A Theory of the Market Response to Macroeconomic News under Bounded Rationality*

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Abstract

I develop a model of prescheduled macroeconomic announcements. My model analyzes the optimal allocation of attention between systematic and idiosyncratic risk factors when a macroeconomic announcement is anticipated. Skilled investors, when producing information under bounded rationality, allocate more of their attention to analyzing the idiosyncratic risk factor when they anticipate more precise public information about the systematic risk factor from the macroeconomic announcement. Consequently, my model predicts that, the more informative (precise) the macroeconomic announcement is expected to be about the underlying sources of risk, *ceteris paribus*, the more uncertainty pre-announcement, the more resolution of uncertainty post-announcement, and the higher the trading volume around the announcement on the market index. My model is consistent with patterns of abnormal returns, volatility, and trading volume documented in the empirical literature on macroeconomic announcements.

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1 Introduction

There has been considerable interest in investor behavior and asset returns around macroeconomic announcements such as FOMC, GDP growth, inflation, CPI, and PPI. Lucca and Moench (2015) document an average of 49 basis points (bp) increase in the return of S&P500 index during the 24 hours before scheduled Federal Open Market Committee (FOMC) announcements since 1994. Savor and Wilson (2013) document that the average return on the day of scheduled macroeconomic announcements such as CPI, PPI, employment, and FOMC announcements is 11.4 bp while it is 1.1 bp for all other days. Savor and Wilson (2014) find that the expected variance of daily market returns is positively related to future aggregated quarterly announcement day returns, but not to aggregated non-announcement day returns. Lucca and Moench (2015) also find that the trading volume of the E-mini S&P500 futures is lower than usual before the announcement and spikes up right after the announcement. This paper presents a model of scheduled macroeconomic announcements that can explain these observed regularities.[1]

I develop a dynamic model to analyze the behavior of investors under bounded rationality when there is a future scheduled macroeconomic announcement. There are two main ingredients in my model. First, investors trade based on both private and public signals about two different sources of risk — the systematic risk factor and an idiosyncratic risk factor — in the economy.[2] Second, there is bounded rationality in the form of limited attention capacity. Following the modeling approach of Kacperczyk, Van Nieuwerburgh, and Veldkamp (2016) for bounded rationality, I define an upper bound for the total precision of the private signals that can be generated by investors. Investors optimally allocate their attention to the production of information (private signals) about the two risk factors.

[1]Existing models for macroeconomic announcements include Ai and Bansal (2018) and Wachter and Zhu (2018). I discuss these papers below. Neither of the two models studies the trading volume around announcements.

[2]Albuquerque, Bauer, and Schneider (2009) provide evidence consistent with the existence of private information about the macro factor and explain US investors' trading behavior ("global return chasing") accordingly.

Consider a setting with three assets: a stock, the market index, and the riskfree asset. The payoff of the stock is affected by both the systematic risk factor and an idiosyncratic risk factor, while the payoff of the market index is affected only by the systematic risk factor. When engaging in information production, skilled investors allocate more of their attention to the risk factor that matters more to them; if more attention is paid to one risk factor, less attention is paid to the other risk factor.[3]

The capital market consists of skilled investors and liquidity traders. Skilled investors are able to produce information about the future realization of both the systematic and the idiosyncratic risk factors (therefore about the stock and the market index) under the constraint of bounded rationality. At date 0, before any signal (private or public) is revealed, skilled investors optimally make their attention allocation decisions on the systematic and idiosyncratic risk factors. At date 1, each skilled investor produces information about the systematic and idiosyncratic risk factors according to his/her *ex ante* attention allocation and forms his/her optimal portfolio. At date 2, the prescheduled macroeconomic announcement is released, each skilled investor observes the announcement and simultaneously (but independently) produces another round of information, and then rebalances his/her portfolio. At date 3, all payoffs are realized. Liquidity traders create no more than a mean-zero noise in the supply of assets.

Analysis of the model leads to the following results: First, for any given precision of the public signal, on the date of announcement, there is more information on the market observed from the macroeconomic announcement, so that both the uncertainty on the market index and the uncertainty on the stock (through the systematic risk factor) decrease, therefore the equilibrium prices of both risky assets are higher after the announcement than before the announcement. The resolution of uncertainty (due to the macroeconomic announcement as well as information production by skilled investors) also increases investors' demands of

[3]As will be mentioned later, the riskfree rate will be normalized as a fixed constant, so the riskfree asset does not require any attention. All of investors' available attention will be allocated between the two risk factors.

the risky assets, so that the levels of the trading volume of both assets are higher on the date of the announcement than before. Second, as the public signal from the prescheduled macroeconomic announcement gets more precise, *ceteris paribus*, investors shift some of their attention from the systematic risk factor and allocate more of their attention to the idiosyncratic risk factor. Intuitively, the information from the prescheduled macroeconomic announcement and the information from investors' private information on the systematic risk factor are substitutes for each other, so that, when investors anticipate that more information will come "for free" from the macroeconomic announcement, they would like to save that part of their attention to produce information on the idiosyncratic risk factor. Because of the attention shift, the precision of information produced about the systematic risk factor is lower, and the uncertainty on the market index is higher as the macroeconomic announcement is expected to be more precise. Consequently, the price of the market index decreases before the date of announcement while, by a similar argument, the price of the stock increases. Thus, when information is revealed, the price of the market index jumps by a greater extent at the time of the macroeconomic announcement if the public information is more precise.[4] Moreover, as the macroeconomic announcement gets more precise, the relative increase in the trading volume (the ratio of the post-announcement trading volume over the pre-announcement trading volume) on the market index is higher.

Because of bounded rationality, investors' attention allocation is an endogenous decision in my model, so that the precision of the private signals they receive is endogenously determined rather than exogenously fixed as in classical rational expectations equilibrium (REE) models. In equilibrium, investors respond to a more precise public signal by investing less of their attention to that risk factor. In thinking about the role of bounded rationality, one can compare with a benchmark REE model where the precision of private signals is exogenously fixed at the average between the precision of the private signal for the systematic risk factor

[4] In fact, the attention shift raises the uncertainty on the market index relative to the fully rational case, therefore, in equilibrium, the return on the market index is higher in my model than its counterpart in a fully rational model.

and the precision of the private signal for the idiosyncratic risk factor in a bounded rationality model. The tilt of attention allowed in the bounded rationality model leads (endogenously) to more uncertainty pre-announcement, more resolution of uncertainty post-announcement, and higher trading volume around macroeconomic announcements than in the benchmark model with a fixed precision of private signals.

My model is consistent with many of the stylized facts on macroeconomic announcements that have been documented in the empirical literature. First, my model predicts a positive relation between the expected variance and the expected return on the market index upon macroeconomic announcements, which is consistent with the evidence documented by Savor and Wilson (2014). Second, my model generates the prediction of an increase in the trading volume on the market index after a macroeconomic announcement. This is consistent with the spike in the trading volume of E-mini S&P500 futures right after scheduled FOMC announcements documented in Lucca and Moench (2015). Third, as the anticipated precision of the macroeconomic announcement increases, my model predicts a higher return on the market index upon the announcement. This is consistent with Brusa, Savor, and Wilson (2017) who show that, while high returns are documented in the case of FOMC announcements, similar high returns do not appear around monetary policy announcements by other central banks. Since the US is the dominant financial market in the world, it is possible that the information about the upcoming macroeconomic situation contained in the announcements from other central banks is not as precise as that provided by FOMC announcements, and thus FOMC announcements generate a uniquely high return afterwards.

Besides explaining the stylized facts documented by the existing empirical literature, my model also offers several empirical implications that have not yet been tested. First, as the anticipated precision of the macroeconomic announcement increases, my model predicts a higher relative increase in trading volume (a higher ratio between the post-announcement trading volume and the pre-announcement trading volume) on the market index (e.g. as measured by the trading volume of E-mini S&P500 futures), after controlling for the information effect of the macroeconomic announcement. Second, my model potentially allows a comparison between pre-scheduled and unscheduled announcements. If an announcement is a surprise, investors will not allocate their attention optimally, unlike in the case where they anticipate the announcement. In other words, in the case of an unanticipated announcement, we should only observe facts related to an information effect but not those related to attention shifting. Thus, conditional on the same magnitude of information surprise, both the market return and the trading volume on the market index should be lower around an unscheduled macroeconomic announcement than those around a scheduled macroeconomic announcement. This prediction has not been tested in the literature so far and can therefore serve as a unique test of my model.

The rest of the paper is organized as follows: In Section 2, I discuss how my paper is related to the existing literature. In Section 3, I describe the setup of the model. In Section 4, I characterize the equilibrium of the model, develop the analytical results, and present some numerical results from simulations. In Section 5, I discuss the empirical implications of my model. The proofs of all propositions and additional simulation results are provided in Appendices A and B, respectively.

2 Relation to the Existing Literature

My paper is related to several strands in the literature. The first is the theoretical literature consisting of fully rational models of macroeconomic announcements. Ai and Bansal (2018) characterize the intertemporal preferences that can generate positive announcement premia. Wachter and Zhu (2018) explain the more prominent relation between beta and expected returns on announcement days than on non-announcement days using a continuous-time rational model with possible rare disasters. They focus on the comparison between the security market line (SML) on announcement days and the SML on non-announcement days and do not study the trading volume around announcements. My model, where skilled investors have bounded rationality, provides not only the results on asset returns and the uncertainty-return relation but also the result on trading volume.

The second is the theoretical literature on bounded rationality and limited attention. Kacperczyk, Van Nieuwerburgh, and Veldkamp (2016) develop a static model with limited attention to study the behavior of mutual funds during expansions and recessions in the economy. I extend their framework to a dynamic setting with a public (macroeconomic) announcement. Sims (2003) models limited attention by suggesting an information-processing constraint (Shannon capacity) to be added into dynamic programming problems ("rational inattention") to model the inertial reactions documented in a macroeconomic setting. With entropy as the measure of uncertainty, the "informativeness" of information channels is defined through entropy. In his rational inattention setting, agents dynamically optimize the information channel depending on the distribution of incoming information so that the transformation errors are endogenous. Maćkowiak and Wiederholt (2009) build a model of limited attention to study the attention shift from aggregate conditions to idiosyncratic conditions by price-setting firms so that the price reaction to aggregate shocks is sticky while its reaction to idiosyncratic shocks is immediate.[5] Mondria (2010) develops a model in which investors are allowed to choose the structure of the information they desire to get, and explains the comovement of prices in seemingly unrelated assets. Gabaix (2014) introduces the sparse max operator to model agents' levels of attention paid to different goods and its consequences in a setting of consumer choice.[6]

The third strand in the literature related to my paper is the empirical literature on stock returns around macroeconomic announcements. Lucca and Moench (2015) document that there is an average of 49 basis points (bp) increase in the return of S&P500 index during the 24 hours before scheduled FOMC announcements. They also find that the trading volume of the E-mini S&P500 futures is lower than usual before the announcement, but then spikes up

[5] Maćkowiak and Wiederholt (2015) apply the concept of rational inattention to both firms and households to match the empirical impulse responses to both monetary policy shocks and aggregate technology shocks.

[6] Follow-up work along this stream of research includes Gabaix (2016a) on basic dynamic macroeconomics and Gabaix (2016b) on macroeconomic fiscal and monetary policy.

right after the announcement. Savor and Wilson (2013) document that the average return on the day of scheduled macroeconomic announcements, such as CPI, PPI, employment, and FOMC announcements, is 11.4 bp while 1.1 bp for all other days. Bernanke and Kuttner (2005) document a 1% increase in various broad stock indices and industry portfolios after an unanticipated 25 basis point cut in the Fed funds target rate. Boyd, Hu, and Jagannathan (2005) study the stock market reaction to announcements of the unemployment rate. Chen, Jiang, and Zhu (2017) find that, while the excess market trading volume is significantly higher on days with important macroeconomic news announcements, the excess turnover on stocks after earnings announcements on firms are significantly lower if there is a macroeconomic news announcement on the same day as the earnings announcement.

Finally, my model is related to the broader literature on information production and trading in the capital market with fully rational investors. Starting with the seminal papers by Grossman and Stiglitz (1980) and Hellwig (1980), a number of papers have applied the noisy REE equilibrium concept to modeling information production and trading in the capital markets. In these models, the stock price plays a dual role: one is to clear the markets, and the other is to (partially) reveal the private information generate by each investor to other investors. Admati (1985) extends the above models to a multi-asset setting, and Brennan and Cao (1997) provide an extension to a dynamic setting. Albuquerque (2012) builds a stationary model of firms with periodic but heterogeneous earnings announcement dates and dividend announcement dates, and show that the conditional variance of stock returns can increase by little or even drop at an earnings announcement if there is sufficient noise in the signals observed before the announcement. His prediction of a small post-announcement increase in the variance of stock returns is consistent with the evidence in Savor and Wilson (2013) that the realized volatility of daily stock market returns increases by only 4%.

