Uncovering Subjective Models from Survey Expectations[*]

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Abstract

Households perceive macroeconomic variables to move together in a way different from the patterns seen in their realizations, professionals' forecasts, and the standard macroeconomic models. In particular, they expect the unemployment rate to go up when expecting higher inflation and hear about inflation news. We perform a structural test based on a noisy-information framework and provide empirical evidence using survey expectations and newspapers' economic reporting to show that such perceived correlations reflect subjective models instead of simply imperfect information.

Keywords: Expectation Formation, Noisy Information Model, Survey Data, Subjective Models, News Narratives

1 Introduction

When households expect a higher inflation rate, they also perceive the unemployment rates to go up, and the economy to underperform.[1] Figure 1 depicts such a pattern using the rolling-window time-series correlation between the average households' inflation and unemployment expectations in *Michigan Survey of Consumer Expectations* (MSC), that of professionals in *Survey of Professional Forecasters* (SPF) and those of the realization of the two series. [2] Although the realized correlation between the two variables was positive before the 1990s and turns negative after 2000, as reflected more or less by professionals' forecasts in SPF, the correlation of the two expectations remain mostly positive throughout the entire sample period.[3]

Figure 1: Time-varying correlation between inflation and unemployment change
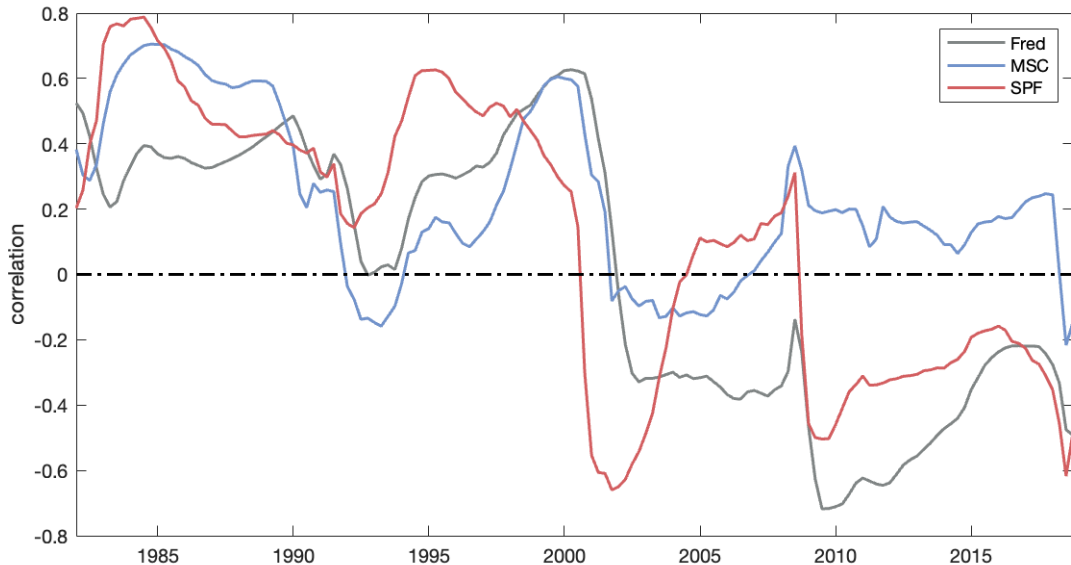
Correlation using 10-year rolling window, 1982-2018. Grey line: realized data from FRED. Blue line: expectations from MSC. Red line: expectations from SPF.

Such data pattern naturally calls for studying how agents form expectation about different macroeconomic variables jointly. We extend the commonly used test on information rigidity as in Coibion and Gorodnichenko (2012) and Andrade and Le Bihan (2013) from a

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[1]Several contemporaneous studies (Bhandari *et al.*, 2019; Kamdar, 2019; Han, 2023; Andre *et al.*, 2022) also documented a similar pattern.

[2]They are obtained from Federal Reserve Bank of St. Louis (FRED). Detailed data description is included in Appendix A.1.

[3]Additional results in Appendix A.3 and A.4 confirm that such a positive correlation is seen across the time and not driven by certain group of consumers.

single-variable to a multi-variable environment, allowing for possibly subjectively perceived correlation between variables. In the presence of both information rigidity and subjective model, we characterize how exactly expectations are formed jointly instead of independently and investigate the causes of such correlation in expectations.

Two possibilities arise when expectations regarding different variables are correlated with each other. Agents may hold a subjective belief about the correlations between variables (the transition matrix in the noisy information model). Or they may simply receive signals that contain information about both variables. One example of such correlated information could be a non-sophisticated newspaper article commenting on both inflation and general macroeconomic status. Although it is natural to assume what people believe is driven by the information, we show that the test results from survey data are at odds with a model in which only correlated signals drive the observed correlation in expectations.

The essence of the test is a joint sign restriction on the contemporaneous correlations of expectations and their between-variable serial correlation of forecast errors. We show that under very general conditions, a subjective model perceiving correlation between variables is consistent with the coexistence in the survey data of positively correlated expectations and a positive between-variable serial correlation in forecast errors. Not only do households expect the two variables to move in the same direction, but also overforecasting inflation today leads to overforecasting the unemployment rate tomorrow. In contrast, such a joint pattern is not admitted by an alternative environment that only features incomplete information about the state of the economy where correlated signals could also potentially drive expectation comovements.

Our test results also suggest the asymmetric impacts of inflation expectations in driving such a positive association across expectations. We first use the perceived news measure documented by MSC to show that different types of news all have domain-specific impacts on consumers' expectations. For example, consumers who hear news about inflation are likely to expect a higher inflation rate and those exposed to labor market news revise their unemployment expectations accordingly. Consumers can distinguish many between different types of news. But among all types of news, it is dominantly the inflation news that leads to expectations of worse economic conditions in the future across domains.

Lastly, we investigate what is special about inflation that makes it trigger the inflation-unemployment association, based on directly measured news coverage on macroeconomic topics by a sample of 250,000 economic news articles published in *Wall Street Journal* between 1984 to 2022.[4] We first confirm that newspaper coverage of inflation and unemployment is

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[4]As a robustness check, we also find similar patterns with a sample of 250,000 articles published in *New York time* between 1989-2022. Meanwhile, there are intuitive differences between these two news sources: compared to WSJ, *New York Times* reports unemployment news more often than inflation news.

indeed highly correlated with self-reported and topic-specific exposures in MSC. Then, we show that, central to the asymmetric impacts of inflation news, a more intense news coverage of inflation is perceived to be particularly unfavorable while the unemployment news has no such directional implications as households perceive. Meanwhile, relying upon the identified topics of each news article, we show that newspaper articles are particularly likely to draw an inflation-unemployment association during episodes of high realized inflation instead of high unemployment rates. The evidence altogether suggests that the negativity with inflation news might be one of the possible explanations for why the perceived correlation between inflation and unemployment goes from the former to the latter.

Related Literature

This paper is based on the literature on information rigidity, which uses the implications on forecasting error and forecast revisions by noisy information model (Woodford, 2001; Sims, 2003) or sticky expectation model (Mankiw *et al.*, 2004) to perform understand expectation formation. The seminal Coibion and Gorodnichenko (2012) and Andrade and Le Bihan (2013) consider tests using current and lag forecast errors. Coibion and Gorodnichenko (2015) and Bordalo *et al.* (2018) use forecast errors and revisions obtained from survey data. We extend the insight from these papers that the serial correlation of forecast errors of single variables reveals information rigidity by showing between-variable correlations in forecast errors reveal correlation in information or perceived correlation in subjective models. In our framework, the forecasters may have a subjective belief on the law of motion of states that differs from the actual one. This is similar to the single-variable case in Ryngaert (2017).

We are among the few contemporaneous papers that study a positive correlation between inflation and unemployment rate in household expectations, such as Bhandari *et al.* (2019); Kamdar (2019); Andre *et al.* (2022); Candia *et al.* (2020); Stantcheva (2024). Our additional finding regarding this empirical pattern is that the direction of such a perceived correlation in subjective models particularly goes from inflation to unemployment, instead of the other way around. Closely related is the expanding empirical evidence that most households hold negative views toward inflation, despite the potential macroeconomic benefits of mild inflation (Shiller, 1997). Various hypotheses have been put forward to explain such a pattern. For instance, supply over demand view (Kamdar, 2019; Andre *et al.*, 2022; Han, 2023); ambiguity aversion (Bhandari *et al.*, 2019); neglect of macroeconomic trade-offs (Stantcheva, 2024); partisan biases(Gillitzer *et al.*, 2021); personal finance (Bolhuis *et al.*, 2024), the erosion of real income (Hajdini *et al.*, 2022; Jain *et al.*, 2022; Stantcheva, 2024). Complementing these studies, this paper is agnostic about the relative importance of these channels. Instead, we show that the well-documented inflation negativity views held by households, and reported in newspaper, make inflation more likely to be the trigger of the inflation-unemployment

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association.

More generally, this paper contributes to the literature on subjective models in macroeconomic expectation formation, particularly how expectations of different macroeconomic variables are related to each other. Andre *et al.* (2022) use survey vignettes to show both households and experts hold heterogeneous views about how the same hypothetically exogenous macroeconomic shocks affect the inflation and unemployment rate. Compared to their paper, we adopt a different approach to detect the subjective perceptions of how macroeconomic variables are correlated with each other, relying on cross-variable restrictions in observational data. Similar to their finding, we found that households have a strong tendency to predict the same directions of the changes in the unemployment rate and inflation regardless of the nature of the macroeconomic shocks.

The rest of the paper proceeds as follows. Section 2 derives testable implications and performs a test of joint expectation formation under the noisy information model. Section 3 documents independent evidence on the connection between cross-correlation and joint learning using perceived news data in MSC. Section 4 provides further supporting evidence for subjective models using newspaper-based evidence. Finally, Section 5 sets forth our conclusions.

2 Test of Joint Expectation Formation

In this section, we first examine different possible sources that can create the positive correlation between expected inflation and unemployment documented in the introduction. We do so through the lens of the popular noisy information model as in Woodford (2001) and Sims (2003). We show that in this simple framework, different hypotheses can lead to the same correlation between expectations. Consequently, one cannot distinguish between these different hypotheses using the correlation between expectations alone. To solve this problem, we show that these various explanations have different testable implications on the *serial correlations of forecast errors* on inflation and unemployment. Furthermore, the serial correlations of forecast errors are informative about whether agents are forming expectations jointly or independently.

2.1 Model Environment

The testable implications on forecast errors we consider are in the spirit of those from Coibion and Gorodnichenko (2012) and Andrade and Le Bihan (2013). In our model, there will be multiple macroeconomic states that are not directly observable to agents. The agents may have subjective beliefs about how these states evolve over time. They observe multiple

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noisy signals about the states that can be arbitrary combinations of these states they try to form beliefs about. Consider the states $\boldsymbol{L}_{t+1,t}$ are macroeconomic variables that follow the state-space representation (1). The agents observe noisy signals on these variables, the observational equation is given by (2).

$$\boldsymbol{L}_{t+1,t} = A\boldsymbol{L}_{t,t-1} + w_{t+1,t} \tag{1}$$

$$\boldsymbol{s}_t^i = G\boldsymbol{L}_{t,t-1} + v_t^i + \eta_t \tag{2}$$

Equation (1) is sometimes referred to as the "Actual Law of Motion" (ALM). The agents may have a subjective model in their mind, which is their "Perceived Law of Motion" (PLM) about how states evolved:[5]

$$\boldsymbol{L}_{t+1,t} = \hat{A}\boldsymbol{L}_{t,t-1} + w_{t+1,t} \tag{3}$$

We call $\hat{A}$ the households' subjective model of the economy. It may or may not be the same as A. We show later whether $\hat{A}$ is diagonal or not has testable implications on the serial correlations of agents' forecast errors as well as correlations between expectational variables.

The signals observed contain an individual-specific noise v_t^i and a time-specific one η_t, both of which follow a normal distribution with a mean zero. The individual noise is independent across agent and time, and the time-specific noise is not autocorrelated and independent with the structural shock $w_{t+1,t}$. Adding a time-specific noise does not change the nature of the individual's signal extraction problem. The only difference is to allow for an imprecise signal after aggregation at each time point. To ease notations we define $\epsilon_{i,t} := v_t^i + \eta_t$. The distribution of shocks and noises:

$$w_{t+1,t} \sim N(0,Q) \quad \epsilon_{i,t} := v_t^i + \eta_t \sim N(0,R)$$

Where Q and R are the corresponding variance-covariance matrices.

The agents then update their beliefs upon observing $\boldsymbol{s}_t^i$ and form expectations according to a linear Kalman Filter as described in (4), where K is the Kalman Gain.[6]

$$\begin{aligned}
\boldsymbol{L}_{t+1,t|t}^i &= \hat{A}\boldsymbol{L}_{t,t-1|t}^i \\
&= \hat{A}\left(\boldsymbol{L}_{t,t-1|t-1}^i + K(\boldsymbol{s}_t^i - G\boldsymbol{L}_{t,t-1|t-1}^i)\right)
\end{aligned} \tag{4}$$

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[5]We do not consider the case where G is also subjective as in the rational inattention literature, G can usually be chosen by the agents themselves. See Mafákowiak *et al.* (2018) as an example. For this reason, we assume the agents always use the correct G.

[6]For derivations of standard Kalman Filter, please see Appendix B.1.

From equation (4), it is immediate that the beliefs about different macroeconomic states in $\boldsymbol{L}^i_{t+1,t|t}$ would be correlated for different reasons, even if the actual states are not correlated (i.e. A and Q are diagonal). First, consider the case where the agents learn about different states independently, i.e. $\hat{A}$ is diagonal.[7] We call this scenario "independent learning". The beliefs would be correlated if either the signals are combinations of the states, i.e. G is non-diagonal, or the noises in signals are correlated, i.e. R is non-diagonal. These two cases concern mainly the information frictions that can lead to correlations in expectational variables. They can also be thought of as two different formulations of pessimistic/optimistic heuristics. In the first case, the agent confuses multiple states in one signal and will adjust beliefs on all the states while observing this signal. In the second case, if the noises are positively correlated, the agent is more likely to observe signals about states biased toward the same direction.

Another possibility for observing correlated beliefs is that the agent has a subjective model $\hat{A}$ that is non-diagonal. The form of $\hat{A}$ represents the agent's belief on the joint dynamics of the macroeconomic states in $\boldsymbol{L}_{t+1,t}$. We call this scenario "joint learning", as the agents believe the underlying macroeconomic states are correlated and this will be incorporated into their belief formation process. As a result, they will adjust their beliefs on multiple states even if they observe uncorrelated noisy signals about only one of the states.

As all of the aforementioned possibilities can give rise to the same correlation between beliefs, it is then important to consider other moments from the belief data that can distinguish between these possibilities. To achieve this, we propose a test using the serial correlations of forecasting errors because they give distinct testable implications for independent learning and joint learning models. We call this test *"joint learning test"*. To derive this test, consider the forecasting error for one period ahead:

$$
\begin{aligned}
FE^i_{t+1,t|t} &\equiv \boldsymbol{L}_{t+1,t} - \boldsymbol{L}^i_{t+1,t|t} \\
&= A\boldsymbol{L}_{t,t-1} - [\hat{A}(I-KG)\boldsymbol{L}^i_{t,t-1|t-1} + \hat{A}KG\boldsymbol{L}_{t,t-1} + \hat{A}K\epsilon_{i,t}] + w_{t+1,t} \\
&= \hat{A}(I-KG)(\boldsymbol{L}_{t,t-1} - \boldsymbol{L}^i_{t,t-1|t-1}) + \underbrace{(A - \hat{A}KG - \hat{A}(I-KG))}_{M}\boldsymbol{L}_{t,t-1} + w_{t+1,t} - \hat{A}K\epsilon_{i,t} \\
&= \hat{A}(I-KG)FE^i_{t,t-1|t-1} + M\boldsymbol{L}_{t,t-1} + w_{t+1,t} - \hat{A}K\epsilon_{i,t} \qquad (5)
\end{aligned}
$$

Averaging across agents i at each time t, we get an aggregate test on forecasting errors:

$$
FE_{t+1,t|t} = \hat{A}(I-KG)FE_{t,t-1|t-1} + M\boldsymbol{L}_{t,t-1} + w_{t+1,t} - \hat{A}K\eta_t \qquad (6)
$$

We call equation (5) the individual-level *joint learning test* and (6) is the aggregate *joint learning test*. The key parameters we will focus on are the elements in $\hat{A}(I-KG)$. Considering the state vector $\boldsymbol{L}$ contains unemployment rate change and inflation, both equations can

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[7]This case includes Coibion and Gorodnichenko (2012), Andrade and Le Bihan (2013), Ryngaert (2017) and many others.

be estimated from survey data using OLS as $w_{t+1,t}$ and η_t are independent with $FE_{t,t-1|t-1}$ and $\boldsymbol{L}_{t,t-1}$. Before we show the results from actual survey data, we will discuss what the joint learning tests can tell us about the different possibilities that can result in correlated expectational variables.

