is greater that that of a negative unanticipated news of the same magnitude.

□

*Proof of Proposition 2.4.* This follows directly from Proposition 2.2 and the definition of uncertainty, $\omega_t$. □

## B.2 Estimation of Markov Regime Switching Vector Autoregressions (MS-VAR)

In this section, we discuss the algorithm employed to estimate the MS-VAR in Equation (2.39). The Markov regime switching model of Hamilton (1989) can be considered as a special case of an MS-VAR where the number of variables in the vector autoregression is one. Hence, a special case of the estimation approach discussed here is used to estimate the empirical model in Equation (2.21)[2].

The conditional likelihood of an MS-VAR can be calculated recursively similar to GARCH estimation. In this algorithm, the focus is on the conditional probability of observing a state rather than the switching probabilities between states. The conditional probability of observing a state is the weight on the mixture components. In its most general form, the specification for an MS(M)-VAR(P) of a $K$-dimensional vector of variables, $\mathbf{Y}_t = (Y_{1t}, \ldots, Y_{Kt})'$, where $M$ is the number of states and $P$ is the order of the vector autoregression, can be expressed as follows:

$$\mathbf{Y}_t = \begin{cases} \mathbf{A}_{01} + \mathbf{A}_{11}\mathbf{Y}_{t-1} + \ldots + \mathbf{A}_{p1}\mathbf{Y}_{t-P} + \mathbf{\Sigma}_1^{1/2}\mathbf{u}_t, & \text{if } S_t = 1 \\ \vdots & \vdots \\ \mathbf{A}_{0M} + \mathbf{A}_{1M}\mathbf{Y}_{t-1} + \ldots + \mathbf{A}_{PM}\mathbf{Y}_{t-P} + \mathbf{\Sigma}_M^{1/2}\mathbf{u}_t, & \text{if } S_t = M \end{cases} \tag{B.19}$$

for $t = 1, \ldots, T$ and $\mathbf{Y}_0, \ldots, \mathbf{Y}_{1-P}$ are fixed. $\mathbf{u}_t$ is a multivariate standard normal random variable, i.e. $\mathbf{u}_t \sim NID(\mathbf{0}, \mathbf{I}_K)$. Let $A_m(L) = \mathbf{I}_K - \mathbf{A}_{1m}L - \ldots - \mathbf{A}_{Pm}L^P$ denote the $(K \times K)$ dimensional lag operator in state $m$ where $L$ is the lag operator, so that $\mathbf{Y}_{t-p} = L^p\mathbf{Y}_t$. For stationarity, we assume that there are no roots on or inside the unit circle $|\mathbf{A}_m(z)| \neq 0$ for $|z| \leq 1$ and $m = 1, \ldots, M$. $S_t \in \{1, \ldots, M\}$ is the unobservable state variable that follows a discrete time, discrete state first-order irreducible ergodic Markov chain with the following transition probability matrix,

$$\{\Pr(S_t = i | S_{t-1} = j)\} = \{q_{ji}\} = \mathbf{Q} \tag{B.20}$$

Let $\mathcal{F}_{t-1}$ denote the $\sigma$-field generated by the lagged endogenous variables, i.e. $\mathcal{F}_{t-1} =$

[2]One should note that the notation used in this section is independent of the notation used in the text.

$\sigma(\mathbf{Y}'_{t-1},\ldots,\mathbf{Y}'_1,\mathbf{Y}'_0,\ldots,\mathbf{Y}'_{1-p})$, then the probability distribution of $\mathbf{Y}_t$ conditional on the state variable and the information set at time $t-1$, $f(\mathbf{Y}_t|S_t=m,\mathcal{F}_{t-1})$, can be expressed as follows:

$$f(\mathbf{Y}_t|S_t=m,\mathcal{F}_{t-1}) = \log(2\pi)^{-1/2}\log|\mathbf{\Sigma}_m|^{-1/2}\exp((\mathbf{Y}_t-\overline{\mathbf{Y}}_{mt})'\mathbf{\Sigma}_m^{-1}(\mathbf{Y}_t-\overline{\mathbf{Y}}_{mt})) \quad \text{(B.21)}$$

where $\overline{\mathbf{Y}}_{mt} = E[\mathbf{Y}_t|S_t=m,\mathcal{F}_{t-1}]$ is the conditional expectation of $\mathbf{Y}_t$ in regime $m$. In other words, the conditional density of $\mathbf{Y}_t$ for a given state $m$, i.e. $S_t=m$, is a multivariate normal, i.e. $\mathbf{Y}_t \sim NID(\overline{\mathbf{Y}}_{mt},\mathbf{\Sigma}_m)$. Collect these conditional probability distributions in an $(M\times 1)$ vector $\eta_t$:

$$\eta_t = \begin{pmatrix} f(\mathbf{Y}_t|S_t=1,\mathcal{F}_{t-1}) \\ \vdots \\ f(\mathbf{Y}_t|S_t=M,\mathcal{F}_{t-1}) \end{pmatrix} \quad \text{(B.22)}$$

Furthermore, let an $(M\times 1)$ vector $\xi_{t|t}$ denote the probability of the state variable, $S_t$, conditional on data obtained through date $t$, i.e.

$$\xi_{t|t} = \begin{pmatrix} \Pr(S_t=1|\mathcal{F}_t) \\ \vdots \\ \Pr(S_t=M|\mathcal{F}_t) \end{pmatrix} \quad \text{(B.23)}$$

One could also imagine forming forecasts of how likely the process is to be in state $m$ in period $t+1$ given observations through date $t$. Collect these forecasts in an $(M\times 1)$ vector $\xi_{t+1|t}$, which is a vector whose $m^{\text{th}}$ element represents $\Pr(S_{t+1}=m|\mathcal{F}_t)$.

The optimal inference and forecast for each date $t$ in the sample can be found by iterating on the following pair of equations:

$$\xi_{t|t} = \frac{(\xi_{t|t-1}\odot\eta_t)}{\mathbf{1}'(\xi_{t|t-1}\odot\eta_t)} \quad \text{(B.24)}$$

$$\xi_{t+1|t} = \mathbf{Q}\cdot\xi_{t|t} \quad \text{(B.25)}$$

where $\mathbf{1}$ represents an $(M\times 1)$ vector of 1s, and the symbol $\odot$ denotes element-by-element multiplication. Given a starting value $\xi_{1|0}$ and assumed values for the population parameters of the model, one can iterate Equations (B.24) and (B.25) for $t=1,2,\ldots,T$ to calculate the values of $\xi_{t|t}$ and $\xi_{t+1|t}$ for each date in the sample. One should note that the filtering algorithm discussed here is identical to investors' learning process. The log likelihood function $\mathcal{L}$ for the observed data in the information set, $\mathcal{F}_T$, can also be calculated as a by-product of this algorithm from

$$\mathcal{L} = \sum_{t=1}^{T} \log(\mathbf{1}'(\xi_{t|t-1} \odot \eta_t)) \tag{B.26}$$

Maximum likelihood (ML) estimation of the model is based on an implementation of the Expectation Maximization (EM) algorithm proposed by Hamilton (1989) for this class of models.

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