3 Model Setup

I develop a discrete-time model to study how skilled investors optimally allocate their attention in anticipation of a prescheduled macroeconomic announcement. The model builds on the dynamic trading model in Brennan and Cao (1997) and the static attention allocation model in Kacperczyk, Van Nieuwerburgh, and Veldkamp (2016). Different from the linear attention allocation optimization problem in Kacperczyk, Van Nieuwerburgh, and Veldkamp (2016), the attention allocation optimization here becomes nonlinear because of the multiple-period dynamics and brings in mathematical complexity in solving it.

3.1 Assets and Risk Factors

There are three assets in the market: a stock, the market index, and the riskfree asset.

Riskfree asset. The riskfree asset offers a net return of r, which is normalized to 0. The riskfree asset has unlimited supply.

Risky assets. Asset s is a stock, and asset m is the market index. Their terminal payoffs, f_s and f_m, are represented by the following vector $\boldsymbol{f}$:

$$\boldsymbol{f} \equiv \begin{pmatrix} f_s \\ f_m \end{pmatrix} \equiv \boldsymbol{\mu} + \boldsymbol{\Gamma} \boldsymbol{z} \equiv \begin{pmatrix} \mu_s \\ \mu_m \end{pmatrix} + \begin{pmatrix} 1 & b \\ 0 & 1 \end{pmatrix} \begin{pmatrix} z_s \\ z_m \end{pmatrix} \tag{1}$$

where $\boldsymbol{z} \equiv (z_s, z_m)' \sim MVN(0, \boldsymbol{\Sigma})$ represents the vector of independent risk factors and its var-cov matrix $\boldsymbol{\Sigma} = \begin{pmatrix} \sigma_s^2 & 0 \\ 0 & \sigma_m^2 \end{pmatrix}$ is diagonal.

Two sources of risks affect the payoff of the individual stock: the systematic (market) risk z_m (with b the corresponding market beta) and the idiosyncratic risk z_s. The market index is affected only by the systematic risk z_m.

The supply vector of risky assets is defined through the supply of risk factors, as the model will be solved on risk factors. I represent the supply vector of risk factors by $\bar{\boldsymbol{x}} + \sum_{s=1}^{t} \boldsymbol{x}_s$, where $\boldsymbol{x}_s \sim MVN(0, \sigma_x^2 \boldsymbol{I}_2)$ is the amount of additional noisy supply at time s. In particular, the supply of risk factors at $t = 1$ is given by $\bar{\boldsymbol{x}} + \boldsymbol{x}_1$, and at $t = 2$ given by $\bar{\boldsymbol{x}} + \boldsymbol{x}_1 + \boldsymbol{x}_2$. Correspondingly, the supply of risky assets is $\boldsymbol{\Gamma}'^{-1}(\bar{\boldsymbol{x}} + \sum_{s=1}^{t} \boldsymbol{x}_s)$.

For the simplicity of notations but still to distinguish the items on risk factors from the items on risky assets, I use regular letters for the terms related to risk factors, e.g. $\boldsymbol{P}_t$ for the equilibrium price vector of the synthetic assets for risk factors, and $\boldsymbol{D}_t$ for the demand vector on the synthetic assets.[7] All corresponding terms on risky assets will be emphasized by "~", e.g. $\tilde{\boldsymbol{P}}_t$ and $\tilde{\boldsymbol{D}}_t$ for the equilibrium price vector of risky assets and the demand vector on risky assets respectively.

3.2 Timeline

There are four dates (three periods) in the model (Figure 1): $t = 0, 1, 2, 3$.

t=0	t=1	t=2	t=3
initial attention allocation	information production; portfolio formed	another round of information production; **macroeconomic announcement;** portfolio rebalanced	payoff realization

Figure 1: Timeline of Model

At $t = 0$, investors allocate their attention between the systematic risk factor and the idiosyncratic risk factor.[8] This allocation determines the precision of the private signals each investor will receive at $t = 1$ and 2. At $t = 1$, all investors observe private signals, as a result of information production, at their chosen precision levels, and form their optimal portfolios. At $t = 2$, the prescheduled macroeconomic announcement on the market occurs, and all

[7] For more details on the synthetic assets, please refer to Section 4.

[8] We interpret the attention allocated to the systematic risk factor as the attention allocated to the market index, since the payoff of the market index is only affected by the systematic risk factor. Similarly, the attention allocated to the idiosyncratic risk factor is interpreted as the attention allocated to the stock because the additional information investors learned about the stock is equivalent to the shock from the idiosyncratic risk factor.

investors observe another round of private signals at their chosen precision levels and then rebalance their portfolios optimally. At $t = 3$, all payoffs are realized.

3.3 Market Participants

There is a continuum of *ex ante* homogeneous skilled investors, indexed by $i \in [0, 1]$. Each investor is endowed with initial wealth W_0.[9,10]

Utility. On each trading date ($t = 1$ and 2), each investor i forms his/her optimal portfolio, by choosing the demand vector $\tilde{\boldsymbol{D}}_t^i$ on risky assets, in order to maximize his/her expected CARA utility of terminal wealth ($t = 3$),[11]

$$\max_{\tilde{\boldsymbol{D}}_t^i} E_t^i(-\exp[-\rho W_3^i]), \text{ at } t = 1 \text{ and } t = 2, \tag{2}$$

subject to the following budget constraints:

$$\text{at } t = 1 : \quad \text{initial wealth } W_1^i \equiv W_0, \forall i \in [0, 1]; \tag{3}$$

$$\text{at } t = 2 : \quad W_2^i = W_1^i + (\tilde{\boldsymbol{D}}_1^i)'(\tilde{\boldsymbol{P}}_2 - \tilde{\boldsymbol{P}}_1). \tag{4}$$

Investor i's terminal wealth is expressed by

$$W_3^i = W_2^i + (\tilde{\boldsymbol{D}}_2^i)'(\boldsymbol{f} - \tilde{\boldsymbol{P}}_2) = W_1^i + (\tilde{\boldsymbol{D}}_1^i)'(\tilde{\boldsymbol{P}}_2 - \tilde{\boldsymbol{P}}_1) + (\tilde{\boldsymbol{D}}_2^i)'(\boldsymbol{f} - \tilde{\boldsymbol{P}}_2). \tag{5}$$

Attention Allocation. At $t = 0$, each investor i allocates his/her attention capacity (upper limit) K to the idiosyncratic and systematic risk factors so that his/her time-0 expected utility is maximized. i.e., For each investor i, $K_s^i + K_m^i = K$, where K_s^i is investor i's

[9] Or, equivalently, each investor is endowed with $\boldsymbol{\Gamma}'^{-1}(1, 1)'$ of risky assets and $W_0 - (1, 1)'\boldsymbol{P}_0$ in cash (riskfree asset), where the initial price vector, $\boldsymbol{P}_0$, of risk factors clears the market at $t = 0$. I will only need this definition when comparing trading volumes across time.

[10] The assumption of homogeneous initial wealth is without loss of generality because the constant absolute risk aversion (CARA) utility used in the model has no wealth effect.

[11] Since the model will be solved *backwards*, I will explain portfolio formation (at $t = 1, 2$) first and attention allocation (at $t = 0$) next.

attention paid to the idiosyncratic risk factor, and K^i_m is his/her attention paid to the systematic risk factor. According to the allocated attention (K^i_s, K^i_m), investor i receives independent private signals for the two risk factors at $t = 1$ and 2: $\boldsymbol{\eta}^i_t = \boldsymbol{z} + \boldsymbol{\epsilon}^i_t$, where $\boldsymbol{\epsilon}^i_t \sim MVN(0, \boldsymbol{\Sigma}^i_\eta)$ and $\boldsymbol{\Sigma}^i_\eta \equiv \begin{pmatrix} [K^i_s]^{-1} & 0 \\ 0 & [K^i_m]^{-1} \end{pmatrix}$.

The utility maximization problem to be solved at $t = 0$ is therefore:

$$\max_{(K^i_s, K^i_m)} E_0(-\exp[-\rho W^i_3]), \text{ subject to } K^i_s + K^i_m = K \tag{6}$$

3.4 Macroeconomic Announcement

At $t = 2$, a public signal

$$\eta_{pub,m} = z_m + \epsilon_{pub,m}, \text{ where } \epsilon_{pub,m} \sim N(0, [prec_{pub,m}]^{-1}), \tag{7}$$

is observed by all skilled investors and reveals information on the systematic risk factor.[12]

4 Equilibrium and Results

The equilibrium concept I use is that of the symmetric noisy Rational Expectations Equilibrium (REE) of Grossman and Stiglitz (1980). All skilled investors have the same optimal attention allocation in equilibrium because of the *ex ante* homogeneity among skilled investors. However, notice that the realization of private signals is still different among investors and therefore skilled investors are *ex post* heterogenous and allocate their portfolios differently.

We solve for the equilibrium prices and demands analytically. To take the advantage of the independence between risk factors, I solve the model on the level of risk factors and then pull back for the results on assets as linear combinations.[13] Each risk factor (together

[12] In later sections, I also use the formal vector $\boldsymbol{\eta}_{pub} \equiv (0, \eta_{pub,m})'$ to accommodate the matrix expression in the analytical results. See Section 4.1 for more details.

[13] This also avoids the potential concern of changing correlations among assets (including market beta) in

with a linear transform of the expected return $\boldsymbol{\mu}$) can be viewed as a synthetic asset created by a linear combination of risky assets, so that the payoff vector of the synthetic assets is $\boldsymbol{\Gamma}^{-1}\boldsymbol{f} \equiv \boldsymbol{\Gamma}^{-1}\boldsymbol{\mu} + \boldsymbol{z}$ and the supply vector of these synthetic assets is $\bar{\boldsymbol{x}} + \sum_{s=1}^{t} \boldsymbol{x}_s$ for $t = 1, 2$. Notice that because of the fixed relation between factors and assets through a linear combination, once investors retrieve information on risky assets (equilibrium prices or public/private signals), they also know the corresponding information on risk factors and the synthetic assets and *vice versa*.

4.1 Bayesian Updating of Beliefs

Conditional on the attention allocation, (K_s^i, K_m^i), chosen at $t = 0$, investor i observes a vector of private signals on the two risk factors, $\boldsymbol{\eta}_t^i$ at $t = 1, 2$. I denote the information set of investor i at time $t \in \{1, 2\}$ by $\mathcal{F}_t^i$, i.e.,

$$\mathcal{F}_1^i = \{\boldsymbol{P}_1, \boldsymbol{\eta}_1^i, \boldsymbol{p}_1\} \tag{8}$$

$$\mathcal{F}_2^i = \{\boldsymbol{P}_1, \boldsymbol{P}_2, \boldsymbol{\eta}_1^i, \boldsymbol{\eta}_2^i, \boldsymbol{\eta}_{pub}\}, \tag{9}$$

where $\boldsymbol{P}_t$ is the equilibrium price vector of the synthetic assets for risk factors, and $\boldsymbol{\eta}_{pub} = \begin{pmatrix} 0 \\ \eta_{pub,m} \end{pmatrix}$, with $\boldsymbol{\Sigma}_{pub}^{-1} \equiv \begin{pmatrix} 0 & 0 \\ 0 & prec_{pub,m} \end{pmatrix}$.[14,15]

As I will prove in Proposition 1, the equilibrium price vector $\boldsymbol{P}_t$ generates an unbiased "signal" (estimator) for the final payoffs of risk factors, i.e.

$$\boldsymbol{\eta}_{\boldsymbol{p},t} \equiv \boldsymbol{z} + \boldsymbol{\epsilon}_{\boldsymbol{p},t}, \text{ where } \boldsymbol{\epsilon}_{\boldsymbol{p},t} \sim MVN(0, \boldsymbol{\Sigma}_{\boldsymbol{p},t}). \tag{10}$$

By the standard process of Bayesian updating, the posterior belief of investor i about $\boldsymbol{z}$ at

the case of receiving signals directly on assets.

[14]Without loss of generality, I set 0 as the first component of $\boldsymbol{\eta}_{pub}$ so that the dimensions of the matrices balance. Because of the zeros in $\boldsymbol{\Sigma}_{pub}^{-1}$, the value of the first component of $\boldsymbol{\eta}_{pub}$ does not matter essentially.

[15]From the discussion at the end of the preamble of this section, it is equivalent for investors to know prices on assets or the synthetic assets of risk factors.