2.2 Properties of Joint Learning Test

To ease the exposition, we make the following assumptions:

Assumption 1. *The subjective transition matrix $\hat{A}$ has positive eigenvalues within the unit circle.*

Assumption 2. *The diagonal elements of the G matrix are positive.*

Assumption 3. *The var-cov matrix of prior $\boldsymbol{L}^i_{t,t-1|t-1}$ is a diagonal matrix and common to each individual:*

$$\Sigma := diag(\{\sigma_i^2\}_{i=1}^n)$$

Assumption 1 above suggests that the agent considers a stationary process for the unobservable states. Assumption 2 guarantees that each signal increases as the corresponding state increases.[8] Finally, Assumption 3 assumes that the agent uses independent priors. [9]

Under these assumptions, expectations formed by independent learning and joint learning will lead to different properties of the coefficient matrix $\hat{A}(I-KG)$. Following the convention from the literature, we first consider the case of FIRE.

Proposition 1. *Under FIRE, e.g. $A = \hat{A}$, $G = I$ and $R \to \boldsymbol{0}$, the coefficient matrix $\hat{A}(I - KG) = \boldsymbol{0}$.*

Proof. See Appendix C.1. □

The above proposition makes clear that lag forecast errors will not predict current forecast errors under FIRE. Note that this is true even under joint expectation formation, i.e. A is non-diagonal. This is consistent with the standard results from the single variable noisy information model.

Then we turn to the cases with imperfect information where $R \neq \boldsymbol{0}$. The matrix $\hat{A}(I - KG)$ would have different patterns under joint or independent learning. First, we consider the case of independent learning where $\hat{A}$ is diagonal:

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[8]This is a regularity assumption, which helps anchor our discussions about the sign restrictions regarding $\hat{A}(I - KG)$. Oppositely moved signals relative to the underlying states imply the same predictions.

[9]We do not separately consider another scenario where the *prior* beliefs of the agents perceive non-zero correlations, i.e. a non-diagonal Σ, as it is inherently similar to the case of the subjective model perceiving such a correlation, i.e. a non-diagonal $\hat{A}$.

Proposition 2. (Independent Learning) *If $\hat{A} = diag(\{a_i\}_{i=1}^n)$, denote the off-diagonal elements of $\hat{A}(I - KG)$ as w_{ij} with $i \neq j$. We have:*
(1) $w_{ij} = 0$ if G and R are diagonal.
(2) $w_{ij} = w_{ji} = 0$ or $w_{ij}w_{ji} > 0$ if G or R is non-diagonal.

Proof. See Appendix C.2. $\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad$ □

Proposition 2 makes two distinct points. First, if the agents do not consider the macroeconomic states to be correlated ($\hat{A}$ is diagonal) and they observe uncorrelated, separate signals regarding each state, the expectation formation process collapses to the single-variable noisy information model as in Coibion and Gorodnichenko (2012) and Andrade and Le Bihan (2013). The forecast errors of one variable predict its future forecast errors due to information rigidity, but the forecast errors of other variables can not. Secondly, under independent learning, if signals on different states are mixed, the forecast errors of one state can predict future forecast errors of the other symmetrically. In particular, the directions of such predictability are related to how the signals are generated. For simplicity, we formalize these properties in the case with two states:

Corollary 1. (Non-diagonal R: correlated noises) *If $\hat{A}$ and G are diagonal and $R = \begin{pmatrix} \sigma_{1,s}^2 & \rho \\ \rho & \sigma_{2,s}^2 \end{pmatrix}$, the off-diagonal elements of $\hat{A}(I - KG)$ have the same signs as ρ if $\hat{A}$ have positive entries on the diagonal.*

Proof. See Appendix C.3. $\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad$ □

Corollary 1 shows that the forecast error of one state predicts the future forecast error of the other positively if the noises are positively correlated. The intuition is the following. Suppose that the agents want to infer the first state w.l.o.g. When they see both signals, as they recognize the noises are positively correlated, they will put positive weight on the signal about the first state and negative weight on the signal about the other state to correct for the correlation in noises.[10] As a result, a positive shock on state 1 leads to positive forecast errors in both states. The forecast errors of both states are persistent due to information rigidity, so a positive forecast error in the first state predicts a positive forecast error in the second state.

Another possibility is that the signal observed combines information about both states, i.e. G is non-diagonal. In this case, we consider only *triangular G*. This configuration is without loss of generality as any signals with general 2 by 2 $\hat{G}$ can be reformulated into signals with triangular G and they lead to the same posterior beliefs.[11]

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[10]One can see this from the fact that the off-diagonal elements in the Kalman Gain are both negative in this case.

[11]The formal proof is included in Appendix C.

Corollary 2. (Non-diagonal G: correlated signals) *If $\hat{A}$ is diagonal, $R = \begin{pmatrix} \sigma_{1,s}^2 & 0 \\ 0 & \sigma_{2,s}^2 \end{pmatrix}$ is diagonal, and $G = \begin{pmatrix} g_1 & g_2 \\ 0 & g_4 \end{pmatrix}$, the off-diagonal elements of $\hat{A}(I - KG)$ have the opposite signs as $g_1 g_2$.*

Proof. See Appendix C.4. □

To get the intuition behind Corollary 2, consider the case where g_1 and g_2 are both positive. When the first state increases and the second state stays the same, the agent sees a positive signal 1. As she is not sure which state increases, the agent will adjust beliefs on both signals upwards. As a result, she will have a positive forecast error in the first state and a negative forecast error in the second. Due to information rigidity, a positive forecast error in one state now will predict a negative forecast error in the other state in the future.

Now we move to the case of joint learning. Note that the counter-positive argument of Proposition 2 leads to the testable implications under models of *joint expectation formation*:

Proposition 3. (Joint Learning) *If off-diagonal elements of $\hat{A}(I - KG)$ are not both zeros and of different signs, then $\hat{A}$ is non-diagonal, regardless whether G and R are diagonal or not.*

Proof. This is the counter-positive of Proposition 2 □

Moreover, if we consider the case where signals are separate and not correlated, we can get more informative results about $\hat{A}$ by looking at the off-diagonal elements of $\hat{A}(I - KG)$:

Proposition 4. (Joint Learning with separate signals) *If both G and R are diagonal and $\hat{A} = (a_{ij})_{n \times n}$ is non-diagonal, denote $\hat{A}(I - KG) = (w_{ij})_{n \times n}$. The signs of these off-diagonal elements are the same as their counterparts in $\hat{A}$, i.e. $w_{ij} a_{ij} > 0$.*

Proof. See Appendix C.5. □

The above proposition shows that when the signals on multiple states are separate and noises are uncorrelated, the coefficient matrix $\hat{A}(I - KG)$ will have non-zero off-diagonal elements if and only if the agent believes in a non-diagonal $\hat{A}$. The signs on the off-diagonal elements in $\hat{A}(I - KG)$ are the same as those in $\hat{A}$.

The intuition behind this proposition is also straightforward. Suppose that the first element in $\mathbf{L}_{t,t-1}$ is the change in the unemployment rate, and the second element is inflation. If one under-predicted inflation yesterday, she will also under-predict current inflation due to information rigidity. Such an under-prediction will create an under-prediction of unemployment tomorrow if the agent believes that higher inflation leads to a higher unemployment

rate in the future. Or it will create an over-prediction of unemployment in the future if she believes that current inflation lowers future unemployment.

Finally, it is important to note that the properties of the joint learning test we described in this section do not depend on the actual A matrix at all. In other words, the joint learning test is useful to uncover the agent's subjective model $\hat{A}$ no matter what the true model (A) is.

2.3 Taking Stock

In section 2.2, we show that the coefficient matrix $\hat{A}(I - KG)$ in the proposed joint learning test has different properties when beliefs are formed under FIRE, single-variable learning, or joint learning. It is now useful to link the results from such tests with implied correlations between belief variables under these different scenarios. We focus on the case where the hidden macroeconomic states $\boldsymbol{L}_{t+1,t}$ are inflation and change in the unemployment rate. Recall the consensus mean forecast is given by the average of (4) across individuals. Define $Y_t = \begin{pmatrix} L_{t,t-1|t-1} \\ L_{t,t-1} \end{pmatrix}$ and we can write (4) and ALM (1) as the following vectorial autoregression (VAR) model:

$$Y_{t+1} = \underbrace{\begin{pmatrix} \hat{A}(I - KG) & \hat{A}KG \\ \mathbf{0}_{2\times 2} & A \end{pmatrix}}_{:=\Phi} \cdot Y_t + \underbrace{\begin{pmatrix} \hat{A}K & \mathbf{0}_{2\times 2} \\ \mathbf{0}_{2\times 2} & I_{2\times 2} \end{pmatrix}}_{F} \cdot \begin{pmatrix} \eta_t \\ w_{t+1,t} \end{pmatrix} \tag{7}$$

Then we know the stationary Variance-covariance matrix is given by:

$$vec(\Sigma_L) = (I_{16} - \Phi \otimes \Phi)^{-1} vec\left(F(R+Q)F'\right) \tag{8}$$

The correlation between belief variables implied by the above covariance matrix will differ depending on whether expectations are formed independently, jointly, or under FIRE. Guided by the results from the previous section, we can simply separate these different frictions into the following formulations w.l.o.g:

$$\hat{A} = \begin{pmatrix} \cdot & m_1 \\ 0 & \cdot \end{pmatrix}, \quad G = \begin{pmatrix} \cdot & g_2 \\ 0 & \cdot \end{pmatrix}, \quad R = \begin{pmatrix} \cdot & \rho \\ \rho & \cdot \end{pmatrix}$$

Table 1 summarizes the testable implications of these different frictions in the noisy information model:

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Table 1: Summary of Joint Learning Test

Cases:	$\hat{A}$	G	R	Off-diagonal elements of $\hat{A}(I - KG)$	$Corr(E\pi, Eun)$
				Assuming actual A being diagonal	
FIRE	$= A$	N/A	$= \mathbf{0}$	both $= 0$	$= Corr(\pi, un)$
	Diag	Diag	Diag	both $= 0$	$= 0$
	Diag	Diag	$\rho > 0$	both > 0	$\gtreqless 0$
	Diag	Diag	$\rho < 0$	both < 0	$\gtreqless 0$
Σ is Diagonal	Diag	$g_2 > 0$	Diag	both < 0	$\gtreqless 0$
	Diag	$g_2 < 0$	Diag	both > 0	$\gtreqless 0$
	$m_1 > 0$	Diag	Diag	> 0 at (1,2), $= 0$ at (2,1)	> 0
	$m_1 < 0$	Diag	Diag	< 0 at (1,2), $= 0$ at (2,1)	< 0

Notes: The implied signs of the cross-terms in the forecast error test we proposed before, and the correlation between two macroeconomic states, for different configurations of $\hat{A}$, G, and R: $R = \begin{pmatrix} \cdot & \rho \\ \rho & \cdot \end{pmatrix}$, $G = \begin{pmatrix} \cdot & g_2 \\ 0 & \cdot \end{pmatrix}$, $\hat{A} = \begin{pmatrix} \cdot & m_1 \\ 0 & \cdot \end{pmatrix}$ We maintain the assumption as in section 2.2 and 2.3 that A and Σ are both diagonal.

Unlike the properties of the joint learning test, the correlation between belief variables clearly depends on the form of A. We focus on the most clear-cut case where A is diagonal.[12]

In Table 1, first note that under FIRE or Independent Learning with separate signals ($\hat{A}$, G and R are all diagonal), they have the same implications on the off-diagonal elements of $\hat{A}(I - KG)$ and $Corr(E\pi, Eun)$. However, under FIRE the diagonal elements of $\hat{A}(I - KG)$ would be zeroes whereas under Independent Learning they would be between zero and one. More importantly, Table 1 shows that the positive correlation between expected inflation and unemployment status can come from a correlation in noises, a mix of states in the signals observed, or the agent's subjective model. The off-diagonal elements of $\hat{A}(I - KG)$ from the joint learning test offer additional moments that can help to distinguish between these possible explanations. In particular, if the off-diagonal elements are estimated to have different signs, it suggests the agents have a non-diagonal subjective model $\hat{A}$ and correlated or mixed signals *cannot* be the only reasons that lead to the correlation between expectation variables.

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[12]When A is non-diagonal, correlation between inflation and unemployment will be non-zero. In that case, the properties of off-diagonal elements in $\hat{A}(I - KG)$ remain the same as in Table 1. The correlation $corr(E\pi, Eun)$ will be bigger (smaller) than $corr(\pi, un)$ if the off-diagonal elements in $\hat{A}$ are bigger (smaller) than the corresponding elements in A.

2.4 Empirical Tests on Joint Learning

Guided by Table 1, we perform the joint learning test using survey data from MSC and SPF. To do this, we follow (6) and simply estimate the following regressions:

$$\begin{pmatrix} fe^{\pi}_{t+1,t|t} \\ fe^{un}_{t+1,t|t} \end{pmatrix} = \boldsymbol{\beta}_0 + \begin{pmatrix} \beta_{11} & \beta_{12} \\ \beta_{21} & \beta_{22} \end{pmatrix} \begin{pmatrix} fe^{\pi}_{t,t-1|t-1} \\ fe^{un}_{t,t-1|t-1} \end{pmatrix} + \boldsymbol{\Theta} X_{t,t-1} + e_t \tag{9}$$

where $fe^{x}_{t+h,t|t}$ stands for the h-period ahead forecasting errors of variable x.

However with MSC, we do not observe $fe^{x}_{t+1,t|t}$ directly, rather we have data on year-ahead forecast errors $fe^{x}_{t+4,t|t}$. We can then use the 4 periods ahead version of equation (6):

$$FE_{t+4,t|t} = \hat{W}\hat{A}(I-KG)\hat{W}^{-1}FE_{t+3,t-1|t-1} + (I - \hat{W}\hat{A}(I-KG)\hat{W}^{-1})\boldsymbol{L}_{t+3,t-1}$$
$$- (\hat{W}\hat{A}KG + I)\boldsymbol{L}_{t,t-1} + A\boldsymbol{L}_{t+3,t+2} + w_{t+4,t+3} - \hat{W}\hat{A}K\eta_t \tag{10}$$

where $\hat{W} = I + \hat{A} + \hat{A}^2 + \hat{A}^3$, the fact that $\hat{A}$ is stationary guarantees that $\hat{W}$ is invertible. The derivation that extends (6) to (10) is in **Appendix B.2**. More importantly, the properties of β's derived in the last section hold true for the year-ahead specification as well. To illustrate the similar performance of the proposed quarter-ahead test (6) and year-ahead test (10), we perform the proposed tests with simulated data and include these results in **Appendix D**. We can then estimate:

$$\begin{pmatrix} fe^{\pi}_{t+4,t|t} \\ fe^{un}_{t+4,t|t} \end{pmatrix} = \boldsymbol{\beta}_0 + \begin{pmatrix} \beta_{11} & \beta_{12} \\ \beta_{21} & \beta_{22} \end{pmatrix} \begin{pmatrix} fe^{\pi}_{t+3,t-1|t-1} \\ fe^{un}_{t+3,t-1|t-1} \end{pmatrix} + \boldsymbol{\Theta} X_{t+3,t-1} + e_t \tag{11}$$

The parameters of interest are $\beta_{11}, \beta_{12}, \beta_{21}$ and β_{22}. They can be estimated using OLS because, in equation (10), the two components of the error term are uncorrelated with all the regressors. The $w_{t+4,t+3}$ is an unpredictable error happening after $t + 3$, thus uncorrelated with forecasting errors up to $t + 3$ as well as any variable realized before $t + 4$. The noise attached to public signal η_t is realized at time t and thus does not correlate with forecast error with the information set at time $t - 1$. Here we have to assume there is no feedback effect of η_t on realized macroeconomic variables after time t through general equilibrium so that η_t is uncorrelated with any variable(except for expectational ones) realized beyond time t.[13]

Another complication to performing the test is that it requires unemployment rate change to be comparable to the realized data to create forecast errors. The data in MSC on unemployment expectation is categorical. We follow Bhandari *et al.* (2019) and Mankiw *et al.* (2004) to impute the expectation series. [14]

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[13]Notice v^i_t disappeared as we derive the consensus expectation, this is because the idiosyncratic noise has mean zero at each time point.