$t = 1$ is $\boldsymbol{z}|_{\mathcal{F}_1^i} \sim MVN(\hat{\boldsymbol{z}}_1^i, \hat{\boldsymbol{\Sigma}}_1^i)$, where

$$
\begin{aligned}
\hat{\boldsymbol{z}}_1^i &= \hat{\boldsymbol{\Sigma}}_1^i[(\boldsymbol{\Sigma}_{\boldsymbol{\eta}}^i)^{-1}\boldsymbol{\eta}_1^i + \boldsymbol{\Sigma}_{\boldsymbol{p},1}^{-1}\boldsymbol{\eta}_{\boldsymbol{p},1}], & (11)\\
(\hat{\boldsymbol{\Sigma}}_1^i)^{-1} &= \boldsymbol{\Sigma}^{-1} + (\boldsymbol{\Sigma}_{\boldsymbol{\eta}}^i)^{-1} + \boldsymbol{\Sigma}_{\boldsymbol{p},1}^{-1}. & (12)
\end{aligned}
$$

Similarly, the posterior belief at $t = 2$ is $\boldsymbol{z}|_{\mathcal{F}_2^i} \sim MVN(\hat{\boldsymbol{z}}_2^i, \hat{\boldsymbol{\Sigma}}_2^i)$, where

$$
\begin{aligned}
\hat{\boldsymbol{z}}_2^i &= \hat{\boldsymbol{\Sigma}}_2^i[(\hat{\boldsymbol{\Sigma}}_1^i)^{-1}\hat{\boldsymbol{z}}_1^i + (\boldsymbol{\Sigma}_{\boldsymbol{\eta}}^i)^{-1}\boldsymbol{\eta}_2^i + \boldsymbol{\Sigma}_{\boldsymbol{p},2}^{-1}\boldsymbol{\eta}_{\boldsymbol{p},2} + \boldsymbol{\Sigma}_{pub}^{-1}\boldsymbol{\eta}_{pub}] & (13)\\
(\hat{\boldsymbol{\Sigma}}_2^i)^{-1} &= (\hat{\boldsymbol{\Sigma}}_1^i)^{-1} + (\boldsymbol{\Sigma}_{\boldsymbol{\eta}}^i)^{-1} + \boldsymbol{\Sigma}_{\boldsymbol{p},2}^{-1} + \boldsymbol{\Sigma}_{pub}^{-1} & (14)
\end{aligned}
$$

4.2 Equilibrium Prices and Demands

Given their updated beliefs of $\boldsymbol{z}$, skilled investors form their optimal portfolios $\{\boldsymbol{D}_t^i\}_{i\in[0,1]}$ to maximize their expected CARA utility of terminal wealth $E_t^i(-\exp[-\rho W_3^i])$. The equilibrium prices $\boldsymbol{P}_t$ clear markets, i.e.,

$$
\int_0^1 \boldsymbol{D}_t^i di = \bar{\boldsymbol{x}} + \sum_{s=1}^{t} \boldsymbol{x}_s \qquad (15)
$$

Proposition 1 *At $t = 1, 2$, the vectors of equilibrium prices of the synthetic assets for risk factors are, respectively,*

$$
\begin{aligned}
\boldsymbol{P}_1 &= [\boldsymbol{\Gamma}^{-1}\boldsymbol{\mu} - \rho\overline{\hat{\boldsymbol{\Sigma}}}_1\bar{\boldsymbol{x}}] + \overline{\hat{\boldsymbol{\Sigma}}}_1[(\boldsymbol{I}_2 + \rho^{-2}\sigma_x^{-2}\overline{\boldsymbol{\Sigma}}_{\boldsymbol{\eta}}^{\prime -1})\overline{\boldsymbol{\Sigma}}_{\boldsymbol{\eta}}^{-1}(\boldsymbol{z} - \rho\overline{\boldsymbol{\Sigma}}_{\boldsymbol{\eta}}\boldsymbol{x}_1)] & (16)\\
\boldsymbol{P}_2 &= [\boldsymbol{\Gamma}^{-1}\boldsymbol{\mu} - \rho\overline{\hat{\boldsymbol{\Sigma}}}_2\bar{\boldsymbol{x}}] \\
&\quad + \overline{\hat{\boldsymbol{\Sigma}}}_2[\boldsymbol{\Sigma}_{pub}^{-1}\boldsymbol{\eta}_{pub} + \sum_{t=1}^{2}(\boldsymbol{I}_2 + \rho^{-2}\sigma_x^{-2}\overline{\boldsymbol{\Sigma}}_{\boldsymbol{\eta}}^{\prime -1})\overline{\boldsymbol{\Sigma}}_{\boldsymbol{\eta}}^{-1}(\boldsymbol{z} - \rho\overline{\boldsymbol{\Sigma}}_{\boldsymbol{\eta}}\boldsymbol{x}_t)] & (17)
\end{aligned}
$$

where $\overline{\boldsymbol{\Sigma}}_{\boldsymbol{\eta}}^{-1}$ represents the average precision of private signals among all skilled investors and $\overline{\hat{\boldsymbol{\Sigma}}}_t^{-1}$ represents the average precision of skilled investors' posterior beliefs on $\boldsymbol{z}$ at $t = 1, 2$, and $\boldsymbol{\eta}_{pub} = \begin{pmatrix} 0 \\ \eta_{pub,m} \end{pmatrix}$, with $\boldsymbol{\Sigma}_{pub}^{-1} \equiv \begin{pmatrix} 0 & 0 \\ 0 & prec_{pub,m} \end{pmatrix}$.

Accordingly, the equilibrium price vector of risky assets at $t = 1, 2$ is $\tilde{\boldsymbol{P}}_t = \boldsymbol{\Gamma}\boldsymbol{P}_t$.

Conditional on the private signals and the public announcement (if applicable), the extra information investors learn from the equilibrium price $\boldsymbol{P}_t$ is

$$\boldsymbol{\eta}_{p,t} = \boldsymbol{z} - \rho\overline{\boldsymbol{\Sigma}}_{\boldsymbol{\eta}}\boldsymbol{x}_t, \text{ where } \overline{\boldsymbol{\Sigma}}_{\boldsymbol{\eta}}^{-1} \equiv \int_0^1 (\boldsymbol{\Sigma}_{\boldsymbol{\eta}}^i)^{-1} di. \tag{18}$$

Thus, in (10), $\boldsymbol{\Sigma}_{\boldsymbol{p},t} = \rho^2\sigma_x^2\overline{\boldsymbol{\Sigma}}_{\boldsymbol{\eta}}\overline{\boldsymbol{\Sigma}}_{\boldsymbol{\eta}}'$.

Proposition 2 *Investor i's demand vector for (the synthetic asset of) risk factors at $t = 1, 2$ is*

$$\boldsymbol{D}_t^i = \rho^{-1}(\hat{\boldsymbol{\Sigma}}_t^i)^{-1}[\boldsymbol{\Gamma}^{-1}\boldsymbol{\mu} + \hat{\boldsymbol{z}}_t^i - \boldsymbol{P}_t] \tag{19}$$

Accordingly, the demand vector for risky assets at time t is $\tilde{\boldsymbol{D}}_t = (\boldsymbol{\Gamma}^{-1})'\boldsymbol{D}_t^i, t = 1, 2$.

4.3 Attention Allocation

Moving backward to $t = 0$, with results from Propositions 1 and 2 substituted in, I write down the final optimization to solve:

Proposition 3 *Investor i's optimal attention allocation is determined by the following utility maximization problem:*

$$\begin{aligned}
& \max_{\boldsymbol{\Sigma}_\eta^i} E_0(-\exp[-\rho W_3^i]) \\
= \; & -\det([(\hat{\boldsymbol{\Sigma}}_2^i)^{-1}\boldsymbol{V}_{1,\Delta\boldsymbol{P}}^i(\boldsymbol{y}) + \boldsymbol{I}_2]^{-1}[\boldsymbol{B}'\boldsymbol{V}_{1,\Delta\boldsymbol{P}}^i(\boldsymbol{z})^{-1}\boldsymbol{B}\boldsymbol{V}_1^i(\Delta\boldsymbol{P}) + \boldsymbol{I}_2]^{-1} \\
& [\boldsymbol{M}\boldsymbol{V}_0^i + \boldsymbol{I}_2]^{-1})^{-1} \\
& \cdot \exp(-\rho W_0 + \frac{1}{2}(\boldsymbol{E}^i)'[(\boldsymbol{V}^i)^{-1}(\boldsymbol{M} + (\boldsymbol{V}^i)^{-1})^{-1}(\boldsymbol{V}^i)^{-1} - (\boldsymbol{V}^i)^{-1}]\boldsymbol{E}^i), \\
& \textit{subject to } trace([\boldsymbol{\Sigma}_{\boldsymbol{\eta}}^i]^{-1}) \equiv K_s^i + K_m^i = K
\end{aligned} \tag{20}$$

where $\boldsymbol{E}^i$ and $\boldsymbol{V}^i$ denote investor i's time-0 expectation and variance of $\boldsymbol{\Gamma}^{-1}\boldsymbol{\mu} + \hat{\boldsymbol{z}}_1^i - \boldsymbol{P}_1$ (expected return at $t = 1$ in investor i's opinion), and $\boldsymbol{y} \equiv \boldsymbol{\Gamma}^{-1}\boldsymbol{\mu} + \hat{\boldsymbol{z}}_2^i - \boldsymbol{P}_2$ represents the *expected return at $t = 2$ in investor i's opinion, and other notations are as follows:*

$$
\begin{aligned}
\boldsymbol{B} &\equiv \boldsymbol{V}^i_{1,\Delta\boldsymbol{P}}(\boldsymbol{z})[\boldsymbol{V}^{-1}(\boldsymbol{\epsilon}_{\Delta\boldsymbol{P}})(\overline{\hat{\boldsymbol{\Sigma}}_2}^{-1} - \overline{\hat{\boldsymbol{\Sigma}}_1}^{-1})\overline{\hat{\boldsymbol{\Sigma}}_1}^{-1} - (\hat{\boldsymbol{\Sigma}}^i_1)^{-1}] \\
\boldsymbol{M} &\equiv (\hat{\boldsymbol{\Sigma}}^i_1)^{-1}\boldsymbol{V}^i_{1,\Delta\boldsymbol{P}}(\boldsymbol{z})(\hat{\boldsymbol{\Sigma}}^i_1)^{-1} \\
&\quad +(\overline{\hat{\boldsymbol{\Sigma}}_2}^{-1} - \overline{\hat{\boldsymbol{\Sigma}}_1}^{-1})\overline{\hat{\boldsymbol{\Sigma}}_2}V^i_1(\Delta\boldsymbol{P})^{-1}\overline{\hat{\boldsymbol{\Sigma}}_2}(\overline{\hat{\boldsymbol{\Sigma}}_2}^{-1} - \overline{\hat{\boldsymbol{\Sigma}}_1}^{-1}) \\
\boldsymbol{V}^i_{1,\Delta\boldsymbol{P}}(y) &\equiv \textit{cov-var. matrix of } \boldsymbol{y} \textit{ conditional on } \mathcal{F}^i_1 \textit{ and } \boldsymbol{P}_2 - \boldsymbol{P}_1 \\
\boldsymbol{V}^i_{1,\Delta\boldsymbol{P}}(z) &\equiv \textit{cov-var. matrix of } \boldsymbol{z} \textit{ conditional on } \mathcal{F}^i_1 \textit{ and } \boldsymbol{P}_2 - \boldsymbol{P}_1 \\
\boldsymbol{V}^i_1(\Delta\boldsymbol{P}) &\equiv \textit{cov-var. matrix of } \boldsymbol{P}_2 - \boldsymbol{P}_1 \textit{ conditional on } \mathcal{F}^i_1
\end{aligned}
$$

4.4 Simulation Results

Because of mathematical complexity, I use numerical simulations to solve for the optimal attention allocation at $t = 0$ and the corresponding equilibrium prices, asset returns, and trading volumes around macroeconomic announcements. To interpret results intuitively in the stylized model, I apply a set of benchmark parameters that are symmetric between the two risk factors. Table 1 lists all the parameters used.

Parameter	Symbol	Value
Risk aversion parameter	ρ	1
Expected payoff of assets	$\boldsymbol{\mu}$	$(15, 15)'$
Market beta of stock	b	0.7
Distribution of shocks in risk factors	$\boldsymbol{z}$	$MVN(0, \begin{bmatrix} 0.5 & 0 \\ 0 & 0.5 \end{bmatrix})$
Number of skilled investors		500
Attention capacity	K	1
Expected supply of risk factors	$\bar{\boldsymbol{x}}$	$(1, 1)'$
Distribution of additional supply of risk factors	$\boldsymbol{x}_t$	$MVN(0, \begin{bmatrix} 0.5 & 0 \\ 0 & 0.5 \end{bmatrix})$

Table 1: Parameters Used in Simulation

Result 1. Attention allocation:

If there is no public signal, or a very imprecise public signal, investors have to allocate their attention to both risk factors to maximize their utility. With my symmetric setup of parameters, investors devote their attention equally between the two risk factors, as shown by the y-intercept in Figure 2. As the public signal from the macroeconomic announcement gets more precise, investors shift some of their attention from the market factor and allocate more of their attention to the idiosyncratic risk factor (Figure 2).

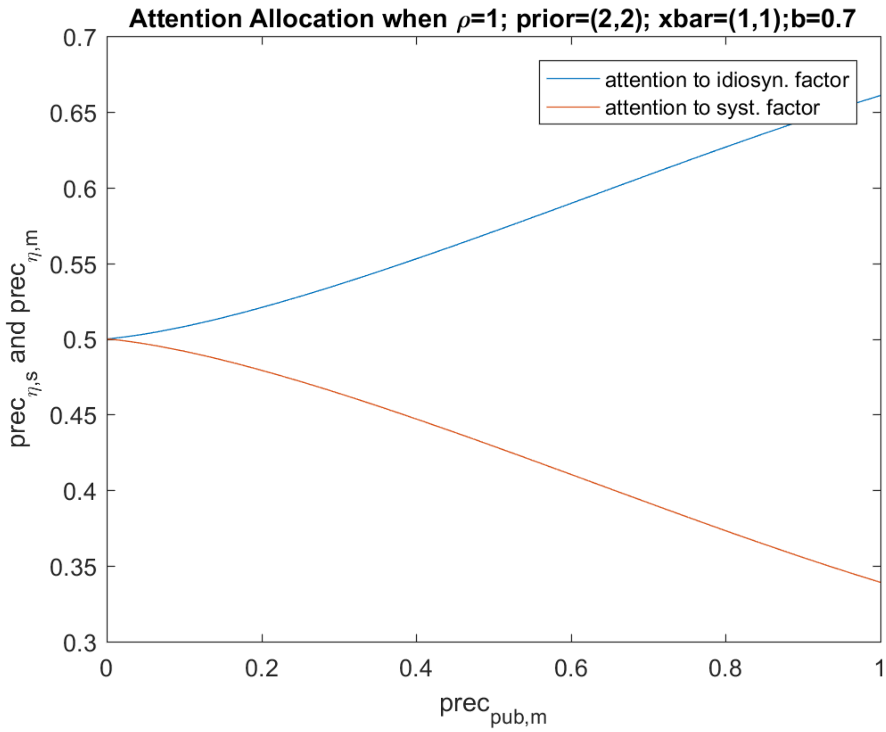

Figure 2: Attention Allocation as a Function of Public Signal Precision

Result 2. Equilibrium Prices:

From Result 1, the more precise the macroeconomic announcement is, the more attention is allocated to the idiosyncratic risk factor and less attention to the systematic risk factor. Thus, at $t = 1$, the private signal for the market from information production is less precise and then uncertainty on the market is higher, so that the price of the market index decreases; by a similar argument, the price of the stock increases. At $t = 2$, because of the macroeconomic announcement, there is more public information about the systematic risk factor even though the private information production is still at the same precision level as that of $t = 1$, so that the price of the market index increases. The price of the stock still increases as more private signals are observed from information production (Figure 3).

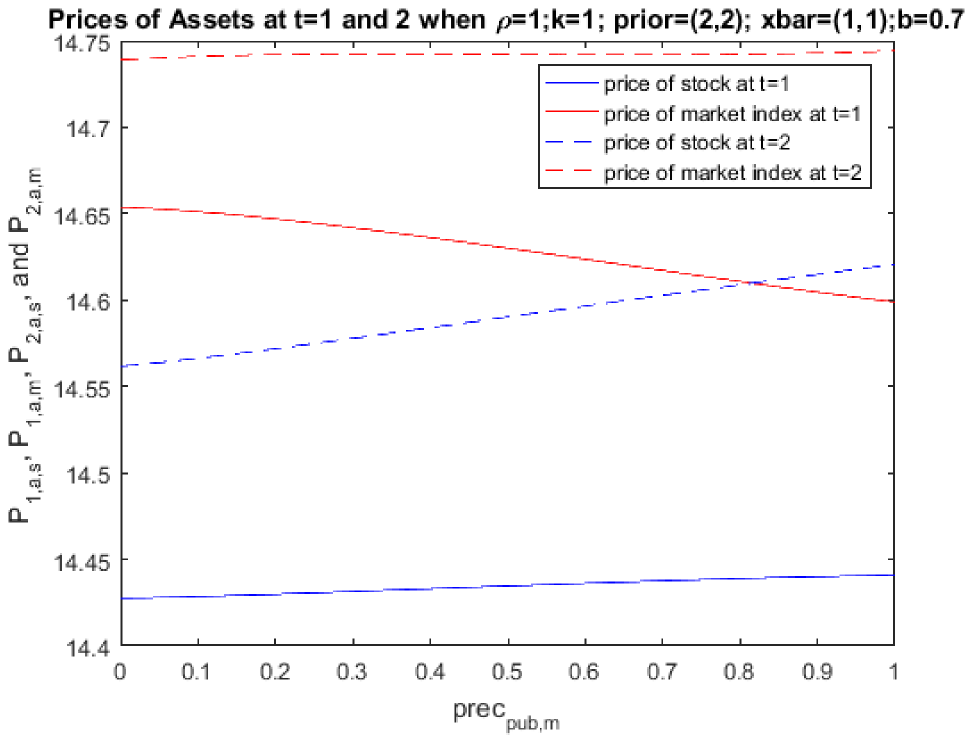

Figure 3: Equilibrium Price as a Function of Public Signal Precision

Result 3. Returns on Assets:

As I compare the trends of the prices of the two assets at $t = 2$ to their counterparts at $t = 1$, it is easy to see that both the return on the market index and the return on the stock should increase when the macroeconomic announcement gets more precise. This is confirmed by Figure 4. This result is consistent with the strong stock market reaction to surprise Fed fund rate changes as documented in Bernanke and Kuttner (2005). It also matches the observed stylized facts on market index (Lucca and Moench, 2015) when we take potential information leakage into consideration.[16]

The trend of asset returns is accompanied by the similar trend of return volatility, represented by the standard deviation of asset returns from $t = 1$ to $t = 2$ (Figure 5). This is consistent with the positive relation between the expected variance of daily market returns and the aggregated quarterly announcement day returns documented by Savor and Wilson

[16]See Bernile, Hu, and Tang (2016) and Cieslak, Morse, and Vissing-Jorgensen (2018) for discussion on information leakage during the 30-min period (news embargoes) before FOMC meetings and other informal communication on days other than FOMC announcements, respectively.

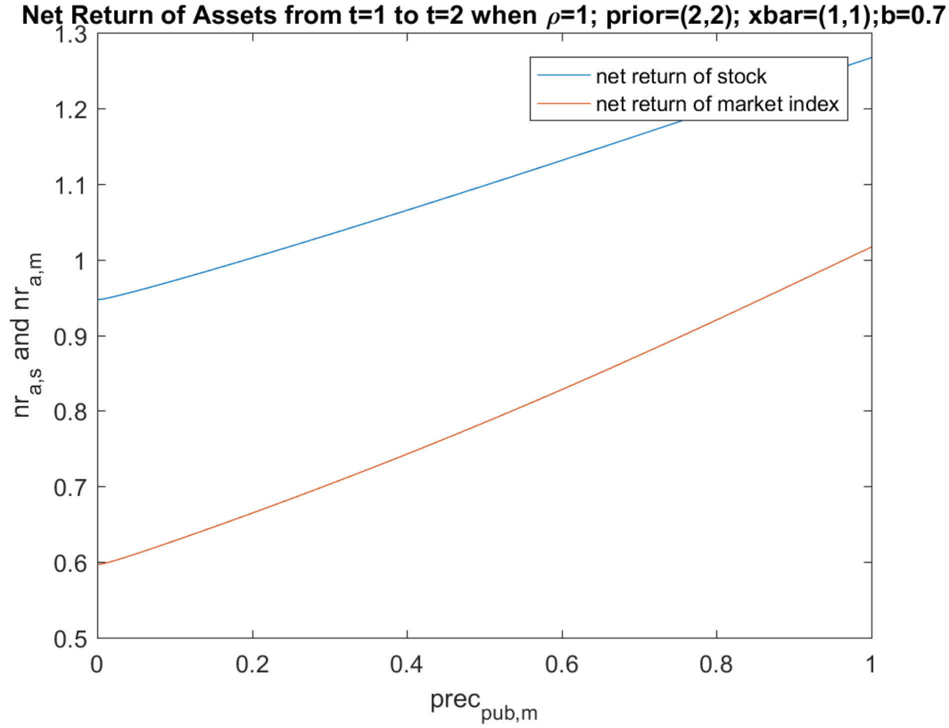

Figure 4: Return of Assets as a Function of Public Signal Precision

(2014).

Result 4. Trading volume of market index:

As public announcement reveals more information about the market, uncertainty is lower and thus demand for the index is higher. This leads to the first observation in Figure 6 that the trading volume increases on the index overall regardless of the precision of the announcement. Besides, recalled from Result 1, the more precise the macroeconomic announcement is, the more attention is allocated to the idiosyncratic risk factor. From (13) and (14), the posterior belief of a skilled investor at $t = 2$ is a weighted average of that investor's prior belief (i.e. posterior belief at $t = 1$), private signal received, and the public announcement, with weights determined by the precision of each component. As the precision of the macroeconomic announcement increases, the weight of the public information in investors' posterior beliefs of the market increases. This will drive skilled investors' beliefs of the market close to each other and therefore decreases the trading volume on the market index gradually. A similar argument follows at $t = 1$ since investors' prior beliefs take greater weight when

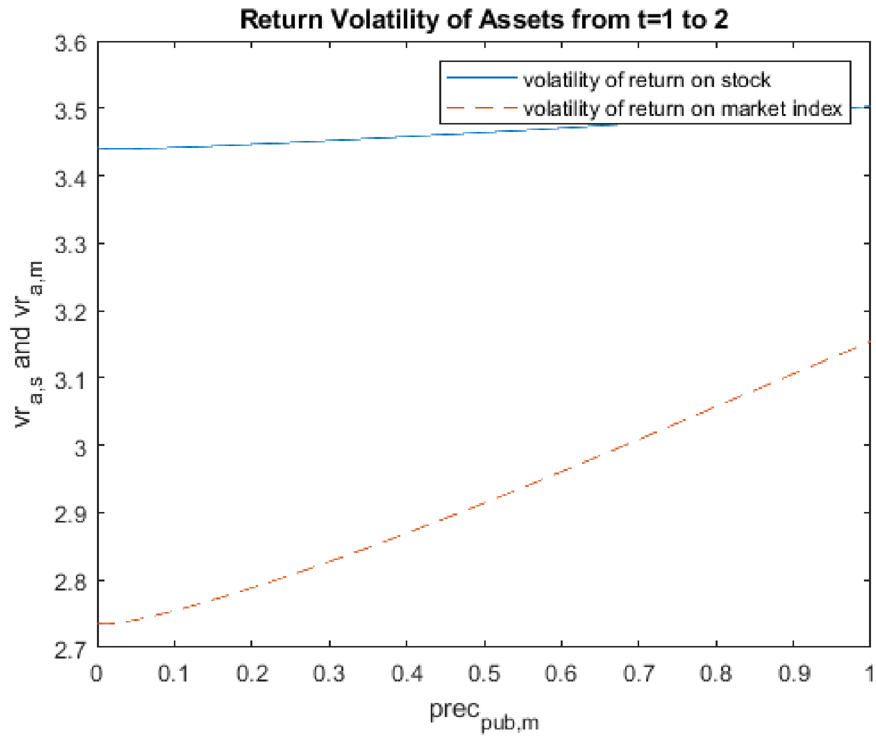

Figure 5: Return Volatility of Assets as a Function of Public Signal Precision

updating beliefs (shown in (11) and (12)) as the public announcement gets more precise. This leads to the downward trend shown in Figure 6.

Result 5. Ratio of trading volume of market index across time:

To have a better interpretation of the increase in trading volume from $t = 1$ to $t = 2$, I calculate the ratio of the trading volumes across the two periods. The result is shown in Figure 7. The trading volume at $t = 2$ can be interpreted as "corrections" to the portfolio allocation at $t = 1$ after investors observe more information at $t = 2$. On the one hand, as more precise public signal is expected to be observed from the macroeconomic announcement, less attention is paid to the systematic risk factor, and this creates more "mistakes" *a priori* at $t = 1$ in skilled investors' portfolio allocation. On the other hand, at $t = 2$, the precise public signal is actually observed, and investors are more able to "correct" their "mistakes" by then. Altogether, the relative increase in trading volumes increases in the precision of the announcement, as confirmed by the upward trend of the ratio.