[14]The imputation approach is discussed in Appendix A.5.

It is worth noting that the assumption essential to recovering unemployment expectation is that the predicted unemployment change follows a normal distribution with a constant variance across time. This assumption is particularly plausible in the framework of a noisy information model with a stationary Kalman Filter, as the posterior distributions of forecasted variables are normally distributed, and stationarity guarantees a time-invariant posterior variance.

We then estimate (11) with year-ahead forecast errors on expected inflation, and expected unemployment rate change with OLS, controlling for corresponding realized variables according to (10).[15] Four coefficients in (11) are estimated. Among these, β_{11} and β_{22} are the typical indicators for the presence of information rigidity as in Coibion and Gorodnichenko (2012) and Andrade and Le Bihan (2013). Higher values of these terms imply higher degrees of information rigidity (noisier signals). The key coefficients related to joint learning are β_{12} and β_{21}. We call them *the cross-terms* of coefficients on forecast errors, the properties of which are summarized in Table 1. The goal of this exercise is to assess which model of expectation formation can be reconciled with the estimates of these four coefficients from survey data. The Table 2 presents the key results with MSC and SPF.

The first column of Table 2 contains estimation results using the baseline sample between 1984-2023. The estimates on β_{11} and β_{22} being significantly positive means that the consumers form expectations with limited information. The significant estimates on β_{21} suggest that consumers *do not* form expectations on unemployment and inflation independently, with separate signals. Moreover, the fact that β_{12} and β_{21} have different signs suggests that consumers are forming expectations jointly with subjective beliefs about the structural relationship between inflation and unemployment, $\hat{A}$.[16] According to Proposition 4, the agent's subjective model features that past inflation will lead to an unemployment rate increase. From Table 1, such a belief structure $\hat{A}$ can induce a positive correlation between the two expectations.

The columns (1)-(3) in Table 2 also suggest that the pessimistic heuristics in the form of non-diagonal R or G can not be the *only* reason for the positive correlation between expected inflation and unemployment status. According to Table 1, positive correlation appears when $\rho < 0$ or $g_2 > 0$. If pessimistic heuristics are the only frictions in expectation formation, the β_{21} and β_{12} would both be negative. These are inconsistent with the estimates in Table 2.

On the other hand, the results from columns (4)-(6) show that the professionals seem to have a different $\hat{A}$ from consumers. The significant β_{11} and β_{22} suggest again the presence

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[15]The imputation method involves the use of SPF and uses the consensus expectation on unemployment status. Such an approach does not apply to panel data. For this reason, in the baseline analysis for SPF and MSC, we consider the aggregate version of the joint-learning test (10).

[16]This follows from Proposition 3. To be clear, the test results in Table 2 suggest that $\hat{A}$ is non-diagonal, but they DO NOT exclude the possibility that G and R may also be non-diagonal.

Table 2: Aggregate Test on Joint Learning, MSC v.s. SPF

	MSC			SPF		
	1984-2023	1981-2018	1990-2018	1984-2023	1981-2018	1990-2018
	(1)	(2)	(3)	(4)	(5)	(6)
β_{11}	0.64***	0.61***	0.65***	0.70***	0.63***	0.61***
	(0.080)	(0.066)	(0.085)	(0.076)	(0.056)	(0.086)
β_{12}	−0.11	−0.14	−0.02	0.23	−0.16	0.00
	(0.076)	(0.087)	(0.095)	(0.285)	(0.180)	(0.221)
β_{21}	0.13***	0.11***	0.21***	0.04	0.02	0.06
	(0.033)	(0.039)	(0.063)	(0.034)	(0.033)	(0.053)
β_{22}	0.71***	0.60***	0.50***	0.40***	0.42***	0.40***
	(0.044)	(0.079)	(0.091)	(0.126)	(0.101)	(0.143)
Observations	152	149	116	152	149	116

* ***,**,*: Significance at 1%,5% and 10% level. Estimation results for joint-learning test (11). Columns (1)-(3) are results from MSC and (4)-(6) are results from SPF. Columns (1) and (4) use a sample of 1984-2023, excluding the outlier of the year 2019 where the change of unemployment is around 10%. Columns (2) and (5) use samples 1981q3-2018q4 to avoid the COVID-19 period. Column (3) and (6) use a sample from 1990-2018 to stay away from Volker and COVID-19 periods. Newey-West standard errors are reported in brackets.

of information rigidity. The estimates are comparable to previous studies imposing independent learning.[17] Contrary to the results with MSC, the small and insignificant β_{12} and β_{21} imply that they do not believe lagged inflation will raise the future unemployment rate. These results are consistent with the finding that there is a positive correlation between expected unemployment and inflation in MSC, whereas such a correlation does not appear in SPF. All in all, the estimates from SPF suggest that professionals are closer to independent expectation formation or at least use a different structure $\hat{A}$ from consumers when forming expectations.

Moreover, all the above results hold for different cuts of samples. In columns (2) and (5) we omit the COVID-19 episode and the results for both MSC and SPF are consistent with those in the baseline results. Recall in Figure 1 the correlations between realized inflation and unemployment fell below zero after the 1990s.[18] Meanwhile, the correlation between expected variables in MSC stays positive. It is in this episode the two correlations have the starkest disconnection. In columns (3) and (6) we include the estimates using a subsample

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[17]For example, in Coibion and Gorodnichenko (2012) and Andrade and Le Bihan (2013).

[18]In Figure 1 we used a 10-year rolling window and plotted the correlation against the ending date of that window. The figure suggests using realized data after the 1990s, inflation and unemployment become negatively correlated.

1990-2018 for both MSC and SPF. The results are qualitatively in line with those using the baseline sample. Moreover, the estimated β_{21} is twice as large, suggesting the consumers believe in a stronger response of future unemployment rate to current inflation.

3   Empirical Evidence I: Perceived News and Expectation

So far, we have shown that consumers form expectations of inflation and unemployment jointly rather than independently. They believe in a specific transition matrix $\hat{A}$ where past inflation will lead to a higher unemployment rate. This contributes to the fact that they make a positive association between inflation and unemployment expectations. Moreover, pessimistic heuristics in the form of mixed or correlated signals can not be the only reason to create such a positive correlation. In this section, we want to assess the economic significance of how much a subjective model $\hat{A}$ contributes to the positive correlation between expectations. We provide some independent evidence using additional information from MSC to make the connection between the positive correlation and the subjective model $\hat{A}$.

One key distinction between the frictions in G, R, and $\hat{A}$ are the responses of different expectations to news the agents hear about. If signals contain mixed information about unemployment and inflation (G is non-diagonal), the agents typically can't distinguish between news about inflation or unemployment, and unlabelled bad news will positively affect inflation and unemployment expectations. If signals are specific about different variables but noises are correlated (R is non-diagonal), clear-labeled inflation or unemployment signals will affect expectations on both subjects together.[19] Finally, frictions on subjective model $\hat{A}$ suggest agents can distinguish between different signals. According to the estimates in Table 2, those signals on inflation will move both inflation and unemployment forecasts up, whereas news about unemployment will only increase the unemployment forecast, with a negative or no impact on the inflation forecast.

To examine these implications we use the micro-level data from MSC and the perceived news measures as in Doms and Morin (2004), Pfajfar and Santoro (2013) and Lamla and Maag (2012). The survey question asks what kind of news the agent has heard in the last few months. The answers are categorized into different types of news reported by the survey respondents, and we further summarize these types of news into 10 categories.[20]

The MSC labels the reported news as "favorable" or "unfavorable" according to the
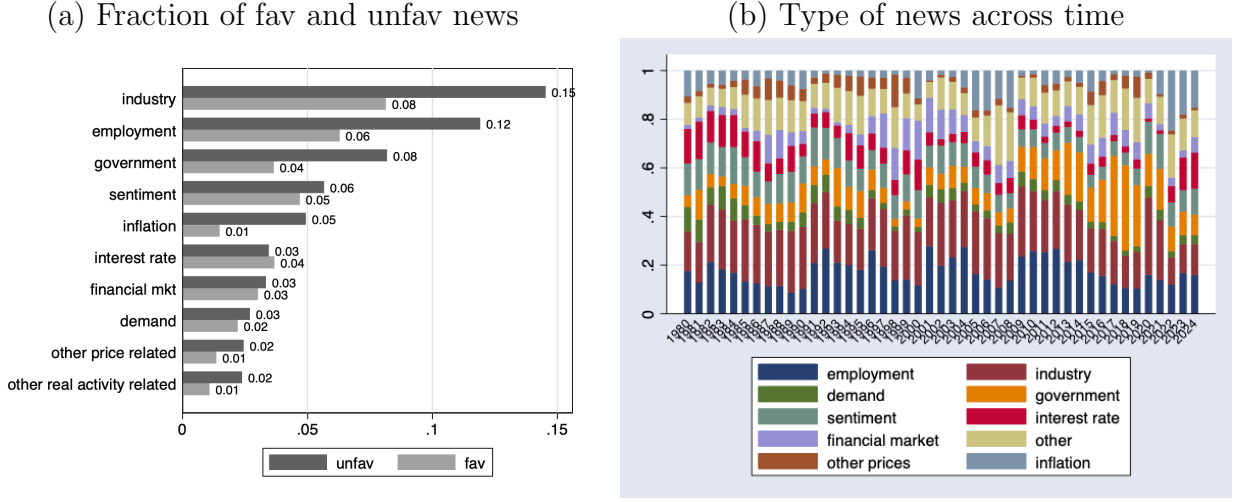
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[19]Under independent learning where G, R and $\hat{A}$ are all diagonal, a clear-labeled signal will only affect the belief on the corresponding subject. But from our test results in Table 2 this shouldn't happen.

[20]The descriptions of the question and the variable are included in Appendix E.1. Table 13 in Appendix E.1 summarizes what types of news are included in each category.

Figure 2: Type of news

(a) Fraction of fav and unfav news

(b) Type of news across time

Notes: Panel (a): fractions of favorable and unfavorable news reported by individuals with news in MSC. Panel (b): shares of different types of news out of total news reported each year.

description of the news. For all the panel respondents in MSC, around 37% report that they have heard no news in the past few months. Among the remaining 63% of respondents who heard about the news, Figure 2 summarizes the types of news reported by them.

In Figure 2, panel (a) shows the fraction of favorable and unfavorable news reported by the survey respondents with news. News on industry, employment, government, and inflation account for 60% of the news reported. Among these types, the respondents report much more unfavorable news than favorable ones. News on industry, employment, and demand are major categories related to real activities in the economy. Panel (b) plots the shares of different types of news out of total news reported in each year. From Figure 2 we see that most of the news is clearly labeled to be related to some specific economic aspect. The news with unclear labels is categorized as "sentiment"[21] and only accounts for around 11% of news reported.

We then perform a panel regression controlling for the individual and time-fixed effect, regressing expected inflation and unemployment status[22] on indicators of receiving different type of news. Table 3 suggests that hearing the news on high (low) inflation increases reported expected inflation by about 0.43% (0.21%) and increases the probability of believing the unemployment rate will rise (fall) by 2.5%. However, employment news only has a significant impact on unemployment expectations but not on inflation expectations. Similar

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[21]See Table 13.

[22]The expected unemployment variable takes value 1/0/-1 if the survey respondent says the unemployment will increase/stay the same/decrease.

to hearing about interest rate news. Moreover, in columns (3) and (4) we include all the types of news in the regression. We see that few types of news affect inflation expectations significantly but all have impacts on unemployment expectations. In particular, news about demand moves unemployment expectations considerably while not having much impact on expected inflation. Finally, the point estimates on favorable news are usually negative, which is in line with findings from Candia *et al.* (2020) and Andre *et al.* (2022). Following from the results in Table 3, it seems inflation news are more related to both high inflation and high unemployment expectations whereas news about real activities and demand mainly affect unemployment expectations alone. To see how much reported news affects the positive association between expected inflation and unemployment, we run a panel regression of expected inflation on the measure of expected unemployment, indicators of different news reported, and the interactions between expected unemployment and news indicators. What we are interested in is to see whether the correlation between expected inflation and unemployment changes depends on what news the individuals hear about.

In column (1) of Table 4, we include only indicators for inflation, employment and interest rate news. The correlation between expected inflation and unemployment for individuals without this news is around 0.36. This figure doubled for the individuals who report to hear news about inflation going up and it falls significantly for individuals who hear unfavorable news on employment or favorable news on interest rate. In column (2), we further include more indicators for all types of news in Table 13. The correlation for individuals with no news is 0.38. This correlation is significantly lower for those who hear news on real activities like employment, specific industries, and demand, a pattern consistent with our explanation through a subjective model. On the other hand, such a correlation is much higher for individuals with inflation news or unfavorable sentiment. This latter result is in line with the explanations through ambiguity aversion as in Bhandari *et al.* (2019).

All in all, Table 3 and 4 suggest that inflation news significantly moves both inflation and unemployment expectations in the same direction and is associated with a much higher correlation between the two at the individual level. Meanwhile, individuals with news on real activities typically make negative or no association between inflation and unemployment expectations. These are in line with the explanations through $\hat{A}$. The news labeled as "sentiment" in our analysis may indicate that the respondents are unsure about the exact content of the news they hear, which may be because the signals they receive contain multiple economic variables. This is in line with the explanation through non-diagonal G, but this type of news only accounts for a small portion of the news reported in MSC. Furthermore, information about demand affects beliefs about unemployment but not inflation, which lowers the positive association between the two. This is consistent with many papers that suggest demand-side interpretation of inflation can help to lower the positive association between

Table 3: FE Panel Regression with Self-reported News

Expectation on:	Inflation	Likelihood Unemployment Increase	Inflation	Likelihood Unemployment Increase
news on:	(1)	(2)	(3)	(4)
Inflation fav	-0.21*	-0.06***	-0.21*	-0.05***
	(0.117)	(0.017)	(0.118)	(0.017)
Inflation unfav	0.43***	0.06***	0.42***	0.05***
	(0.085)	(0.010)	(0.085)	(0.010)
Employment fav	-0.03	-0.14***	-0.01	-0.13***
	(0.056)	(0.009)	(0.057)	(0.009)
Employment unfav	0.05	0.10***	0.04	0.09***
	(0.054)	(0.007)	(0.054)	(0.007)
Interest rate fav	-0.03	-0.06***	-0.01	-0.04***
	(0.071)	(0.012)	(0.072)	(0.012)
Interest rate unfav	0.02	0.11***	0.02	0.10***
	(0.081)	(0.012)	(0.081)	(0.012)
Industry fav			-0.20***	-0.10***
			(0.059)	(0.008)
Industry unfav			0.11**	0.08***
			(0.053)	(0.006)
Demand fav			-0.16	-0.09***
			(0.104)	(0.014)
Demand unfav			-0.04	0.07***
			(0.111)	(0.013)
Gov fav			-0.12	-0.09***
			(0.077)	(0.012)
Gov unfav			0.21***	0.10***
			(0.058)	(0.008)
Sentiment fav			-0.12*	-0.12***
			(0.069)	(0.010)
Sentiment unfav			0.09	0.07***
			(0.078)	(0.009)
Stock fav			-0.07	-0.07***
			(0.059)	(0.011)
Stock unfav			0.05	0.07***
			(0.077)	(0.011)
Other prices fav			-0.22**	-0.04***
			(0.102)	(0.016)
Other prices unfav			0.04	0.04***
			(0.087)	(0.013)
Other real fav			-0.02	-0.07***
			(0.108)	(0.019)
Other real unfav			0.22*	0.04***
			(0.117)	(0.013)
Wage fav			0.03	-0.03
			(0.158)	(0.024)
Wage unfav			-0.09	0.07***
			(0.149)	(0.016)
Observations	169304	189158	169304	189158
R^2	0.673	0.677	0.673	0.681
Time F.E.	Y	Y	Y	Y
Individual F.E.	Y	Y	Y	Y

[*] ***,**,*: Significance at 1%,5% and 10% level. Results come from fixed-effect panel regressions of different dummies of self-reported news on expectations. Columns (1) and (3) use expected inflation as the dependent variable; columns (2) and (4) use the categorical variable of the expected unemployment rate to increase/stay the same/decrease as the dependent variable. The results controlled for individual fixed effects and time-fixed effects. Standard errors are adjusted for heteroscedasticity and autocorrelation.