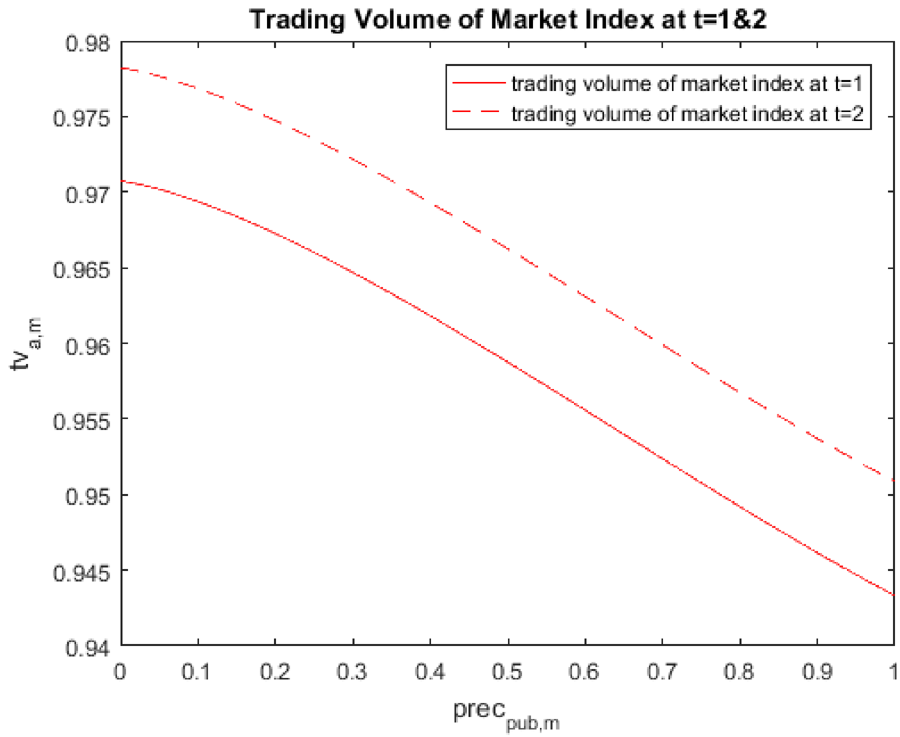

Figure 6: Level of Trading Volume on Market Index as a Function of Public Signal Precision

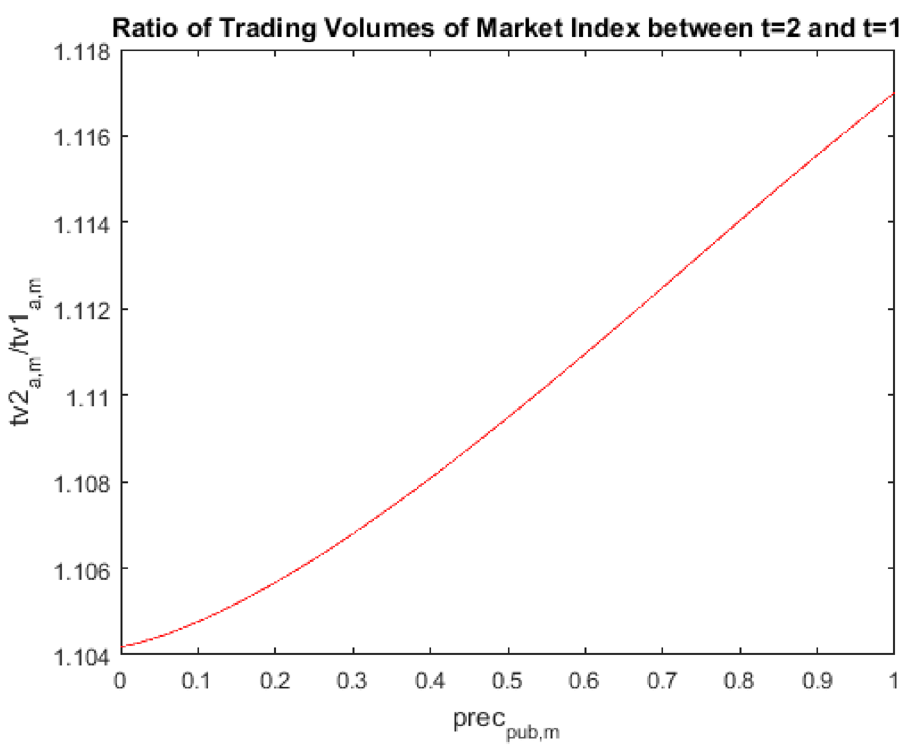

Figure 7: Ratio of Trading Volume on Market Index as a Function of Public Signal Precision

5 Empirical Implications

The model generates several empirical implications, which I describe below.

Implication 1. Attention allocation in anticipation of different macroeconomic announcements.

My model predicts that when a more precise macroeconomic announcement is expected, skilled investors will allocate more of their attention to the idiosyncratic risk factors, i.e. risk factors that do not expect an announcement in the near future. Among all the macroeconomic announcements, e.g. FOMC announcements, consumer price index (CPI), producer price index (PPI), and unemployment, FOMC announcements are likely to contain more precise forward-looking information on the Fed funds target rate while many others are statements of the past and current economic conditions with a less precise forecast of the future. Thus an empirical implication of my model is that investors pay more attention to information production about idiosyncratic risk factors when an FOMC announcement is expected than they pay when other macroeconomic announcements are expected. Potential proxies for attention/inattention include trading volume on assets (Hou, Xiong, and Peng, 2009), whether an announcement occurs on Friday (DellaVigna and Pollet, 2009), and whether the number of competing announcements is high on the same day (Hirshleifer, Lim, and Teoh, 2009).

Implication 2. Return on the market index around different macroeconomic announcements.

My model predicts that the market return will be higher around a more precise macroeconomic announcement than around a less precise announcement. This is consistent with the observation documented by Brusa, Savor, and Wilson (2017) that, while in the case of FOMC announcements high returns are documented, similar high returns do not appear around monetary policy announcements by other central banks. This is consistent with my model's predictions since US is the dominant financial market in the world. This is also consistent with the evidence of Lucca and Moench (2015) who document the pre-FOMC return on the S&P500 index. While the pre-FOMC market return in Lucca and Moench (2015) is specific to the 24 hours before the scheduled FOMC announcements, it does not exclude the possibility of information leakage during that period (Bernile, Hu, and Tang (2016), using high-frequency data, find that during news embargoes before scheduled FOMC announcements there are significant E-mini S&P500 futures abnormal order imbalances in the same direction as the policy surprises to be revealed in the following announcements about 30 mins later).[17] The result predicted by my model here is consistent with their observation if I take information leakage into consideration.

Implication 3. The level of trading volume around macroeconomic announcements.

My model predicts that the level of trading volume on the market index will increase after a macroeconomic announcement. This is consistent with the stylized fact that trading volumes are higher after announcements. For example, Lucca and Moench (2015) document that the trading volume of E-mini S&P 500 futures spikes up right after scheduled FOMC announcements.

Implication 4. Trading volumes around different macroeconomic announcements.

My model predicts that the relative increase in the trading volume of the market index will be higher when the macroeconomic announcement is more precise. In the context of various macroeconomic announcements, I expect to observe a higher increase in the trading volume of market index (e.g. S&P 500 futures) around FOMC announcements than other macroeconomic announcements.

Implication 5. Market return and trading volume around scheduled vs. unscheduled announcements.

If an announcement pops up as a surprise, investors will not allocate their attention in the way as if they anticipate the announcement *a priori*. In that case, I should only observe facts related to information effect but not those related to attention shifting. Thus, conditional on the same magnitude of information surprise, both the market return and the trading volume

[17] Cieslak, Morse, and Vissing-Jorgensen (2018) also mention that there is informal communication about the Fed policies before the official FOMC announcement.

on the market index should be lower around an unscheduled macroeconomic announcement than around a scheduled macroeconomic announcement. This has not been tested so far in the literature and can therefore serve as a unique test of my model.

Implication 6. Attention capacities across investors and trading volume.

We observe from the attention allocation optimization problem that if skilled investors' attention capacity increases, there will be more attention available to be (potentially) allocated to both risk factors, so that skilled investors expect more precise private signals from their information production and further increase the trading volume of assets. In reality, although human beings generally have similar attention limitations, technology can help eliminate the necessary attention need for the same piece of information, or equivalently, help expand the horizon of information production with the same amount of "attention". Thus, my model predicts that the trading volumes from the institutional investors will higher than retail investors.

6 Conclusion

There has been considerable interest in the abnormal returns and pattern of trading volumes on equity indices that have been documented around prescheduled macroeconomic announcements (e.g., Lucca and Moench (2015)). In this paper, I develop a dynamic model analyzing the optimal allocation of attention between idiosyncratic and systematic risk factors when a macroeconomic announcement is prescheduled to explain these empirical regularities. In my setting, institutional (skilled) investors have bounded rationality when engaging in information production about the above two risk factors, with the precision of their private information signals about a given risk factor being an increasing function of the attention they devote to producing information about that risk factor. I develop results for the effect of the expected precision of the macroeconomic announcement on institutional investors' equilibrium allocation of attention to producing information about the above two risk factors and the consequences of this attention allocation for asset prices, stock returns, and trading volumes around the macroeconomic announcement. Some of the results of my theoretical analysis are consistent with the existing empirical evidence and others help to develop testable hypotheses for new empirical tests.

References

Admati, Anat R, 1985, A noisy rational expectations equilibrium for multi-asset securities markets, *Econometrica: Journal of the Econometric Society* 629–657.

Ai, Hengjie, and Ravi Bansal, 2018, Risk preferences and the macroeconomic announcement premium, *Econometrica* 86, 1383–1430.

Albuquerque, Rui, 2012, Skewness in stock returns: reconciling the evidence on firm versus aggregate returns, *The Review of Financial Studies* 25, 1630–1673.

Albuquerque, Rui, Gregory H. Bauer, and Martin Schneider, 2009, Global private information in international equity markets, *Journal of Financial Economics* 94, 18 – 46.

Bernanke, Ben S, and Kenneth N Kuttner, 2005, What explains the stock market's reaction to federal reserve policy?, *The Journal of finance* 60, 1221–1257.

Bernile, Gennaro, Jianfeng Hu, and Yuehua Tang, 2016, Can information be locked up? informed trading ahead of macro-news announcements, *Journal of Financial Economics* 121, 496–520.

Boyd, John H, Jian Hu, and Ravi Jagannathan, 2005, The stock market's reaction to unemployment news: Why bad news is usually good for stocks, *The Journal of Finance* 60, 649–672.

Brennan, Michael J, and H Henry Cao, 1997, International portfolio investment flows, *The Journal of Finance* 52, 1851–1880.

Brusa, Francesca, Pavel G Savor, and Mungo Ivor Wilson, 2017, One central bank to rule them all .

Chen, Linda H, George J Jiang, and Xingnong Zhu, 2017, Interactive distraction: The effect of macroeconomic news on market reaction to earnings news .

Cieslak, Anna, Adair Morse, and Annette Vissing-Jorgensen, 2018, Stock returns over the FOMC cycle .

DellaVigna, Stefano, and Joshua M Pollet, 2009, Investor inattention and friday earnings announcements, *The Journal of Finance* 64, 709–749.

Gabaix, Xavier, 2014, A sparsity-based model of bounded rationality, *The Quarterly Journal of Economics* 129, 1661–1710.

Gabaix, Xavier, 2016a, Behavioral macroeconomics via sparse dynamic programming, Technical report, National Bureau of Economic Research.

Gabaix, Xavier, 2016b, A behavioral new keynesian model, Technical report, National Bureau of Economic Research.

Grossman, Sanford J, and Joseph E Stiglitz, 1980, On the impossibility of informationally efficient markets, *The American economic review* 70, 393–408.

Hellwig, Martin F, 1980, On the aggregation of information in competitive markets, *Journal of economic theory* 22, 477–498.

Hirshleifer, David, Sonya Seongyeon Lim, and Siew Hong Teoh, 2009, Driven to distraction: Extraneous events and underreaction to earnings news, *The Journal of Finance* 64, 2289–2325.

Hou, Kewei, Wei Xiong, and Lin Peng, 2009, A tale of two anomalies: The implications of investor attention for price and earnings momentum .

Kacperczyk, Marcin, Stijn Van Nieuwerburgh, and Laura Veldkamp, 2016, A rational theory of mutual funds' attention allocation, *Econometrica* 84, 571–626.

Lucca, David O, and Emanuel Moench, 2015, The pre-FOMC announcement drift, *The Journal of Finance* 70, 329–371.

Maćkowiak, Bartosz, and Mirko Wiederholt, 2009, Optimal sticky prices under rational inattention, *American Economic Review* 99, 769–803.

Maćkowiak, Bartosz, and Mirko Wiederholt, 2015, Business cycle dynamics under rational inattention, *The Review of Economic Studies* 82, 1502–1532.

Mondria, Jordi, 2010, Portfolio choice, attention allocation, and price comovement, *Journal of Economic Theory* 145, 1837–1864.

Savor, Pavel, and Mungo Wilson, 2013, How much do investors care about macroeconomic risk? evidence from scheduled economic announcements, *Journal of Financial and Quantitative Analysis* 48, 343–375.

Savor, Pavel, and Mungo Wilson, 2014, Asset pricing: A tale of two days, *Journal of Financial Economics* 113, 171–201.

Sims, Christopher A, 2003, Implications of rational inattention, *Journal of monetary Economics* 50, 665–690.

Wachter, Jessica A, and Yicheng Zhu, 2018, The macroeconomic announcement premium, Technical report, National Bureau of Economic Research.