Table 4: Correlation Conditional on News Heard

Dependent var:	$E\pi$	
	(1)	(2)
Eun	0.36***	0.38***
	(0.034)	(0.047)
Inflation fav $\times Eun$	0.17	0.16
	(0.164)	(0.164)
Inflation unfav $\times Eun$	0.36***	0.36***
	(0.117)	(0.118)
Employment fav $\times Eun$	0.03	0.03
	(0.089)	(0.090)
Employment unfav $\times Eun$	-0.20***	-0.16**
	(0.073)	(0.074)
Interest rate fav $\times Eun$	-0.23**	-0.24**
	(0.104)	(0.104)
Interest rate unfav $\times Eun$	-0.16	-0.16
	(0.114)	(0.115)
Industry fav $\times Eun$		0.06
		(0.092)
Industry unfav $\times Eun$		-0.23***
		(0.073)
Demand fav $\times Eun$		-0.14
		(0.145)
Demand unfav $\times Eun$		-0.57***
		(0.155)
Gov fav $\times Eun$		0.08
		(0.107)
Gov unfav $\times Eun$		0.01
		(0.079)
Sentiment fav $\times Eun$		0.01
		(0.112)
Sentiment unfav $\times Eun$		0.24**
		(0.113)
Stock fav $\times Eun$		-0.11
		(0.085)
Stock unfav $\times Eun$		0.06
		(0.115)
Other prices fav $\times Eun$		-0.01
		(0.152)
Other prices unfav $\times Eun$		-0.16
		(0.130)
Other real fav $\times Eun$		-0.11
		(0.168)
Other real unfav $\times Eun$		-0.21
		(0.157)
Wage fav $\times Eun$		-0.17
		(0.235)
Wage unfav $\times Eun$		0.00
		(0.224)
Observations	167346	167346
R^2	0.674	0.675
Time F.E.	Y	Y
Individual F.E.	Y	Y

* ***,**,*: Significance at 1%,5% and 10% level.
  The results controlled for individual fixed effects and time-fixed effects. Standard errors are adjusted for heteroscedasticity and auto-correlation.

inflation and worse economics status in households' expectations.[23]

How much does the individual-level correlation conditional on news heard help to explain the correlation in consensus expectations? In Figure 3, we plot the mean of each year for consensus expectations on inflation and unemployment from 1984 to 2023, conditional on hearing inflation news or unemployment news.[24] In Figure 3 panel (a) and (b), the red dots are consensus expectations in each year, conditional on hearing unfavorable inflation or unemployment news. The gray dots are those of people without employment or inflation news. Several patterns emerge from this figure. First of all, from Panel (a), individuals with high inflation news on average expect higher inflation and unemployment changes than those who don't have inflation or employment news. This contrasts with individuals who heard about the news on the high unemployment rate. These individuals only adjust their unemployment expectations upwards but not their inflation expectations (panel (b)). Secondly, we clearly see the positive correlation between the two expectations across time for individuals with high inflation news. The correlation of consensus expectations among people without inflation or employment news is low and insignificant. Moreover, the correlation becomes negative for people with unfavorable employment news. Finally, favorable inflation news lowers both expected inflation and unemployment, similar to favorable employment news. The correlation between consensus expectations among individuals with favorable news is not significantly different from those among people without this news. These results are in line with the findings from Table 4. Altogether they suggest that types of news play a crucial role in explaining the correlation between consensus expectations. The positive correlations are mostly among individuals who heard of news about inflation being high. Such a correlation disappears among those who have heard about bad employment status.
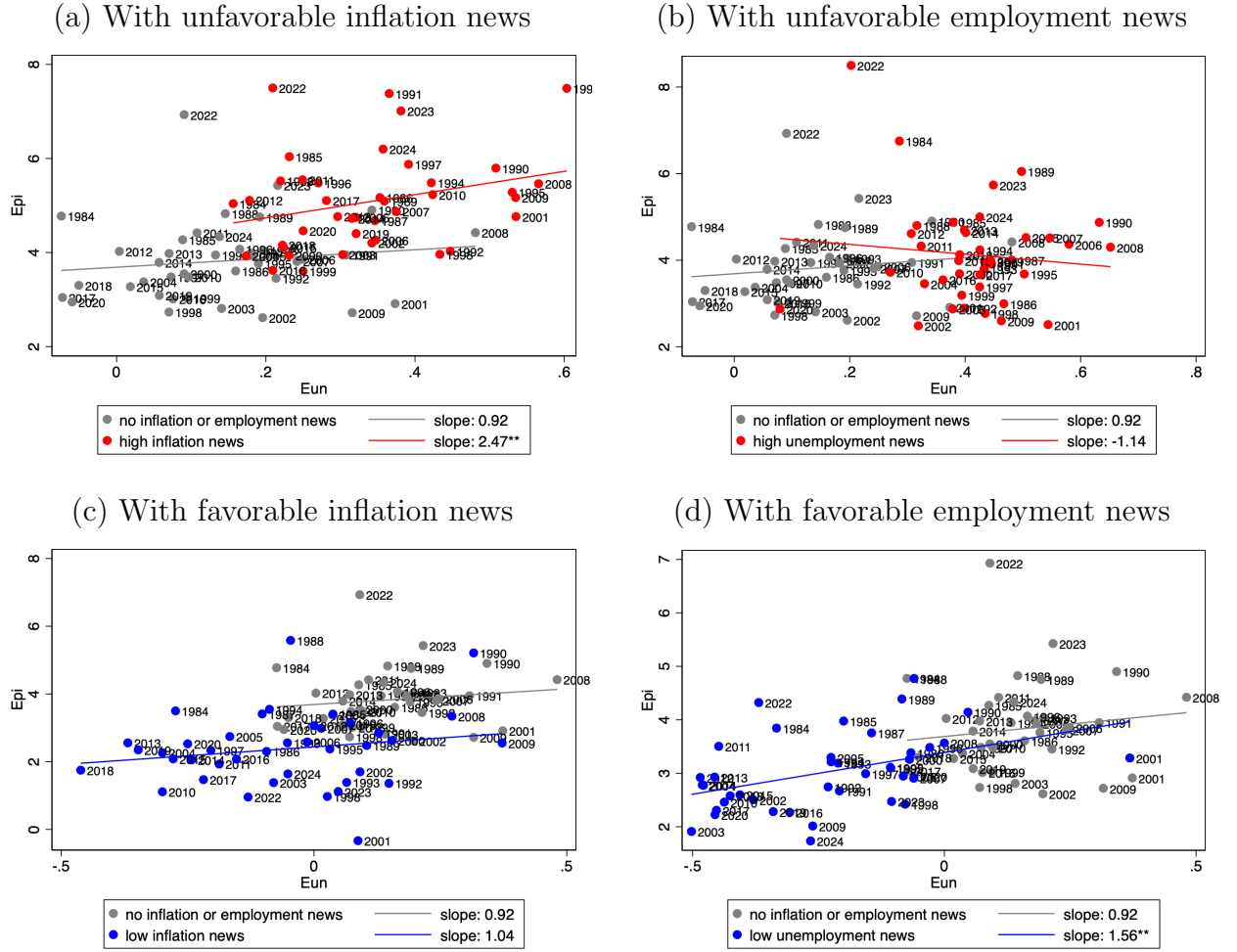
We consider these empirical patterns to support that the subjective model friction is quite important in explaining the correlation between expected inflation and unemployment both at the aggregate and the individual level. The households from MSC can distinguish the types of information they heard of and will adjust their expectations in different ways depending on the content of the information. In particular, news about high inflation will lead them to adjust both inflation and unemployment expectations upwards, contributing to the positive correlation between these two expectations. On the contrary, bad employment news will only move unemployment expectations, thus lowering the correlation. However, the subjective model is not likely to be the only reason. There is also news not clearly labeled that can be due to a mixture of signals, individuals with this type of news also seem to make the higher association between future inflation and unemployment status.

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[23]See Kamdar (2019) for example.

[24]We exclude the Covid years 2020 and 2021 as the unemployment rate numbers are extremely high, making them outliers for the sample.

Figure 3: Consensus expectations conditional on news heard

(a) With unfavorable inflation news

(b) With unfavorable employment news

(c) With favorable inflation news

(d) With favorable employment news

Notes: Scatter plot for consensus expected inflation and unemployment each year from 1984-2023. Gray dots in all panels are expectations for individuals without employment or inflation news. Top left panel: red dots are expectations conditional on hearing high inflation news. Top right panel: red dots are expectations conditional on hearing high unemployment news. Bottom left panel: blue dots are expectations conditional on hearing low inflation news. Bottom right panel: blue dots are expectations conditional on hearing low unemployment news.

4 Empirical Evidence II: Textual Analysis of Newspaper Articles

The previous section shows that self-reported news exposure changes households' domain-specific expectations, but only inflation news has impacts on the expectations across domains. What is special about inflation?

Recognizing the mass news media as one of the important sources of information for households to learn about the macroeconomy,[25] we further corroborate these findings by directly measuring news coverage on inflation, unemployment, and other related macroeconomic topics from a historical news archive. We confirm that measured news coverage is indeed correlated with self-reported news exposure, and is also domain-specific. This suggests that news coverage on the two topics cannot be a common signal that drives both expectations. Second, inflation news coverage is often associated with unfavorable perceptions, while unemployment news coverage has a relatively neutral connotation. Third, news articles are more likely to jointly discuss inflation and unemployment when the inflation is high, while there is no such pattern with the unemployment rates.

In practice, we use a selected sample of 150,000 news articles published in *Wall Street Journal*[26] between January 1984 to June 2022. These are filtered based on several criteria from a repeated random sample of 25,0000 articles in the database, around 25% of the total number of articles published on WSJ in this period. In particular, we exclude articles directly covering the news in non-U.S. countries/regions, and those that are not directly related to macroeconomic and financial markets, e.g. sports and culture and so on. In the main body of the paper, we primarily rely on simple keyword counts to determine if a news article is related to a particular topic.[27] Then we can construct article-specific news coverage of each topic using the frequency of keywords or average topic weights.

Define the news coverage of a particular topic, e.g. inflation, as the sum of the frequencies of the term "inflation" mentioned as a share of the total number of words within each article. Over the sample period, the time series of the news coverage of inflation and unemployment are highly correlated with their respective self-reported news exposure in MSC. (Figure 5) In particular, the correlation coefficient between news measure and the share of MSC

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[25]See evidence from Carroll (2003), Doms and Morin (2004), and Larsen *et al.* (2021).

[26]We choose WSJ as its main focus is economic and financial news targeted at the U.S. audience. Our results are confirmed by exactly the same analysis of another major news outlet, *New York Times*, as reported in the Appendix.

[27]In the Appendix, we report results with topic modeling tools based on Latent Dirichlet Allocation (LDA) as applied by Bybee *et al.* (2020). Compared to the simple metric of frequency counts, LDA admits a topic to be represented by not only one keyword but by a cluster of commonly used words that differ across topics. See Bybee *et al.* (2020) and Macaulay and Song (2022) for similar applications.

Figure 4: News Coverage of "Inflation" and "Unemployment"
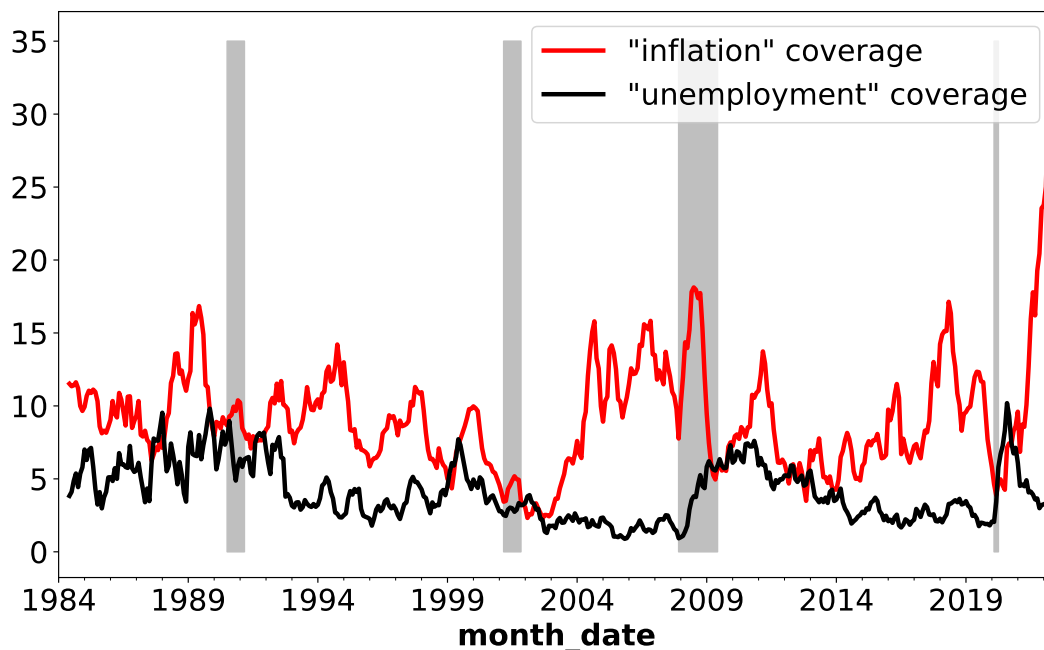
The news coverage is defined as the sum of the ratio of the frequency of the word being mentioned divided by the total number of words in each article.

households who report having heard *any* news about prices is 0.6. The correlation regarding unemployment news is around 0.37. (Table 5) Note that here *any* news is measured by gross exposure: the total fractions who have heard some either good or bad news. (Figure 5)

The news coverage is often domain-specific. Over the sample period, the time variations of news coverage of inflation and unemployment exhibit patterns of their own and do not simultaneously move. (See Figure 4) The correlation coefficients between two measures of news coverage are close to zero across various measures. It suggests that at least the joint news coverage of unemployment and inflation cannot be the common factor that drives the correlations between unemployment and inflation expectations. This is consistent with the finding in the previous section that news on inflation and unemployment can be distinguished from each other by households.