Appendices

A Proof of Propositions

A.1 Proof of Proposition 1

Following Brennan and Cao (1997), I conjecture a linear structure for the equilibrium price which in general reads as

$$
\begin{aligned}
\boldsymbol{P}_t &= [\boldsymbol{\Gamma}^{-1}\boldsymbol{\mu} - \rho\overline{\hat{\boldsymbol{\Sigma}}_t}\bar{\boldsymbol{x}}] \\
&\quad + \overline{\hat{\boldsymbol{\Sigma}}_t}\sum_{j=1}^{t}[\boldsymbol{\Sigma}_{pub,j}^{-1}\boldsymbol{\eta}_{pub,j} + (\boldsymbol{I}_2 + \rho^{-2}\sigma_x^{-2}\overline{\boldsymbol{\Sigma}}_{\boldsymbol{\eta}}'^{-1})\overline{\boldsymbol{\Sigma}}_{\boldsymbol{\eta}}^{-1}(\boldsymbol{z} - \rho\overline{\boldsymbol{\Sigma}}_{\boldsymbol{\eta}}\boldsymbol{x}_j)]
\end{aligned}
\tag{A.1}
$$

where $\boldsymbol{\Sigma}_{pub,j}^{-1} = \boldsymbol{0}$ (a 2×2 zero matrix) if there is no public announcement at time j. This linear form generates an unbiased estimator for $\boldsymbol{z}$,

$$
\boldsymbol{\eta}_{\boldsymbol{p},t} \equiv \boldsymbol{z} - \rho\overline{\boldsymbol{\Sigma}}_{\boldsymbol{\eta}}\boldsymbol{x}_j. \tag{A.2}
$$

Following the Bayesian updating in Section 4.1 and applying the demand vectors in Proposition 2, it is straightforward to confirm that (A.1) clears the market at both $t = 1$ and $t = 2$. Written specifically for each trading period, I have expressions (16) and (17).

This completes the proof of Proposition 1.

A.2 Proof of Proposition 2

Notice from Proposition 1 that the conditional distribution of $\boldsymbol{z}$ in the belief of any given investor i at $t = 2$ is normal, so that the utility maximization problem $\max_{\boldsymbol{D}_2^i} E_2^i(-\exp[-\rho W_3^i])$ is equivalent to the classical maximization for a mean-variance utility,

$$
\max_{\boldsymbol{D}_2^i}(\boldsymbol{D}_2^i)'(\boldsymbol{\Gamma}^{-1}\boldsymbol{\mu} + \hat{\boldsymbol{z}}_2^i - \boldsymbol{P}_2) - \frac{\rho}{2}(\boldsymbol{D}_2^i)'\hat{\boldsymbol{\Sigma}}_2^i\boldsymbol{D}_2^i \tag{A.3}
$$

A standard procedure confirms (19) for $t = 2$. The case of $t = 1$ is more complex since when investors form their beliefs about their terminal wealth W_3^i at $t = 1$, not only their beliefs on $\boldsymbol{z}$ matter, but also their beliefs on the capital gain $\boldsymbol{P}_2 - \boldsymbol{P}_1$ do. I will confirm the optimal demand at $t = 1$ through the calculation of expected utilities.[18]

To calculate the expected utility at $t = 1$, I decompose the belief updating process from $t = 1$ to $t = 2$ into two steps, with $\Delta\boldsymbol{P}$ as an intermediate additional information.

Step 1. Investors update their beliefs $\boldsymbol{z}|_{\mathcal{F}_1^i} \sim MVN(\hat{\boldsymbol{z}}_1^i, \hat{\boldsymbol{\Sigma}}_1^i)$ conditional on the change in price $\Delta\boldsymbol{P} \equiv \boldsymbol{P}_2 - \boldsymbol{P}_1$. In order to do so, I compare (16) and (17) to establish an unbiased estimator for $\boldsymbol{z}$ based on the additional information revealed by $\Delta\boldsymbol{P}$ as follows:[19]

$$\begin{aligned}
& (\overline{\hat{\boldsymbol{\Sigma}}}_2^{-1} - \overline{\hat{\boldsymbol{\Sigma}}}_1^{-1})^{-1}\overline{\hat{\boldsymbol{\Sigma}}}_2^{-1}(\boldsymbol{P}_2 - \boldsymbol{P}_1) + (\boldsymbol{P}_1 - \boldsymbol{\Gamma}^{-1}\boldsymbol{\mu}) \\
= \quad & \boldsymbol{z} + (\overline{\hat{\boldsymbol{\Sigma}}}_2^{-1} - \overline{\hat{\boldsymbol{\Sigma}}}_1^{-1})^{-1}[\boldsymbol{\Sigma}_{pub}^{-1}\boldsymbol{\epsilon}_{pub} - \rho(\overline{\boldsymbol{\Sigma}}_{\boldsymbol{\eta}}^{-1} + \boldsymbol{\Sigma}_{\boldsymbol{p},2}^{-1})\overline{\boldsymbol{\Sigma}}_{\boldsymbol{\eta}}\boldsymbol{x}_2] \\
\equiv \quad & \boldsymbol{z} + \boldsymbol{\epsilon}_{\Delta\boldsymbol{p}}
\end{aligned} \tag{A.4}$$

The expectation and variance of the noise $\boldsymbol{\epsilon}_{\Delta\boldsymbol{p}}$ are

$$E(\boldsymbol{\epsilon}_{\Delta\boldsymbol{p}}) = 0 \tag{A.5}$$

$$V(\boldsymbol{\epsilon}_{\Delta\boldsymbol{p}}) = (\overline{\hat{\boldsymbol{\Sigma}}}_2^{-1} - \overline{\hat{\boldsymbol{\Sigma}}}_1^{-1})^{-1} + (\overline{\hat{\boldsymbol{\Sigma}}}_2^{-1} - \overline{\hat{\boldsymbol{\Sigma}}}_1^{-1})^{-1}(\overline{\boldsymbol{\Sigma}}_{\boldsymbol{\eta}}^{-1} + \rho^2\sigma_x^2 I_2)(\overline{\hat{\boldsymbol{\Sigma}}}_2^{-1} - \overline{\hat{\boldsymbol{\Sigma}}}_1^{-1})'^{-1} \tag{A.6}$$

We denote the mean and variance of $\boldsymbol{z}$ conditional on both $\mathcal{F}_1^i$ and $\Delta\boldsymbol{P}$ by $E_{1,\Delta\boldsymbol{P}}^i(\boldsymbol{z})$ and $V_{1,\Delta\boldsymbol{P}}^i(\boldsymbol{z})$ respectively, and by Bayes Law,

$$V_{1,\Delta\boldsymbol{p}}^i(\boldsymbol{z})^{-1} \equiv V[z|\mathcal{F}_1^i, \boldsymbol{P}_2 - \boldsymbol{P}_1]^{-1} = (\hat{\boldsymbol{\Sigma}}_1^i)^{-1} + V(\boldsymbol{\epsilon}_{\Delta\boldsymbol{p}})^{-1} \tag{A.7}$$

$$E_{1,\Delta\boldsymbol{P}}^i(\boldsymbol{z}) = V_{1,\Delta\boldsymbol{p}}^i(z)[(\hat{\boldsymbol{\Sigma}}_1^i)^{-1}\hat{\boldsymbol{z}}_1^i + V(\boldsymbol{\epsilon}_{\Delta p})^{-1}(\boldsymbol{z} + \boldsymbol{\epsilon}_{\Delta p})] \tag{A.8}$$

[18] To prove Proposition 3, I also need to trace the expected utility back to $t = 0$.

[19] Notice that the signal $\boldsymbol{\epsilon}_{\Delta p}$ is orthogonal to the information set $\mathcal{F}_1^i$.

Incidentally, I will later need the following expectation and variance in calculation:

$$
\begin{aligned}
E_1^i(\Delta \boldsymbol{P}) &= \overline{\hat{\boldsymbol{\Sigma}}}_2(\overline{\hat{\boldsymbol{\Sigma}}}_2^{-1} - \overline{\hat{\boldsymbol{\Sigma}}}_1^{-1})[\boldsymbol{\Gamma}^{-1}\boldsymbol{\mu} + E_1^i(\boldsymbol{z}) - \boldsymbol{P}_1] && \text{(A.9)} \\
V_1^i(\Delta \boldsymbol{P}) &= \overline{\hat{\boldsymbol{\Sigma}}}_2(\overline{\hat{\boldsymbol{\Sigma}}}_2^{-1} - \overline{\hat{\boldsymbol{\Sigma}}}_1^{-1})[\hat{\boldsymbol{\Sigma}}_1^i + V(\epsilon_{\Delta \boldsymbol{P}})](\overline{\hat{\boldsymbol{\Sigma}}}_2^{-1} - \overline{\hat{\boldsymbol{\Sigma}}}_1^{-1})'\overline{\hat{\boldsymbol{\Sigma}}}_2' && \text{(A.10)}
\end{aligned}
$$

Step 2. Investors further update their beliefs by their expected excess returns, denoted by

$$
\boldsymbol{y}_t \equiv \boldsymbol{\Gamma}^{-1}\boldsymbol{\mu} + \hat{\boldsymbol{z}}_t^i - \boldsymbol{P}_t, \text{ for } t = 1, 2 \tag{A.11}
$$

The intermediate conditional expectation is

$$
\begin{aligned}
E_{1,\Delta \boldsymbol{p}}^i(\boldsymbol{y}_2) &\equiv E(\boldsymbol{y}_2 | \mathcal{F}_1^i, \Delta p) \\
&= E_{1,\Delta \boldsymbol{P}}^i(\boldsymbol{z}) - \Delta \boldsymbol{P} - (\boldsymbol{P}_1 - \boldsymbol{\Gamma}^{-1}\boldsymbol{\mu}) \\
&= \boldsymbol{A} + \boldsymbol{B}\Delta \boldsymbol{P}, && \text{(A.12)}
\end{aligned}
$$

where

$$
\begin{aligned}
\boldsymbol{A} &= V_{1,\Delta \boldsymbol{p}}^i(\boldsymbol{z})(\hat{\boldsymbol{\Sigma}}_1^i)^{-1}(\boldsymbol{\Gamma}^{-1}\boldsymbol{\mu} + \hat{\boldsymbol{z}}_1^i - \boldsymbol{P}_1), && \text{(A.13)} \\
\boldsymbol{B} &= V_{1,\Delta \boldsymbol{p}}^i(\boldsymbol{z})V(\boldsymbol{\epsilon}_{\Delta \boldsymbol{p}})^{-1}(\overline{\hat{\boldsymbol{\Sigma}}}_2^{-1} - \overline{\hat{\boldsymbol{\Sigma}}}_1^{-1})^{-1}\overline{\hat{\boldsymbol{\Sigma}}}_2^{-1} - \boldsymbol{I}_2, && \text{(A.14)}
\end{aligned}
$$

and the intermediate conditional variance is

$$
\begin{aligned}
V_{1,\Delta \boldsymbol{p}}^i(\boldsymbol{y}_2) &\equiv V(\boldsymbol{y}_2 | \mathcal{F}_1^i, \Delta p) \\
&= V_{1,\Delta \boldsymbol{p}}^i(\boldsymbol{z}) - E[\hat{\boldsymbol{\Sigma}}_2^i | \mathcal{F}_1^i, \Delta \boldsymbol{P}] \\
&= [(\hat{\boldsymbol{\Sigma}}_1^i)^{-1} + V(\boldsymbol{\epsilon}_{\Delta \boldsymbol{p}})^{-1}]^{-1} - \hat{\boldsymbol{\Sigma}}_2^i. && \text{(A.15)}
\end{aligned}
$$

The last equality applies the fact that all expected variances under the assumption of normality are independent of the actual realizations of signals.

Notice that $\mathcal{F}_2^i = \{\boldsymbol{P}_1, \boldsymbol{P}_2, \boldsymbol{\eta}_1^i, \boldsymbol{\eta}_2^i, \boldsymbol{\eta}_{pub}\} = span\{\mathcal{F}_1^i, \Delta\boldsymbol{P}, \boldsymbol{y}_2\}$, so the conditional expectation $E_1^i(\cdot)$ can be calculated from $E_2^i(\cdot)$ through the calculation of $E_{1,\Delta\boldsymbol{p}}^i(\cdot)$.