But there are differences between the two types of news. Unlike unemployment news, inflation news coverage is most of the time labeled as unfavorable. This can be seen from the fact that the high correlation between news coverage and self-reported exposure to any news on inflation is entirely driven by the share of agents who "have heard about *unfavorable* news about prices". The correlation between self-reported negative exposure and news coverage is almost equal to that of the gross measure. In contrast, the news coverage of unemployment

is less correlated with exposure to either positive or negative news alone than gross exposure. (See Table 5) This suggests that although labor market news coverage is likely to be either favorable or unfavorable from the point of view of the households, inflation news coverage is more likely to be associated with a negative connotation.

Table 5: News Coverage and Self-Reported News Exposure

Topic	Any News	Bad News	Good News
Inflation	0.605	0.627	-0.048
Unemployment	0.373	0.295	0.153

To more systematically assess what drives the newspaper articles' association between inflation and unemployment, we run a Probit regression to explore the factors correlated to an article's tendency to draw an association between inflation and unemployment. The regressors include a range of article-specific topic dummies and the realized inflation rates π_t and unemployment rates u_t. Columns 1-3 in Table 6 report the results.

The association between unemployment and inflation is more likely to be seen in one news article which is also about "Fed", "growth", "economy", "recession", and "uncertainty".

In addition, Columns (1)-(3) include only realized unemployment rates, inflation rates, and both, respectively. They together show that a higher inflation rate π_t is associated with a higher probability of an article mentioning both inflation and unemployment, while the level of unemployment rate does not have any effects. Higher inflation rates not only lead to more coverage of inflation but also result in more associations made between inflation and unemployment in news articles.

To summarize, this section shows that inflation news coverage is not only directionally negative as perceived by households but also more likely to lead to news coverage across domains on topics such as unemployment. One hypothesis regarding this asymmetric pattern might be that inflation news serves as a more salient memory cue for selective recall of subjective models in the minds of households. (Andre *et al.*, 2022) provides suggestive evidence for such mechanisms, which we leave for future research for further exploration.

5   Conclusion

In this paper, we document that the expectational variables from U.S. household surveys correlate with each other. In particular, U.S. consumers predict high inflation with worse economic performances, including higher unemployment and weaker growth. This correlation differs from what is observed in realized macroeconomic variables and professional forecasts. It is also inconsistent with the predictions from the standard New Keynesian model.

Figure 5: News Coverage, Self-reported News Exposure, and Macroeconomic Realizations
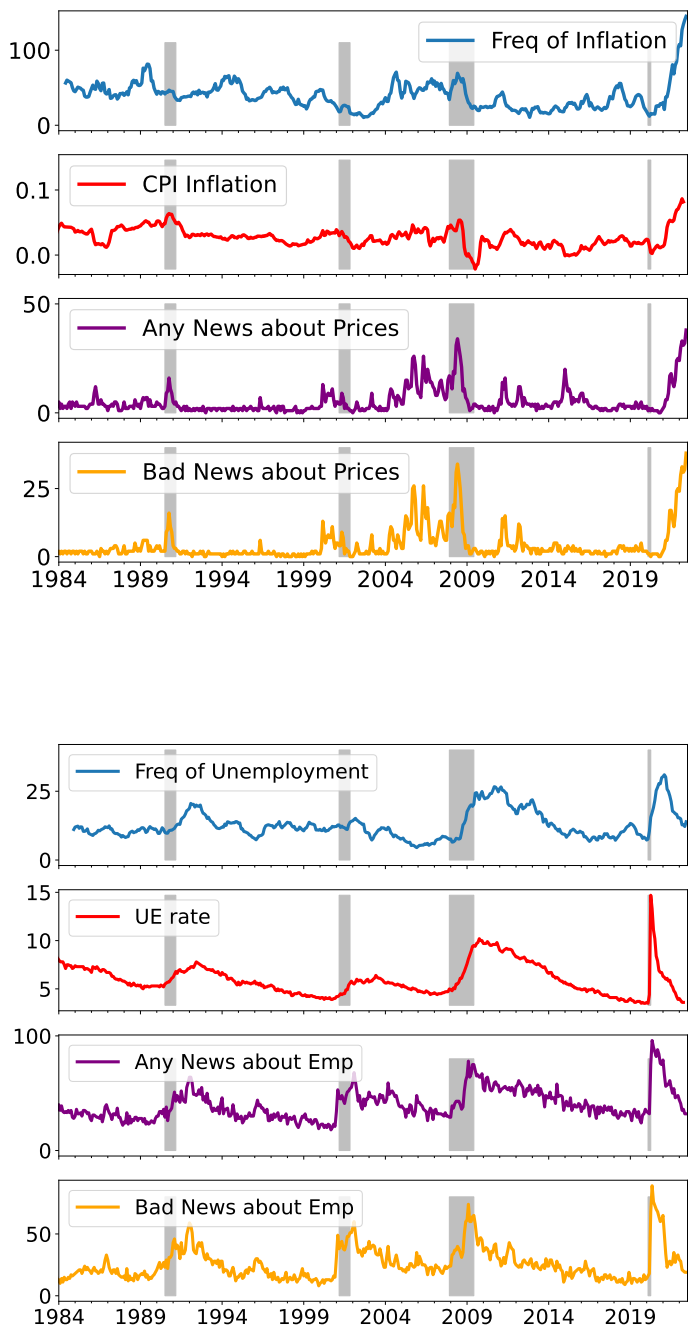
This plots the news coverage measured in WSJ sample, realized inflation and unemployment rates, and two self-reported news exposures in MSC.

Table 6: Drivers of Inflation-Unemployment Association

	(1)	(2)	(3)
economy	1.07***	1.07***	1.07***
	(0.03)	(0.03)	(0.03)
fed	0.22***	0.21***	0.21***
	(0.03)	(0.03)	(0.03)
growth	0.60***	0.61***	0.61***
	(0.03)	(0.03)	(0.03)
oil price	0.24***	0.24***	0.24***
	(0.05)	(0.05)	(0.05)
recession	0.48***	0.47***	0.47***
	(0.03)	(0.03)	(0.03)
uncertainty	0.14***	0.15***	0.15***
	(0.05)	(0.05)	(0.05)
π_t		3.73***	3.62***
		(0.93)	(0.96)
u_t	-0.01		-0.00
	(0.01)		(0.01)
N	150465	150465	150465

** $p<0.001$, ** $p<0.01$ and * $p<0.05$.

The table reports results from Probit regressions with the dependent variable being the dummy indicating if an article mentions both "inflation" and "unemployment" in the texts. Regressors are dummy variables to indicate if the particular keyword, e.g. growth, is mentioned in the article. π_t and u_t are the inflation and unemployment rates at time t, the date of publication of the article.

These patterns are hard to explain using the standard single-variable noisy information model. We propose a joint expectation formation model and a simple test to distinguish it from standard single variable models. We then show survey data strongly support the idea that consumers form expectations on various subjects jointly rather than independently. The joint learning model then can help to understand the cross-correlation we documented in household survey expectations. The cross-correlation can arise from either agents holding subjective beliefs in the structure of the economy that is different from realized data or economic theories or the agents observing mixed signals generated by multiple state variables with possibly correlated noises. We then examine the testable implications from survey data to show that the cross-correlation is majorly driven by agents' subjective belief in the structure of the economy. The test results suggest U.S. consumers believe that past inflation will lead to the deterioration of future real economic conditions. Meanwhile, the professionals do not hold such beliefs. This explains why we did not find the same positive correlation in SPF.

To further support this argument, we supplement the above results with evidence from self-reported news measures in MSC and directly measured news coverage in historical news archives. We show that information related to inflation moves expectations of unemployment and inflation in the same direction. In contrast, information about real economic variables typically fails to create the co-movement of these expectational variables. These results are consistent with the notion that agents' subjective beliefs about the economic model are the main reasons for the cross-correlation documented before.

These findings have important implications for households' behaviors in response to their expectations and Central Bank Communication. Multiple researchers have found negative responses of households' consumption attitudes to their inflation expectations. This paper shows that inflation-specific news makes agents believe economic conditions, in general, will be worse. The precautionary motive and anticipated income decrease can generate a negative response to consumption. For Central Bank Communication, signals on current or future inflation are likely to create pessimistic beliefs on economic performance among households. The findings suggest Central Bank should use an inflation-related expectation management policy with cautious and clear messages that distinguish inflation from real economic conditions will be beneficial.

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A Data Appendix

A.1 Data Description

SCE: Survey of Consumer Expectations is run by the New York Fed started in June 2013, available in monthly frequency.[28]. We use the median year-ahead inflation expectation as proxy for expected inflation and the expected chance that unemployment rate will increase in 12 months as proxy for expected unemployment rate change.

MSC: The monthly component Michigan Survey of Consumers started from 1978.[29] We use the expected price change in one year as proxy for expected inflation and the question about whether the unemployment rate will go up, down or stay the same as proxy for expected unemployment rate change.

FRED: We use year-to-year Headline CPI (CPIAUCSL) as measure of realized inflation and year-to-year change of unemployment rate (UNRATE) as measure of changes in unemployment status.

SPF: We use the series on CPI Inflation Rate (CPI) from the Survey of Professional Forecasters as their measure of expected inflation. And we use the series on Civilian Unemployment Rate as their measure of expected unemployment rate. To make it comparable to consumer surveys we compute the expected year-ahead change of unemployment rate from this series.

A.2 Aggregate Survey Forecast and Real-time Data

To first illustrate the difference between the survey expectation and realized data, Figure 6 plots raw data on average expectation from MSC with realized data for inflation and unemployment rate change. All real-time series are change from a year ago, as the corresponding expectation series are one-year-forward forecasts. The abnormal spikes in unemployment rate changes correspond to the Covid-19 episode.

A.3 Time Series Evidence

We first report the simultaneous correlation between consensus expectations on inflation and unemployment from MSC, SPF, and realized data. All the expectation variables are the
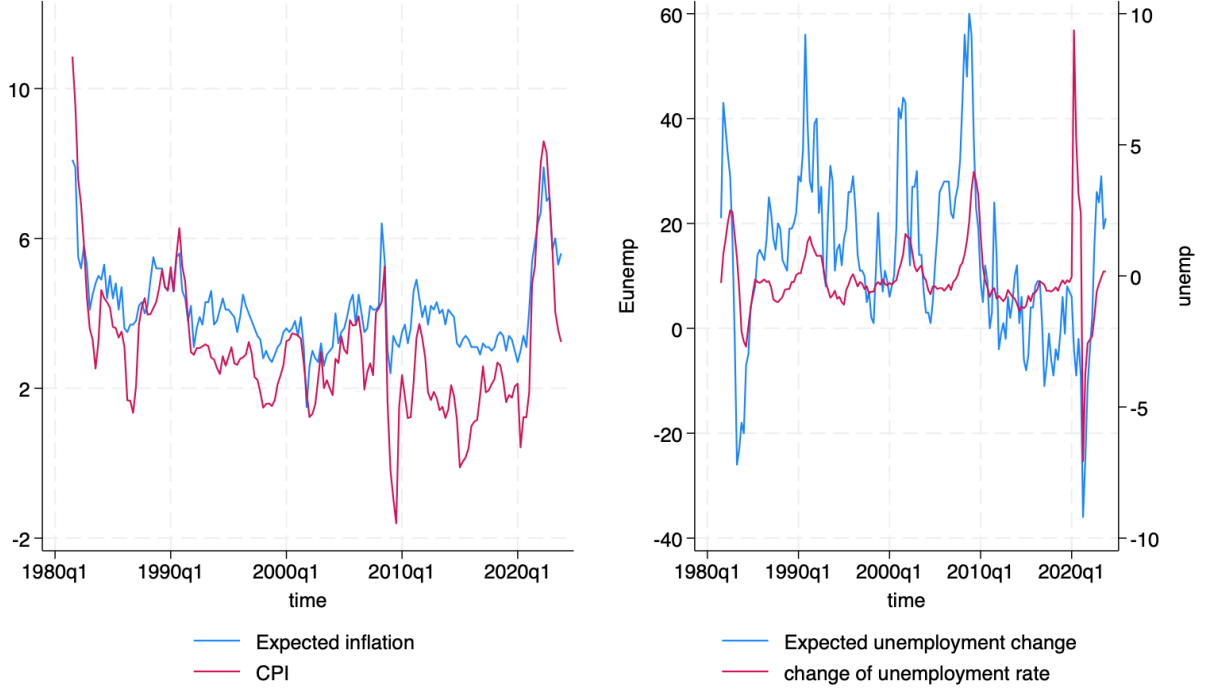
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[28]For details of SCE see Armantier *et al.* (2016)

[29]Quarterly data starts earlier from 1960 but with a lot of dimensions missing.

Figure 6: Actual and Expected Inflation and Unemployment

Survey expectation from MSC against the realized data. All macro data are changes from a year ago, survey expectations are one-year-forward forecasts. Unemployment expectation is aggregated from categorical data. Positive number means more people believes unemployment will increase in the future.

average of individual expectations within the quarter.[30]

Table 7: Correlations between expected/actual inflation and unemployment

Sample	MSC	SPF	FRED
1984-2023	0.14*	−0.03	−0.32***
1981-2018	0.16**	0.03	0.00
1990-2018	0.27***	0.05	−0.08

**** means significant at 1%,** means 5 % and * means 10%, indicating significance level of Pearson Correlation. In sample 1984-2023 we exclude the Covid year 2021.*

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[30]In MSC, expectation data is available at a monthly frequency. We use quarterly data to keep MSC at the same frequency as SPF. The use of monthly data does not change our results qualitatively.

Table 7 summarizes the Pearson correlation between (expected) inflation and unemployment change in different samples we considered in our empirical analysis. Throughout the different samples the correlation between these expected variables in Household surveys are significantly positive, different from those in SPF and actual data.

A.4 Evidence from Individual-level Cross-correlation

There are potentially many possible explanations for the observed positive correlation between consensus expectations. One possibility is that waves of pessimism and optimism move the average unemployment and inflation beliefs in the same direction. Furthermore, as seen from Figure 1, the time-series correlation will heavily depend on the presence of aggregate shocks.

To rule out these possibilities, we examine whether individual respondents in household surveys make a similar association. This will help me understand whether the patterns in aggregate-level data have a micro-level foundation or are mainly coming from the aggregation process. Various former researches suggest that the properties of consensus expectations may differ from those of individual expectations.[31] Figure 7 shows the estimated correlation from the cross-sectional regression in each year.

The top panel of Figure 7 uses data from MSC. In this survey, the respondents are asked whether they think unemployment will go up, stay the same, or go down a year from now. The two lines are the differences in inflation expectations relative to consumers who believe unemployment will stay the same for each year. The figure suggests that households' beliefs on inflation are again positively associated with their beliefs on unemployment change. Such a positive relation is significant and relatively stable across time. This finding is the same as in Kamdar (2019).

The bottom panel of Figure 7 is the cross-sectional correlation between expected inflation and unemployment rate change in SPF. Contrary to consumers, professionals do not associate inflation with the unemployment rate when forming their beliefs.

Could this correlation be driven by a specific group of individuals? For example, if there are groups of pessimistic individuals, they will always form worse-than-average unemployment expectations together with higher-than-average inflation expectations. This will create a positive association in the cross-sectional analysis above. We then utilize the panel dataset in MSC and SPF to control for individual fixed effects as well as time-fixed effects.

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[31]For instance, Coibion and Gorodnichenko (2015) suggests the predictability of forecasts error from forecast revision is an emerging property of aggregation across individuals and may not be seen at the individual level; Bordalo *et al.* (2018) documents over-reaction of inflation expectation to new information on the individual level, in contrary to under-reaction typically found with consensus expectations.