Calculation of expected utilities:

Now I evaluate the sequence of expected utilities in the order of $E_2^i(\cdot) \to E_{1,\Delta\boldsymbol{p}}^i(\cdot) \to E_1^i(\cdot)$. The expected utility at $t=2$ is simply

$$E_2^i(-\exp[-\rho W_3^i]) = -\exp\{-\rho W_2^i - \frac{1}{2}\boldsymbol{y}_2'(\hat{\boldsymbol{\Sigma}}_2^i)^{-1}\boldsymbol{y}_2\}. \tag{A.16}$$

Applying (A.12) and (A.15), the expected utility conditional on $\mathcal{F}_1^i$ and $\Delta\boldsymbol{P}$ is

$$\begin{aligned}
& E_{1,\Delta\boldsymbol{p}}^i(-\exp[-\rho W_3^i]) \\
= \;& E_{1,\Delta\boldsymbol{p}}^i(E_2^i(-\exp[-\rho W_3^i])) \\
= \;& \int -\exp\{-\rho W_2^i - \frac{1}{2}\boldsymbol{y}_2'(\hat{\boldsymbol{\Sigma}}_2^i)^{-1}\boldsymbol{y}_2\}\det(2\pi V_{1,\Delta\boldsymbol{p}}^i(\boldsymbol{y}_2))^{-\frac{1}{2}} \\
& \exp\{-\frac{1}{2}(\boldsymbol{y}_2 - E_{1,\Delta\boldsymbol{p}}^i(\boldsymbol{y}_2))'V_{1,\Delta\boldsymbol{p}}^i(\boldsymbol{y}_2)^{-1}(\boldsymbol{y}_2 - E_{1,\Delta\boldsymbol{p}}^i(\boldsymbol{y}_2))\}d\boldsymbol{y}_2 \\
= \;& -\det(2\pi V_{1,\Delta\boldsymbol{p}}^i(\boldsymbol{y}_2))^{-\frac{1}{2}}\exp(-\rho W_2^i) \\
& \int \exp\{-\frac{1}{2}[\boldsymbol{y}_2'(\hat{\boldsymbol{\Sigma}}_2^i)^{-1}\boldsymbol{y}_2 + (\boldsymbol{y}_2 - E_{1,\Delta\boldsymbol{p}}^i(\boldsymbol{y}_2))'V_{1,\Delta\boldsymbol{p}}^i(\boldsymbol{y}_2)^{-1}(\boldsymbol{y}_2 - E_{1,\Delta\boldsymbol{p}}^i(\boldsymbol{y}_2))]\}d\boldsymbol{y}_2 \\
= \;& -\det(V_{1,\Delta\boldsymbol{p}}^i(\boldsymbol{y}_2)^{-1}[(\hat{\boldsymbol{\Sigma}}_2^i)^{-1} + V_{1,\Delta\boldsymbol{p}}^i(\boldsymbol{y}_2)^{-1}]^{-1})^{\frac{1}{2}} \\
& \exp(-\rho W_2^i - \frac{1}{2}E_{1,\Delta\boldsymbol{p}}^i(\boldsymbol{y}_2)'V_{1,\Delta\boldsymbol{p}}^i(\boldsymbol{y}_2)^{-1}[\boldsymbol{I}_2 - \hat{\boldsymbol{\Sigma}}_2^i V_{1,\Delta\boldsymbol{p}}^i(\boldsymbol{z})^{-1}]E_{1,\Delta\boldsymbol{p}}^i(\boldsymbol{y}_2))
\end{aligned}$$

To arrive at the last step in the above, I complete the squares with respect to $\boldsymbol{y}_2$ in the second to the last step.

With (A.9) and (A.10), investor i's conditional expectation at $t=1$ can be calculated as follows

$$\begin{aligned}
& E_1^i(-\exp[-\rho W_3^i]) \\
= \;& E_1^i(E_{1,\Delta\boldsymbol{p}}^i(-\exp[-\rho W_3^i])) \\
= \;& -\det(V_{1,\Delta\boldsymbol{p}}^i(\boldsymbol{y}_2)^{-1}[(\hat{\boldsymbol{\Sigma}}_2^i)^{-1} + V_{1,\Delta\boldsymbol{p}}^i(\boldsymbol{y}_2)^{-1}]^{-1})^{\frac{1}{2}}
\end{aligned}$$

$$
\begin{aligned}
& \int \exp(-\rho[W_0 + (\boldsymbol{D}_1^i)'\Delta \boldsymbol{P}] - \frac{1}{2} E^i_{1,\Delta \boldsymbol{p}}(\boldsymbol{y}_2)' V^i_{1,\Delta \boldsymbol{p}}(\boldsymbol{y}_2)^{-1}[\boldsymbol{I}_2 - \hat{\boldsymbol{\Sigma}}^i_2 V^i_{1,\Delta \boldsymbol{p}}(\boldsymbol{z})^{-1}] E^i_{1,\Delta \boldsymbol{p}}(\boldsymbol{y}_2)) \\
& \det(2\pi V_1^i(\Delta \boldsymbol{P}))^{-\frac{1}{2}} \exp\{-\frac{1}{2}[\Delta \boldsymbol{P} - E_1^i(\Delta \boldsymbol{P})]' V_1^i[\Delta \boldsymbol{P})^{-1}(\Delta \boldsymbol{P} - E_1^i(\Delta \boldsymbol{P})]\} d(\Delta \boldsymbol{P}) \\
= & -\det([(\hat{\boldsymbol{\Sigma}}^i_2)^{-1} V^i_{1,\Delta \boldsymbol{p}}(\boldsymbol{y}_2) + \boldsymbol{I}_2]^{-1} V_1^i(\Delta \boldsymbol{P})^{-1}[\boldsymbol{B}' V^i_{1,\Delta \boldsymbol{p}}(\boldsymbol{z})^{-1}\boldsymbol{B} + V_1^i(\Delta \boldsymbol{P})^{-1}]^{-1})^{\frac{1}{2}} \\
& \exp\{-\rho W_0 + \frac{1}{2}[\boldsymbol{B}' V^i_{1,\Delta \boldsymbol{p}}(\boldsymbol{z})^{-1}\boldsymbol{A} - V_1^i(\Delta \boldsymbol{P})^{-1} E_1^i(\Delta \boldsymbol{P})^{-1} + \rho \boldsymbol{D}_1^i]' \\
& \quad [\boldsymbol{B}' V^i_{1,\Delta \boldsymbol{p}}(\boldsymbol{z})^{-1}\boldsymbol{B} + V_1^i(\Delta \boldsymbol{P})^{-1}]^{-1}[\boldsymbol{B}' V^i_{1,\Delta \boldsymbol{p}}(\boldsymbol{z})^{-1}\boldsymbol{A} - V_1^i(\Delta \boldsymbol{P})^{-1} E_1^i(\Delta \boldsymbol{P}) + \rho \boldsymbol{D}_1^i] \\
& \quad -\frac{1}{2}[\boldsymbol{A}' V^i_{1,\Delta \boldsymbol{p}}(\boldsymbol{z})^{-1}\boldsymbol{A} + E_1^i(\Delta \boldsymbol{P})' V_1^i(\Delta \boldsymbol{P})^{-1} E_1^i(\Delta \boldsymbol{P})]\}
\end{aligned}
$$

Differentiating the result from the last step with respect to $\boldsymbol{D}_1^i$, I confirm that (19) also holds for $t = 1$. With the optimal portfolio allocation at $t = 1$, the conditional expected utility above is further simplified into

$$
\begin{aligned}
& E_1^i(-\exp[-\rho W_3^i]) \\
= & -\det([(\hat{\boldsymbol{\Sigma}}^i_2)^{-1} V^i_{1,\Delta \boldsymbol{p}}(\boldsymbol{y}_2) + \boldsymbol{I}_2]^{-1} V_1^i(\Delta \boldsymbol{P})^{-1}[\boldsymbol{B}' V^i_{1,\Delta \boldsymbol{p}}(\boldsymbol{z})^{-1}\boldsymbol{B} + V_1^i(\Delta \boldsymbol{P})^{-1}]^{-1})^{\frac{1}{2}} \\
& \exp\{-\rho W_0 - \frac{1}{2}[\boldsymbol{A}' V^i_{1,\Delta \boldsymbol{p}}(\boldsymbol{z})^{-1}\boldsymbol{A} + E_1^i(\Delta \boldsymbol{P})' V_1^i(\Delta \boldsymbol{P})^{-1} E_1^i(\Delta \boldsymbol{P})]\} \qquad \text{(A.17)}
\end{aligned}
$$

This completes the proof of Proposition 2.

A.3 Proof of Proposition 3

Continuing from the calculation of expected utility in the proof of Proposition 2, I now move backwards to $t = 0$ and calculate investors' unconditional expected utility at $t = 0$. Skilled investors allocate their attention before observing any information. Recall that $\boldsymbol{y}_1 \equiv \boldsymbol{\Gamma}^{-1}\boldsymbol{\mu} + \hat{\boldsymbol{z}}_1^i - \boldsymbol{P}_1$, and I take a closer look at the exponent of the second component in (A.17):

$$
\begin{aligned}
& \boldsymbol{A}' V^i_{1,\Delta \boldsymbol{p}}(\boldsymbol{z})^{-1}\boldsymbol{A} + E_1^i(\Delta \boldsymbol{P})' V_1^i(\Delta \boldsymbol{P})^{-1} E_1^i(\Delta \boldsymbol{P}) \\
= & [\boldsymbol{\Gamma}^{-1}\boldsymbol{\mu} + \hat{\boldsymbol{z}}_1^i - \boldsymbol{P}_1]'\{(\hat{\boldsymbol{\Sigma}}^i_1)'^{-1} V^i_{1,\Delta \boldsymbol{p}}(\boldsymbol{z})'(\hat{\boldsymbol{\Sigma}}^i_1)^{-1} \\
& +(\overline{\hat{\boldsymbol{\Sigma}}}_2^{-1} - \overline{\hat{\boldsymbol{\Sigma}}}_1^{-1})'\overline{\hat{\boldsymbol{\Sigma}}}_2' V_1^i(\Delta \boldsymbol{P})^{-1}\overline{\hat{\boldsymbol{\Sigma}}}_2(\overline{\hat{\boldsymbol{\Sigma}}}_2^{-1} - \overline{\hat{\boldsymbol{\Sigma}}}_1^{-1})\}[\boldsymbol{\Gamma}^{-1}\boldsymbol{\mu} + \hat{\boldsymbol{z}}_1^i - \boldsymbol{P}_1] \qquad \text{(A.18)}
\end{aligned}
$$

$$\equiv \boldsymbol{y}_1' \boldsymbol{M} \boldsymbol{y}_1,$$

where I denote the middle component (all terms inside the curly brackets in (A.18)) above by $\boldsymbol{M}$ for convenience. The calculation of the unconditional expectation and variance of $\boldsymbol{y}_1$ is standard and straightforward. i.e.,

$$\boldsymbol{E}^i \equiv E_0(\boldsymbol{y}_1) = \rho \overline{\hat{\boldsymbol{\Sigma}}}_1 \bar{x} \tag{A.19}$$

$$\boldsymbol{V}^i \equiv V_0(\boldsymbol{y}_1) = \overline{\hat{\boldsymbol{\Sigma}}}_1 \boldsymbol{\Sigma}^{-1} \overline{\hat{\boldsymbol{\Sigma}}}_1' - (\hat{\boldsymbol{\Sigma}}_1^i)' + (\overline{\hat{\boldsymbol{\Sigma}}}_1 \boldsymbol{\Sigma}^{-1} - \boldsymbol{I}_2) \boldsymbol{\Sigma}_{\boldsymbol{p},1} (\overline{\hat{\boldsymbol{\Sigma}}}_1 \boldsymbol{\Sigma}^{-1} - \boldsymbol{I}_2)' \tag{A.20}$$

Finally, the expected utility at $t = 0$ of investor i is

$$\begin{aligned}
& E_0(-\exp[-\rho W_3^i]) \\
= \; & E_0(E_1^i(-\exp[-\rho W_3^i])) \\
= \; & -\det([(\hat{\boldsymbol{\Sigma}}_2^i)^{-1} V_{1,\Delta \boldsymbol{p}}^i(\boldsymbol{y}_2) + \boldsymbol{I}_2]^{-1} V_1^i(\Delta \boldsymbol{P})^{-1} [\boldsymbol{B}' V_{1,\Delta \boldsymbol{p}}^i(\boldsymbol{z})^{-1} \boldsymbol{B} + V_1^i(\Delta \boldsymbol{P})^{-1}]^{-1})^{\frac{1}{2}} \\
& \int \exp[-\rho W_0 - \frac{1}{2} \boldsymbol{y}_1' \boldsymbol{M} \boldsymbol{y}_1] \det(2\pi \boldsymbol{V}^i)^{-\frac{1}{2}} \exp\{-\frac{1}{2}(\boldsymbol{y}_1 - \boldsymbol{E}^i)'(\boldsymbol{V}^i)^{-1}(\boldsymbol{y}_1 - \boldsymbol{E}^i)\} d\boldsymbol{y}_1 \\
= \; & -\det([(\hat{\boldsymbol{\Sigma}}_2^i)^{-1} V_{1,\Delta \boldsymbol{p}}^i(\boldsymbol{y}_2) + \boldsymbol{I}_2]^{-1} [\boldsymbol{B}' V_{1,\Delta \boldsymbol{p}}^i(\boldsymbol{z})^{-1} \boldsymbol{B} V_1^i(\Delta \boldsymbol{P}) + \boldsymbol{I}_2]^{-1} [\boldsymbol{M} \boldsymbol{V}^i + \boldsymbol{I}_2]^{-1})^{\frac{1}{2}} \\
& \exp\{-\rho W_0 + \frac{1}{2}(\boldsymbol{E}^i)'[(\boldsymbol{V}^i)'^{-1}(\boldsymbol{M} + (\boldsymbol{V}^i)^{-1})'^{-1}(\boldsymbol{V}^i)^{-1} - (\boldsymbol{V}^i)^{-1}]\boldsymbol{E}^i\}
\end{aligned} \tag{A.21}$$

This completes the proof of Proposition 3.