Figure 7: Time-varying correlation between inflation and unemployment change
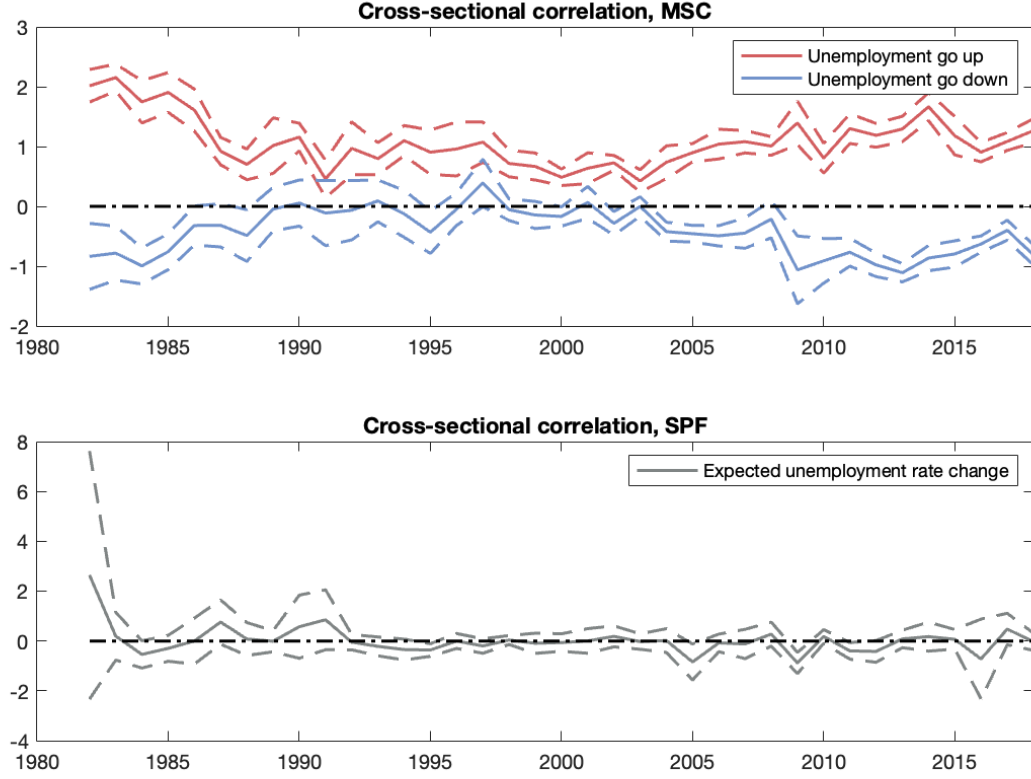
The top panel reports estimates β_1 from: $E_{i,t}\pi_{t+12,t} = \beta_0 + \beta_1 U_{t+12,t} + \theta\mu_i + D_t + \epsilon_{i,t}$. Where $U_{t+12,t}$ stands for two dummy variables indicating the MSC consumer believes the unemployment rate will go up or down in the next 12 months. The bottom panel reports estimates β_1 from: $E_{i,t}\pi_{t+4,t} = \beta_0 + \beta_1 E_{i,t}un_{t+4,t} + \theta\mu_i + D_t + \epsilon_{i,t}$. Where $E_{i,t}un_{t+4,t}$ stands for the expected change of unemployment rate from SPF. The data from MSC is monthly and from SPF is quarterly. 10% confidence interval is reported in dash lines.

$$E_{i,t}\pi_{t+12,t} = \beta_0 + \beta_1 E_{i,t}un_{t+12,t} + \beta_2 E_{i,t}i_{t+12,t} + \theta X_{i,t} + D_t + \mu_i + \epsilon_{i,t} \tag{12}$$

Again because in MSC, the expected unemployment change is a categorical variable, β_1 in (12) contains coefficients when expected unemployment goes up or down. $X_{i,t}$ includes controls such as expectations on other subjects and social-economic status, μ_i and D_t stand for individual and time-fixed effects respectively. Because the panel dataset from MSC contains fewer observations and only keeps the participants for two waves of surveys six months apart, we also report the results from the same regression using panel data from SCE. [32]

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[32]When using MSC, the expected unemployment and interest rate change are categorical variables, and we construct dummies that stand for increase or decrease for each of these variables. In SCE, those variables are reported as percentage points for the likelihood of the corresponding variable increasing.

Table 8: FE Panel Regression

	MSC		SCE		SPF
Unemployment up	0.30***	$\hat{\beta}_1$	0.012***	$\hat{\beta}_1$	−0.17***
	(0.05)		(0.002)		(0.06)
Unemployment down	−0.22***				
	(0.05)				
FE	Y		Y		Y
Time dummy	Y		Y		Y

* ***,**,*: Significance at 1%,5% and 10% level. Estimation results for specification (12) controlling for individual and time-varying characteristics, individual fixed effect, and time-fixed effect. Standard errors are adjusted for heteroscedasticity and autocorrelation.

Table 8 column 1 shows that for MSC, an agent that expects the unemployment to go up will predict inflation to be 0.3% higher on average than one that believes unemployment to be stable; and 0.52% higher than one that believes the unemployment rate will fall. Meanwhile, the standard deviation of expected inflation across this episode is 1.17%, and the standard deviation of CPI is around 2.19%. These results are comparable to those from Kamdar (2019), where the author estimates a similar fixed-effect model but only on the correlation between expected inflation and unemployment change, without controlling for other expectational variables. The estimates shown in column 2 from SCE are consistent with those from MSC: if the consumer expects a 22% higher chance (which is the standard deviation of the variable) unemployment rate will increase in 12 months, she will also expect inflation to be 0.22% higher. It's worth noting that controlling individual and time-fixed effects means the positive correlation between unemployment and inflation is not due to a common time-varying bias, which should have been captured by the time-fixed effect. It is also not due to the effect of "pessimistic individuals", which is taken out by individual fixed effects. Finally, in contrast to the consumers' expectations, column three shows that there is a negative correlation between expected inflation and change in the unemployment rate. On average, a 1% increase in the expected unemployment rate is associated with a 0.17% fall in expected inflation for professionals. This again coincides with the message from the aggregate correlation that professionals believe in a different relationship between future inflation and unemployment movements than consumers.

A.5 Recover Survey Mean from Categorical Data

From the cross-sectional dataset of MSC, we can acquire information on the fraction of respondents with different answers. Denote f_t^u as fraction of responses that are "increase" and f_t^d as "decrease". Assume for each period of t, there is a cross-section of answers formed by individuals about the change of the asked subject (unemployment rate or business condition and price). And assume this measure follows a normal distribution with mean μ_t and variance σ_t^2.

Assumption 4. *At each period t, survey respondent i forms a belief $x_{i,t}$ that indicates the change of asked variable x, this belief follows a normal distribution:*

$$x_{i,t} \sim N(\mu_t, \sigma_t^2)$$

Then suppose the agents have a common scale in answering the categorical question: If $x_{i,t}$ is close to some level b, then he will consider the subject will barely change; if $x_{i,t}$ is much bigger than b, he will answer increase, otherwise answer decrease.

$$category_{i,t} = \begin{cases} increase & x_{it} > b + a \\ decrease & x_{it} < b - a \\ same & x_{it} \in [-a + b, b + a] \end{cases}$$

Then the fraction of answer "increase", denoted as f_t^u, and "decrease", denoted f_t^d, will directly follow from normality:

$$f_t^d = \Phi\left(\frac{b - a - \mu_t}{\sigma_t}\right) \tag{13}$$

$$f_t^u = 1 - \Phi\left(\frac{a + b - \mu_t}{\sigma_t}\right) \tag{14}$$

The items we want to recover is μ_t, which is the corresponding average change of the asked subject a year from now. This can be computed using:

$$\sigma_t = \frac{2a}{\Phi^{-1}(1 - f_t^u) - \Phi^{-1}(f_t^d)} \tag{15}$$

$$\mu_t = a + b - \sigma_t \Phi^{-1}(1 - f_t^u) \tag{16}$$

From (15) and (16), compute the average across time we have:

$$\hat{\sigma} = 1/T \sum_t^T \sigma_t = 1/T \sum_t^T \frac{2a}{\Phi^{-1}(1 - f_t^u) - \Phi^{-1}(f_t^d)} \tag{17}$$

$$\hat{\mu} = 1/T \sum_t^T \mu_t = 1/T(a + b - \sigma_t \Phi^{-1}(1 - f_t^u)) \tag{18}$$

As in MSC there is no information on $\hat{\sigma}$ and $\hat{\mu}$, we use the time-series mean of the data from Survey of Professional Forecast (SPF) on comparable questions to approximate those from MSC[33]. Following (Bhandari *et al.*, 2019) we assume the ratio of the time-series average between inflation expectation and other expectations in MSC equals to its counterpart in SPF:

Assumption 5. *For the variable x asked in the survey:*

$$\hat{\sigma}_x^{MCS} = \frac{1/T \sum_t^T \sigma_{E\pi,t}^{MCS}}{1/T \sum_t^T \sigma_{E\pi,t}^{SPF}} \times 1/T \sum_t^T \sigma_{x,t}^{MCS}$$

And

$$\hat{\mu}_x^{MCS} = \frac{1/T \sum_t^T \mu_{E\pi,t}^{MCS}}{1/T \sum_t^T \mu_{E\pi,t}^{SPF}} \times 1/T \sum_t^T \mu_{x,t}^{MCS}$$

Then from (17) and (18) and Assumption 5 we can back out a and b, and with (16) we can recover $\mu_{x,t}$ for the expectational variable x.

Recovered series: To test whether the above method is plausible, we use the proposed method to recover the $\mu_{\pi,t}$ and compare it with the actual average of expected inflation from MSC. Figure 8 plots the recovered mean and the actual mean.

Figure 8 shows that the recovered data is actually quite close to the actual mean expectation, with a correlation of 0.95. Figure 9 shows the recovered data on expected unemployment change compared to actual data.

B Derivation of Noisy Information Model

B.1 Basic stationary Kalman Filter

Consider the ALM and observational equation as in (1) and (2), where $w_{t+1,t}$, v_t^i and η_t are independent normally distributed:

$$w_{t+1,t} \sim N(\mathbf{0}, Q) \quad v_t^i \sim N(\mathbf{0}, R_1) \quad \eta_t \sim N(\mathbf{0}, R_1)$$

---

[33]For unemployment rate change, we use the average difference between projected unemployment rate at $t + 3$ and the historical data at $t - 1$ which is the last information available to the economist. For real GDP growth, we use the real GDP growth projection for the next four quarters after $t - 1$.

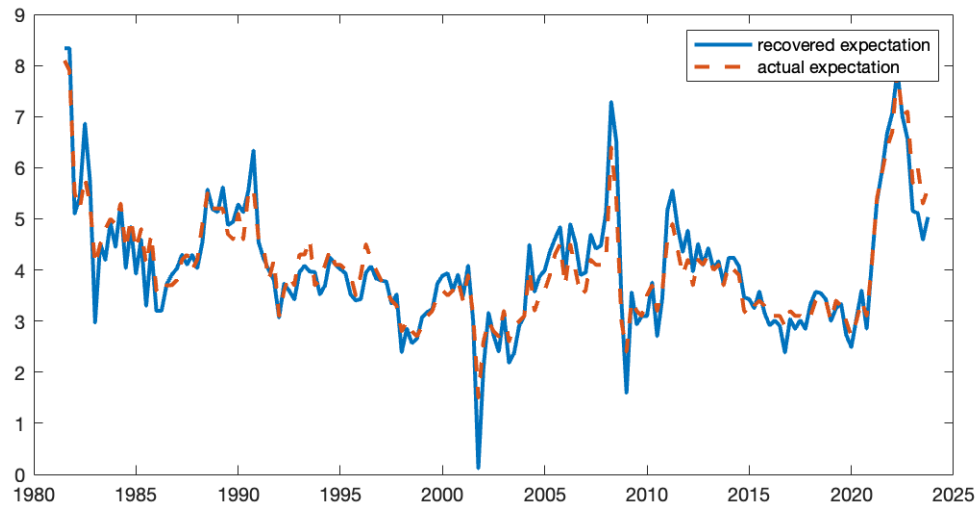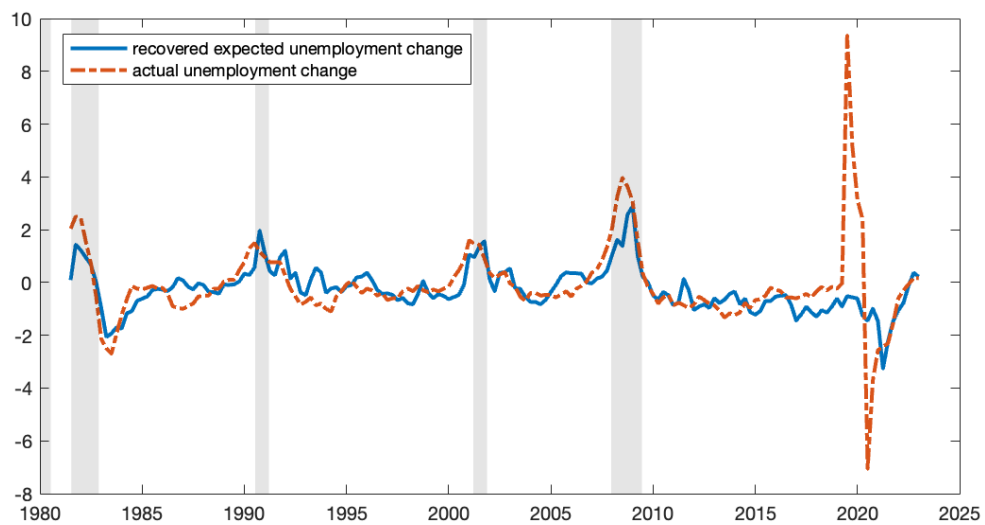Figure 8: Recovered Expected Inflation v.s. Actual

Figure 9: Recovered Expected Unemployment Change v.s. Actual.

Data from 1981q3 to 2023q4 due to availability of quarterly SPF on CPI inflation.

Consistent with the main-text, we denote $R = R_1 + R_2$, and the perceived value of $\boldsymbol{L}_{t,t-1}$ for individual i at time t as $\boldsymbol{L}^i_{t,t-1|t}$. The Filtering process is:

$$\boldsymbol{L}^i_{t,t-1|t} = \hat{A}\boldsymbol{L}^i_{t,t-1|t} = \boldsymbol{L}^i_{t,t-1|t-1} + K(\boldsymbol{s}^i_t - G\boldsymbol{L}^i_{t,t-1|t-1}) \tag{19}$$

The Kalman Filter is given by:

$$K = \Sigma G'(G\Sigma G' + R)^{-1}$$

$$\Sigma_p = \hat{A}\Sigma\hat{A}' - \hat{A}K_t G\Sigma\hat{A}' + Q$$

Where Σ is the covariance matrix of priors as defined in assumption 2, Σ_p is the covariance matrix of posteriors.[34] Then the expectation is given by:

$$\boldsymbol{L}^i_{t+1,t|t} = \hat{A}\big(\boldsymbol{L}^i_{t,t-1|t-1} + K(\boldsymbol{s}^i_t - G\boldsymbol{L}^i_{t,t-1|t-1})\big)$$

B.2 Derivation of Year-ahead Forecasting Error Rule

Consider the year-ahead consensus forecast $\boldsymbol{L}^c_{t+4,t|t}$ and year-ahead realization $\boldsymbol{L}_{t+4,t}$, using ALM (1) we have:

$$\boldsymbol{L}_{t+4,t} \equiv \sum_{j=1}^{4} \boldsymbol{L}_{t+j,t+j-1} = A\boldsymbol{L}_{t+3,t-1} + \sum_{j=1}^{4} w_{t+j,t+j-1} \tag{20}$$

Similar to equation (4), the year-ahead consensus expectation is:

$$\boldsymbol{L}^c_{t+4,t|t} = (\hat{A}^3 + \hat{A}^2 + \hat{A} + I)[\hat{A}(I - KG)\boldsymbol{L}^c_{t,t-1|t-1} + \hat{A}KG\boldsymbol{L}_{t,t-1} + \hat{A}K\eta_t] \tag{21}$$

Meanwhile from (19) and ALM we know:

$$\boldsymbol{L}^c_{t+3,t-1|t-1} = \sum_{j=0}^{3} \boldsymbol{L}^c_{t+j,t+j-1|t-1} = (\hat{A}^3 + \hat{A}^2 + \hat{A} + I)\boldsymbol{L}^c_{t,t-1|t-1}$$

Denote $\hat{W} = (\hat{A}^3 + \hat{A}^2 + \hat{A} + I)$ and stationarity of $\hat{A}$ guarantees $\hat{W}$ is invertible. Plug above equation into (21) we have:

$$\boldsymbol{L}^c_{t+4,t|t} = \hat{W}[\hat{A}(I - KG)\hat{W}^{-1}\boldsymbol{L}^c_{t+3,t-1|t-1} + \hat{A}KG\boldsymbol{L}_{t,t-1} + \hat{A}K\eta_t]$$

---

[34]Given common beliefs on $\hat{A}$ and G, it can be shown prior and posterior covariance matrices converge.

Now write the forecasting error $FE_{t+4,t|t}$ as defined:

$$FE_{t+4,t|t} \equiv \boldsymbol{L}_{t+4,t} - \boldsymbol{L}_{t+4,t|t}^c = A\boldsymbol{L}_{t+3,t-1} + \sum_{j=1}^{4} w_{t+j,t+j-1} - \boldsymbol{L}_{t+4,t|t}^c$$

$$= \hat{W}\hat{A}(I - KG)\hat{W}^{-1}FE_{t+3,t-1|t-1} + (A - \hat{W}\hat{A}(I - KG)\hat{W}^{-1})\boldsymbol{L}_{t+3,t-1}$$

$$- \hat{W}\hat{A}KG\boldsymbol{L}_{t,t-1} - \hat{W}\hat{A}K\eta_t + \sum_{j=1}^{4} w_{t+j,t+j-1}$$

$$= \hat{W}\hat{A}(I - KG)\hat{W}^{-1}FE_{t+3,t-1|t-1} + (A - \hat{W}\hat{A}(I - KG)\hat{W}^{-1})\boldsymbol{L}_{t+3,t-1}$$

$$- \hat{W}\hat{A}KG\boldsymbol{L}_{t,t-1} + \boldsymbol{L}_{t+3,t} - A\boldsymbol{L}_{t+2,t-1} - \hat{W}\hat{A}K\eta_t + w_{t+4,t+3}$$

$$= \hat{W}\hat{A}(I - KG)\hat{W}^{-1}FE_{t+3,t-1|t-1} + (I - \hat{W}\hat{A}(I - KG)\hat{W}^{-1})\boldsymbol{L}_{t+3,t-1}$$

$$- (I + \hat{W}\hat{A}KG)\boldsymbol{L}_{t,t-1} + A\boldsymbol{L}_{t+3,t+2} - \hat{W}\hat{A}K\eta_t + w_{t+4,t+3} \tag{22}$$

The last equation follows from the fact:

$$\boldsymbol{L}_{t+3,t-1} = \boldsymbol{L}_{t+3,t+2} + \boldsymbol{L}_{t+2,t+1} + \boldsymbol{L}_{t+1,t} + \boldsymbol{L}_{t,t-1} = \boldsymbol{L}_{t+2,t-1} + \boldsymbol{L}_{t+3,t+2}$$

C Proofs

C.1 Proposition 1

Proof. The Kalman Gain in this case:

$$K = \Sigma G'(G\Sigma G' + R)^{-1} = I \quad \Rightarrow \quad \hat{A}(I - KG) = \mathbf{0}$$

$\square$

C.2 Proposition 2

Proof. (1) From Kalman Filter:

$$KG = \Sigma G'(G\Sigma G' + R)^{-1}G$$

If both G and R are diagonal, KG will be diagonal and $\hat{A}(I - KG)$ is diagonal.

(2) Define

$$V = G'(G\Sigma G' + R)^{-1}G$$

As both Σ and R are symmetric and positive semi-definite, G is non-singular, it follows $G\Sigma G' + R$ is invertible and symmetric. It is immediately that V is symmetric. Denote $V := (v_{ij})_{n \times n}$, we have:

$$KG = \Sigma V = (\sigma_i^2 v_{ij})_{n \times n}$$

The off-diagonal elements of the coefficient matrix, w_{ij}, is given by:

$$w_{ij} = -a_i \sigma_i^2 v_{ij}$$

As $v_{ij} = v_{ji}$ for any $i \neq j$, it is obvious that either $w_{ij} = w_{ji} = 0$ if $v_{ij} = 0$, or $w_{ij} w_{ji} = a_i a_j \sigma_i^2 \sigma_j^2 v_{ij}^2 > 0$ if $v_{ij} \neq 0$. $\square$

C.3 Corollary 1

Proof. Denote $G = \begin{pmatrix} g_1 & \rho \\ \rho & g_4 \end{pmatrix}$, and $\Omega = (G\Sigma G' + R)$, we have:

$$KG = \Sigma G' \Omega^{-1} G = \begin{pmatrix} g_1 \sigma_1^2 & 0 \\ 0 & g_4 \sigma_2^2 \end{pmatrix} \frac{1}{det(\Omega)} \begin{pmatrix} \sigma_{2,s}^2 & -\rho \\ -\rho & \sigma_{1,s}^2 \end{pmatrix} \begin{pmatrix} g_1 & \rho \\ \rho & g_4 \end{pmatrix}$$

The off-diagonal elements are $-\frac{1}{det(\Omega)} \rho g_1 g_4 \sigma_1^2$ and $-\frac{1}{det(\Omega)} \rho g_1 g_4 \sigma_2^2$. As Ω is positive definite, the off-diagonal elements of $\hat{A}(I - KG)$ have same signs as ρ if $\hat{A}$ have positive entries on the diagonal. $\square$

C.4 Corollary 2

Lemma 1. *Consider 2-dimensional $\boldsymbol{L}_{t,t-1}$, 2 by 2 G, and signals generated by $s_t = G\boldsymbol{L}_{t,t-1} + \eta_t$ with $G = \begin{pmatrix} g_1 & g_2 \\ g_3 & g_4 \end{pmatrix}$ and η_t independent normal. $\exists \tilde{G}$ triangular and $\tilde{\eta}_t$ independent normal such that $\tilde{s}_t = \tilde{G}\boldsymbol{L}_{t,t-1} + \tilde{\eta}_t$ and $\mathbb{E}[\boldsymbol{L}_{t,t-1}|s_t] = \mathbb{E}[\boldsymbol{L}_{t,t-1}|\tilde{s}_t]$.*

Proof. Denote the noise $\eta_t \sim N\left(0, \begin{pmatrix} \sigma_{s,1}^2 & 0 \\ 0 & \sigma_{s,2}^2 \end{pmatrix}\right)$. Consider $\Gamma = \begin{pmatrix} \frac{\sigma_{s,2}^2 g_1}{\sigma_{s,1}^2 g_3} & 1 \\ -\frac{g_3}{g_1} & 1 \end{pmatrix}$ and the new signals:

$$\tilde{s}_t = \Gamma G \boldsymbol{L}_{t,t-1} + \Gamma \eta_t$$

Define $\tilde{G} \equiv \Gamma \eta_t$ and $\tilde{\eta}_t \equiv \Gamma \eta_t$. It is easy to verify that $\tilde{\eta}_t$ is independent normal and $\tilde{G}$ has only one non-zero off-diagonal element. Denote the Kalman gain of the original signals as K and the new signals as $\tilde{K}$. It is straightforward that:

$$\tilde{K}\Gamma G = \Sigma G' \Gamma' \left(\Gamma (G\Sigma G' + R)\Gamma' \right)^{-1} \Gamma G$$

$$= \Sigma G' \Gamma' (\Gamma')^{-1}(G\Sigma G' + R)^{-1}\Gamma^{-1}\Gamma G$$

$$= \Sigma G' (G\Sigma G' + R)^{-1} G = KG$$

The second equality holds as Γ is invertible. For the same reason, $K = \tilde{K}\Gamma$. Then we have:

$$\begin{aligned}
\mathbb{E}[\boldsymbol{L}_{t,t-1}|s_t] &= \hat{A}\big((I - KG)\boldsymbol{L}_{t,t-1|t-1} + Ks_t\big) \\
&= \hat{A}\big((I - \tilde{K}\tilde{G})\boldsymbol{L}_{t,t-1|t-1} + \tilde{K}\tilde{s}_t\big) \\
&= \mathbb{E}[\boldsymbol{L}_{t,t-1}|\tilde{s}_t]
\end{aligned}$$

$\square$

Here we prove the corollary with the general G:

Corollary 3. (Non-diagonal G) *If $\hat{A}$ is diagonal, $R = \begin{pmatrix} \sigma_{1,s}^2 & 0 \\ 0 & \sigma_{2,s}^2 \end{pmatrix}$ is diagonal, and $G = \begin{pmatrix} g_1 & g_2 \\ g_3 & g_4 \end{pmatrix}$, the off-diagonal elements of $\hat{A}(I-KG)$ have signs depending on $g_1 g_2 \sigma_{2,s}^2 + g_3 g_4 \sigma_{1,s}^2$.*

Proof. Again denote $\Omega = G\Sigma G' + R = \begin{pmatrix} a & b \\ c & d \end{pmatrix}$, where:

$$\begin{cases}
a = g_1^2 \sigma_1^2 + g_2^2 \sigma_2^2 + \sigma_{1,s}^2 \\
b = g_1 g_3 \sigma_1^2 + g_2 g_4 \sigma_2^2 \\
c = g_1 g_3 \sigma_1^2 + g_2 g_4 \sigma_2^2 \\
d = g_3^2 \sigma_1^2 + g_4^2 \sigma_2^2 + \sigma_{2,s}^2
\end{cases}$$

Denote the matrix $KG := \frac{1}{det(\Omega)} \begin{pmatrix} x_1 & x_2 \\ x_3 & x_4 \end{pmatrix}$. The off-diagonal elements of $\hat{A}(I - KG)$ depend on the signs of x_2 and x_3. It is easy to show:

$$\begin{cases}
x_2 = \sigma_1^2 (g_1 g_2 d - g_2 g_3 c - g_1 g_4 b + g_3 g_4 a) = \sigma_1^2 (g_1 g_2 \sigma_{2,s}^2 + g_3 g_4 \sigma_{1,s}^2) \\
x_3 = \sigma_2^2 (g_1 g_2 d - g_1 g_4 c - g_3 g_2 b + g_3 g_4 a) = \sigma_2^2 (g_1 g_2 \sigma_{2,s}^2 + g_3 g_4 \sigma_{1,s}^2)
\end{cases}$$

As $det(\Omega) > 0$, if the diagonal elements of $\hat{A}$ are both positive, the off-diagonal elements of $\hat{A}(I - KG)$ are:

$$\begin{cases}
\text{negative} & \text{if } g_1 g_2 \sigma_{2,s}^2 + g_3 g_4 \sigma_{1,s}^2 > 0 \\
\text{positive} & \text{if } g_1 g_2 \sigma_{2,s}^2 + g_3 g_4 \sigma_{1,s}^2 < 0
\end{cases}$$

$\square$

The proof of Corollary 2 follows directly from Lemma 1 and Corollary 3.

C.5   Proposition 4

Proof. If both G and R are diagonal, $KG = \Sigma G'(G\Sigma G' + R)^{-1}G$ is also diagonal. Denote $G = diag(\{g_i\}_{i=1}^n)$ and $R = diag(\{\sigma_{s,i}^2\})$. The matrix KG is also diagonal:

$$KG = \Sigma G'(G\Sigma G' + R)^{-1}G = diag\left(\left\{\frac{g_i^2 \sigma_i^2}{g_i^2 \sigma_i^2 + \sigma_{s,i}^2}\right\}\right)$$

with diagonal elements $0 < \frac{g_i^2 \sigma_i^2}{g_i^2 \sigma_i^2 + \sigma_{s,i}^2} < 1$. It follows immediately that:

$$w_{ij} = a_{ij}\frac{\sigma_{s,j}^2}{g_j^2 \sigma_j^2 + \sigma_{s,j}^2}$$

Consequently, w_{ij} has the same sign as a_{ij}. $\qquad\square$

D   Monte Carlo Simulation

We consider the different learning structures discussed in Table 1 and simulate expectation data according to the noisy information model from (1) and (3) with sample sizes similar to the survey data being used in Section 2.4. We then perform our joint learning test with year-ahead forecast as in (10), or with quarter-ahead forecast as in (6). This comparison is to show the test with year-ahead forecasts has similar performance to the one using quarter-ahead forecasts. Table 9 summarizes the parameters we used for simulation.

Table 9: Parameters for simulation

	Fixed Parameters	
Variable	Value	Description
$Q := \begin{pmatrix} \sigma_{1,t}^2 & 0 \\ 0 & \sigma_{2,t}^2 \end{pmatrix}$	$\begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix}$	Cov matrix of shocks
$\Sigma := \begin{pmatrix} \sigma_1^2 & 0 \\ 0 & \sigma_2^2 \end{pmatrix}$	$\begin{pmatrix} 2 & 0 \\ 0 & 2.5 \end{pmatrix}$	Cov matrix of prior
$A := \begin{pmatrix} \rho_1 & 0 \\ 0 & \rho_2 \end{pmatrix}$	$\begin{pmatrix} 0.9 & 0 \\ 0 & 0.7 \end{pmatrix}$	Structural parameters from ALM
T	152	time-series sample size
	Model-specific Parameters	
$\hat{A} := \begin{pmatrix} \rho_1 & m_1 \\ 0 & \rho_2 \end{pmatrix}$	$\begin{pmatrix} 0.9 & m_1 \\ 0 & 0.7 \end{pmatrix}$	Structural parameters from PLM
$G = \begin{pmatrix} g_1 & g_2 \\ 0 & g_4 \end{pmatrix}$	$\begin{pmatrix} 1 & g_2 \\ 0 & 1 \end{pmatrix}$	Signal Generating Matrix
$R := \begin{pmatrix} \sigma_{1,s}^2 & \rho \\ \rho & \sigma_{2,s}^2 \end{pmatrix}$	$\begin{pmatrix} 3 & \rho \\ \rho & 4 \end{pmatrix}$	Cov matrix of noises

As in Table 1, we consider five different cases: (1) FIRE; (2) Independent Learning with noisy but uncorrelated signals; (3) Independent Learning with mixture of states, i.e. G is non-diagonal; (4) Independent Learning with correlated noise, i.e. R is non-diagonal; (5) Joint Learning with $\hat{A}$ being non-diagonal. In Table 10 below we show the results with the first two cases. In both cases, $\hat{A} = A$ and $G = I$. The difference is that under FIRE, $\sigma_{1,s} = \sigma_{2,s} = 0$.

Table 10: Simulation Results: FIRE or Independent Learning with Uncorrelated Signals

	FIRE or Independent Learning: $\hat{A} = A$, $g_2 = 0$, $\rho = 0$							
	FIRE				Independent Learning			
	Y-ahead Spec (10)		Q-ahead Spec (6)		Y-ahead Spec (10)		Q-ahead Spec (6)	
	Truth	Test	Truth	Test	Truth	Test	Truth	Test
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
β_{11}	0	-0.01	0	0.04	0.54	0.51^{***}	0.54	0.47^{***}
	-	(0.03)	-	(0.09)	-	(0.09)	-	(0.09)
β_{12}	0	0.03	0	0.15	0	-0.14	0	-0.14
	-	(0.04)	-	(0.11)	-	(0.010)	-	(0.10)
β_{21}	0	0.01	0	0.10	0	-0.03	0	-0.09
	-	(0.02)	-	(0.09)	-	(0.04)	-	(0.11)
β_{22}	0	-0.00	0	0.18	0.43	0.49^{***}	0.43	0.61^{***}
	-	(0.05)	-	(0.12)	-	(0.07)	-	(0.11)

* ***,**,*: Significance at 1%,5% and 10% level. Columns (2) and (6) are estimation results for year-ahead joint-learning test (10), and columns (4) and (8) are for quarter-ahead specification (6). Newey-West standard errors are reported in brackets.