B Additional Simulation Results

Because my model is solved on the level of risk factors, here I supply the simulation results on the level of risk factors as references to help interpret the results on assets in the main text. All parameters are same as exhibited in Table 1.

Result B.1. Equilibrium Prices of the Synthetic Assets on Risk Factors:

From Result 1 in Section 4.4, as the precision of the announcement increases, more attention is allocated toward the idiosyncratic risk factor. Thus , at $t = 1$, the private signals for the idiosyncratic risk factor are more precise and lowers the uncertainty, so that the price of the synthetic asset on the idiosyncratic risk factor is higher. At $t = 2$, there is no public signal revealed for the idiosyncratic risk factor, but the private signals received by the skilled investors are of the same precision as at $t = 1$, so by a same argument as above the price of the synthetic asset also increases at $t = 2$ (Figure B.1).

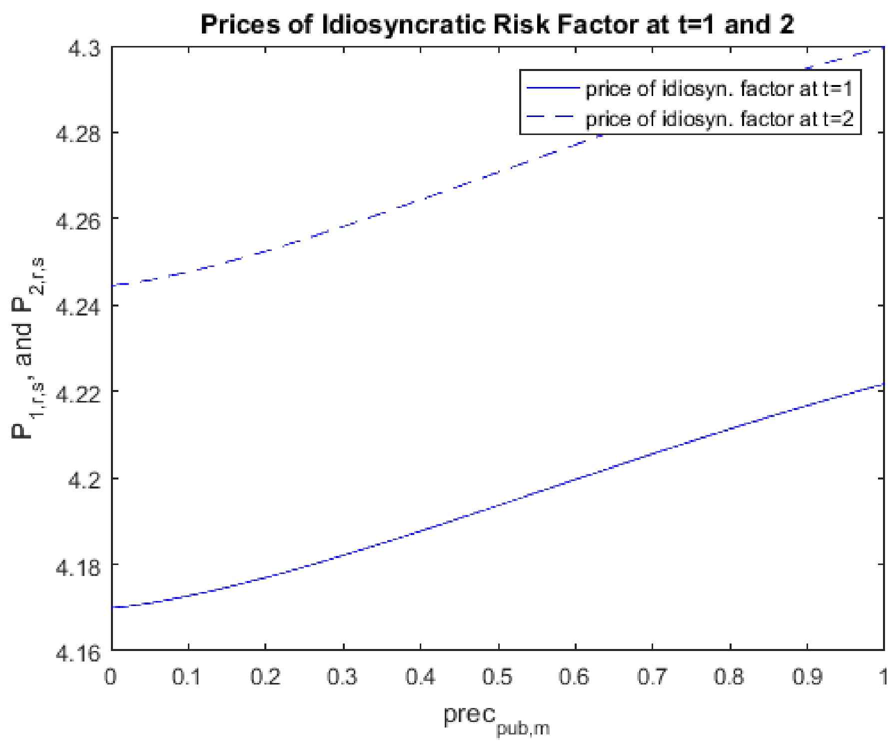

Figure B.1: Equilibrium Price of Synthetic Asset for Idiosyncratic Risk Factor

By an analogy of the discussion above, the price of the synthetic asset on the systematic risk factor at $t = 1$ decreases in the precision of the anticipating macroeconomic announcement. At $t = 2$, however, since more information about the market is released through the announcement, the uncertainty on the systematic risk factor is significantly lowered and thus cancels out the uncertainty from the less precise private signals and further increases the price of the synthetic asset on the systematic risk factor (Figure B.2).

Result B.2. Returns on Synthetic Assets for Risk Factors:

As more precise an announcement is expected, more attention is allocated to the id-

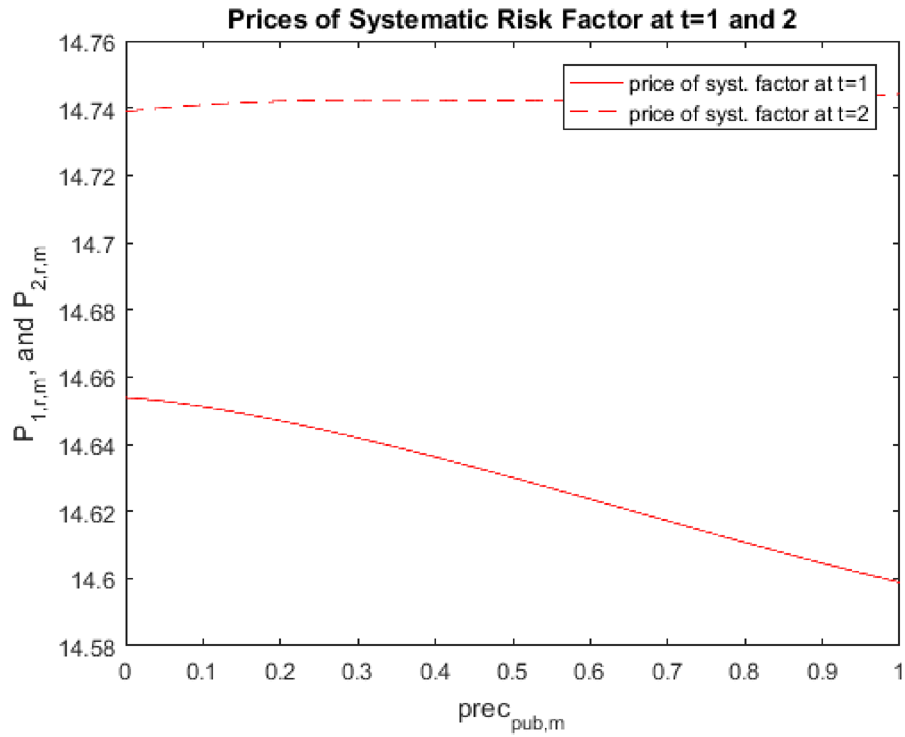

Figure B.2: Equilibrium Price of Synthetic Asset for Systematic Risk Factor

iosyncratic risk factor so that the incremental information received in the period before the announcement increases and the return on the synthetic asset for the idiosyncratic risk factor increases. For the systematic risk factor, even though the private signals on it are less precise because of attention shifting, the public signal from the announcement compensates for the information loss and further increases the precision of the incremental information within the period from $t = 1$ to $t = 2$. Thus, the return of the synthetic asset for the systematic risk factor increases (Figure B.3). The trend of returns on the synthetic assets is accompanied by a similar trend in the standard deviation of returns on these synthetic assets, as shown in Figure B.4, confirming the increase in uncertainty on the systematic risk factor and the decrease of uncertainty on the idiosyncratic risk factor as the public signal gets more precise.

Result B.3. Trading volume of the risk factors:

The overall levels of the trading volumes on both the synthetic asset for the systematic risk factor and the synthetic asset for the idiosyncratic risk factor are higher at $t = 2$ than at $t = 1$ because the uncertainty on both synthetic assets are lower after another round of

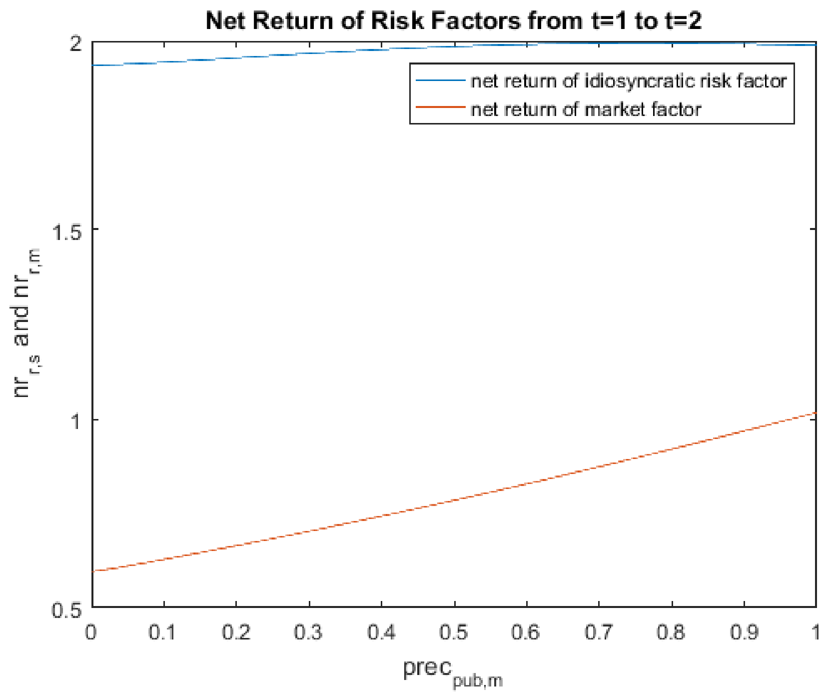

Figure B.3: Return on Synthetic Assets for Risk Factors

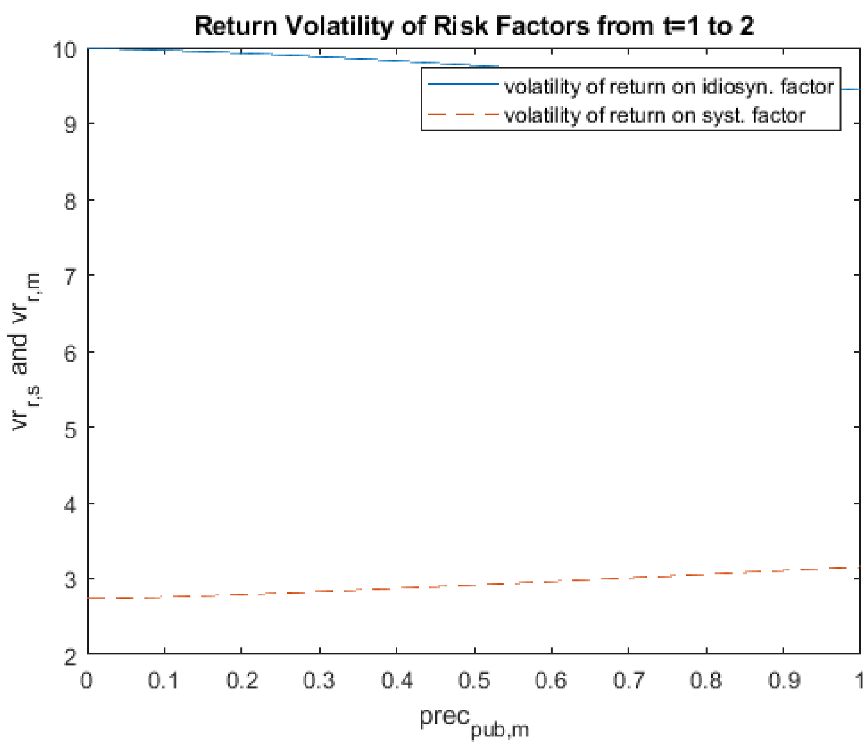

Figure B.4: Return Volatility of Synthetic Assets for Risk Factors information production and the announcement at $t = 2$. As the announcement gets more precise, since more attention is shifted away from the systematic risk factor, investors' beliefs on the systematic risk factor get more similar to each other and create the downward trend in trading volume (Figure B.5).

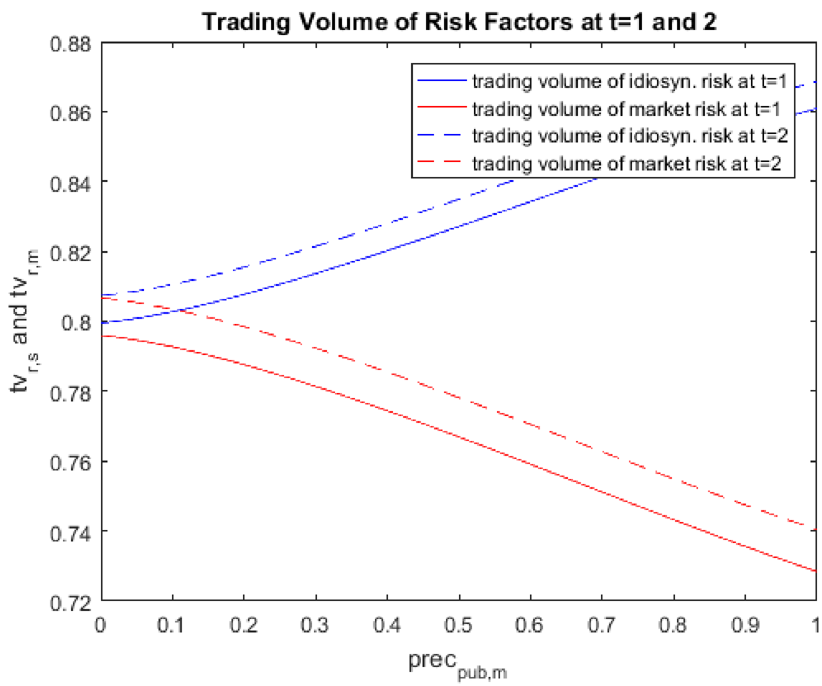

Figure B.5: Level of Trading Volumes on Synthetic Assets for Risk Factors