The results in Table 10 show the clear differences in test results under FIRE or Independent learning. For all specifications considered, if the expectation is formed under FIRE all the β's will be insignificantly different from zero. Meanwhile, if expectations are formed independently but with information friction, only estimates on β_{11} and β_{22} are significantly positive. The estimates on β_{21} and β_{12} will be insignificant.

Table 11: Simulation Results: Independent Learning with Correlated Signals

	Independent Learning when G or R are non-diagonal							
	G non-diagonal:				R non-diagonal:			
	$m_1 = 0$, $g_2 = 0.5$, $\rho = 0$				$m_1 = 0$, $g_2 = 0$, $\rho = -2$			
	Y-ahead spec (10)		Q-ahead spec (6)		Y-ahead spec (10)		Q-ahead spec (6)	
	Truth	Test	Truth	Test	Truth	Test	Truth	Test
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
β_{11}	0.57	0.56***	0.57	0.52***	0.49	0.43***	0.49	0.37***
	–	(0.05)	–	(0.08)	–	(0.05)	–	(0.09)
β_{12}	-0.14	-0.28***	-0.10	-0.26***	-0.17	-0.25***	-0.13	-0.24***
	–	(0.09)	–	(0.10)	–	(0.09)	–	(0.09)
β_{21}	-0.07	-0.10***	-0.10	-0.20**	-0.09	-0.11***	-0.12	-0.17
	–	(0.04)	–	(0.10)	–	(0.04)	–	(0.11)
β_{22}	0.40	0.46***	0.40	0.55***	0.39	0.49***	0.39	0.63***
	–	(0.07)	–	(0.11)	–	(0.07)	–	(0.11)

* ***,**,*: Significance at 1%,5% and 10% level. Columns (2) and (6) are estimation results for year-ahead joint-learning test (10), and columns (4) and (8) are for quarter-ahead specification (6). Newey-West standard errors are reported in brackets.

Table 11 shows the results if beliefs are formed under independent learning with noisy signals that are correlated. We consider two different cases of correlated signals: either G is non-diagonal or R is non-diagonal. In particular, we consider either $g_2 = 0.5$ or $\rho = -2$. According to Corollary 2 and 1, in both these two scenarios β_{12} and β_{21} will be negative. Both regressions with (6) and (10) perform well to uncover such a pattern.

We then consider the test results under joint learning: when $\hat{A}$ is non-diagonal and signals are uncorrelated. In Table 12 we report the test results from simulated data for both year-ahead specification (6) and quarter-ahead specification (10). Both test results are in line with the predictions from Proposition 4.

Table 12: Simulation Results: Joint Learning

	Joint Learning: $m_1 = 0.5$, G and R are diagonal			
	Year-ahead spec (10)		Quarter-ahead spec (6)	
	Truth	Test	Truth	Test
	(1)	(2)	(3)	(4)
β_{11}	0.54	0.48***	0.54	0.44***
	-	(0.08)	-	(0.08)
β_{12}	0.32	0.49**	0.31	0.35***
	-	(0.22)	-	(0.10)
β_{21}	0	-0.02	0	-0.08
	-	(0.04)	-	(0.09)
β_{22}	0.43	0.54***	0.43	0.70***
	-	(0.12)	-	(0.14)

* ***,**,*: Significance at 1%,5% and 10% level. Column (2) contains estimation results for year-ahead joint-learning test (10), and column (4) is for quarter-ahead specification (6). Newey-West standard errors are reported in brackets.

All in all, the test results using simulated data are consistent with the theoretical predictions. The performance of tests using year-ahead forecast error or quarter-ahead forecast error are similar throughout different scenarios we considered.

E   News Measure from MSC

E.1   Description

In MSC there is a question asking about news heard recently about business conditions:

A6. During the last few months, have you heard of any favorable or unfavorable changes in business conditions?
A6a. What did you hear?

The news reported in this question should be considered as self-reported information, it may contain both public and private information heard by the survey respondents. The content of news described by the respondents are categorized into 80 different categories by MSC. We further summarize these categories into 10 different types of news, as described in Table 13. In Figure 10 we plot the share of survey respondents that report hearing any news. Figure 11 depicts the fraction of agents hearing news about unemployment and

inflation conditional on hearing any news.

Table 13: Types of News Reported

| Categories Defined	News description in MSC	
	Favorable	Unfavorable
Employment	Employ is high, plenty of jobs	Drop in employ, less overtime
	Other references to employ and purch power (fav)	Other references to employ and purch power (unfav)
Industry	Opening of plants, factories, stores	Closing of plants, factories, stores
	Improvements in specific industries	Decline in specific industries
	Farm situation good, crops good	Farm situation is bad, low farm prices, drought
Inflation	Lower/stable prices, less inflation	Prices falling, deflation
Interest rate	Easier money, credit easy to get, low int rates	Tight money, int rates high
Demand	Consumer/auto demand high	Consumer/auto demand low
	Population increase, more people to buy	Population increase, immigration
Government	Elections, admin, Congress, President (fav)	Elections, admin, Congress, President (unfav)
	More military spending, more war/tensions (fav)	More military spending, more war/tensions (unfav)
	Less military spending, few tensions (fav)	Less military spending, few tensions (unfav)
	etc.	etc.
Sentiment/Unclear	Better race relations, less crime	Bad race relations; more crime
	Times/business is good in the coming year	Times are bad now and won't change in next year
	Economy more stable, optimism	Economy in general less stable, lack of confidence
	etc.	etc.
Financial Market	Stock market, rise in price of stocks	Stock market decline
Other Real Activities	Low debts, higher savings/assets, invest up	High(er) debts, lower savings/assets
	Production increasing, GNP is up	Production decreasing, GNP down
Other Price Related	Profits high/rising	Profits high, too high
	Balance of payments, dollar devalue	Balance of payments, dollar devalue
	Price or wage controls (fav)	Price or wage controls (unfav)
	etc.	etc.

Notes: The descriptions of news are documented by the Michigan Survey of Consumers. We reclassified them according to these descriptions.

Figure 10: Share of People that Report Hearing of News
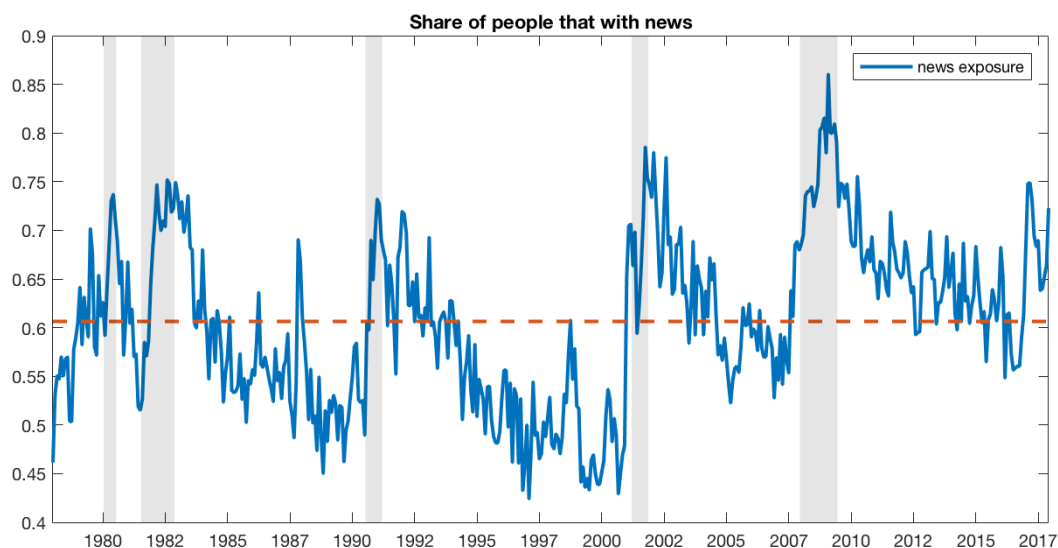
Share of people that report hearing any news across time. The dashed line represents on average 60% survey participants reported hearing about some news in the past few months.

Figure 11: Share of People that Report Hearing of News on Inflation and Employment
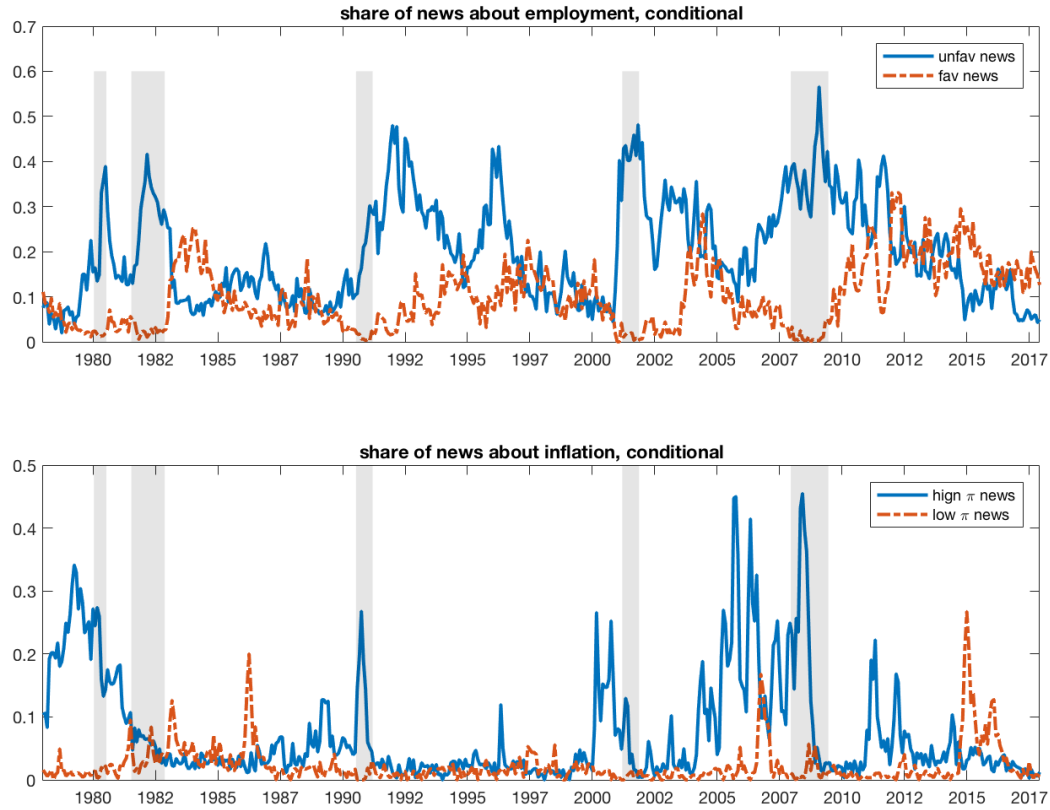
Share of people that report hearing the news on employment or inflation, conditional on hearing any news. In the top panel, the blue line is the fraction with unfavorable news on employment and the red dash line is the fraction with favorable news. In the bottom panel, the blue line is the fraction with news on higher inflation.

On average there are more than 60% agents report they have heard some news about the economy, and the fraction is comoving with the business cycle, peaking in each recessions. Among this news about unemployment and inflation accounts for more than 40% on average, peaking at about 80% in the recent recession. There is an asymmetry in tones of news: the blue curve is almost always above red ones, which suggests agents report to hear of bad news more often than good ones.

F   Additional Evidence from Newspapers

The inflation-unemployment association was seen in different narratives

Since the association between unemployment and inflation is not driven by common signals in the newspaper, we inspect, instead, if such an association is driven by different subjective

models, or narratives in news discourses. We identify a narrative as a correlation between different topics that are *within* a news article.

To get some intuition, consider monetary policy, as one example of a topic. It is indicated by an article mentioning the keyword "Fed", or by having a positive weight of a topic consisting of a list of keywords that can be interpreted as primarily related to the monetary policy, e.g."Fed', "Rate", "Inflation", "Economy"... With these measures, we can examine if one article discussing monetary policy is more likely to draw connections between unemployment and inflation than other articles. Our goal is not to identify causal links or directional correlations made in news articles. Instead, we treat the correlation between the frequencies of mentioning both terms as an indication of an article associating the two variables according to some model. Our goal is then to identify the topics prevailing in inflation-unemployment narratives, and if such an association is particularly more common in certain narratives than in others.

Throughout the entire sample, the correlation between the frequencies of mentioning "inflation" and "unemployment" within each article is 0.2. This indicates that economic news articles tend to associate the two variables/concepts in economic discussions. Note that this is different from the zero correlation across time between the news coverage of unemployment and inflation.

We also found that there is a wide range of contexts in which the article makes an association between inflation and unemployment. Figure 12 shows conditional on mentioning any one of the keywords such as"Fed", "Oil price", "growth", and "recession", economic news all have a higher correlation coefficients between the frequencies of jointly discussing inflation and unemployment.

Going beyond simple word counts, Figure 13 plots the most common LDA topics, ranked by their weights, in articles mentioning both inflation and unemployment and mentioning either topic alone. The articles that jointly mention both words and inflation-only articles largely overlap in the common topics, such as monetary policy, economic growth, prices, and exchange rates. In contrast, the most common topics in unemployment-only articles are not the same, For instance, unemployment, tax policy and union topics are all specific to unemployment news.

Negative sentiment cannot be the common factor, either

One alternative explanation for the correlated inflation and unemployment expectations is a broadly defined negative sentiment. Based on measures of overall and topic-specific sentiment using newspaper texts, we find no direct support for this hypothesis. In particular, we show that the average sentiment score of articles that mention both inflation and unemployment is uncorrelated with the tendency of economic articles to associate the two within articles.

Figure 12: Associations between "Inflation" and "Unemployment" by Topic
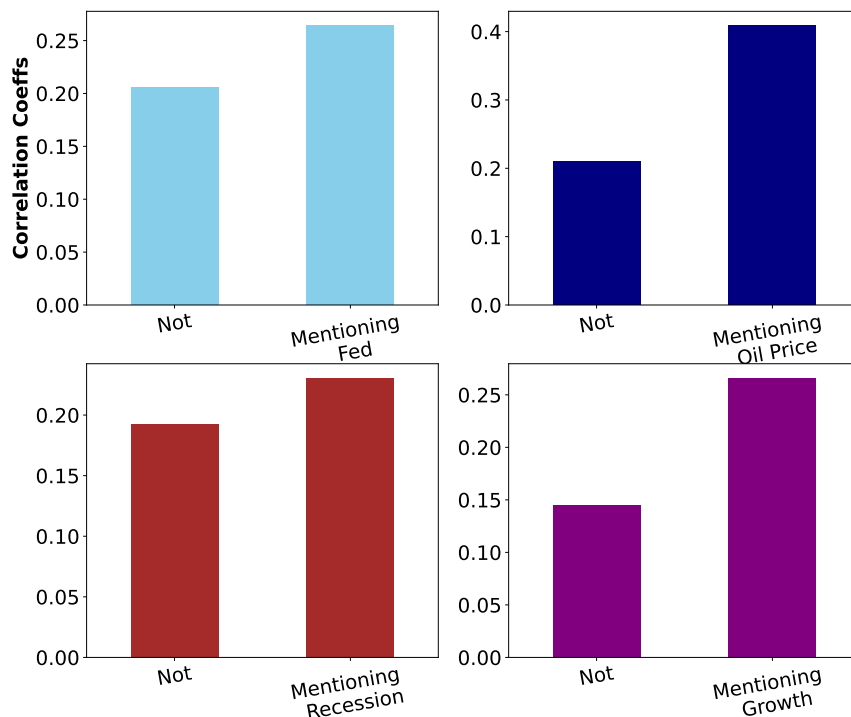
This bar chart shows the correlation coefficients between frequencies of mentioning "inflation" and "unemployment" by all articles conditional on mentioning four other keywords.

Figure 15 shows the time series of within-article correlation between coverage of unemployment and inflation in rolling windows and the measured sentiment of articles that mention both unemployment and inflation. The correlation between the two is weakly positive. It suggests that negative sentiment, as measured in inflation-unemployment news, cannot be the only driver of the inflation-unemployment association.

Figure 13: Topics in Inflation-Unemployment Narratives
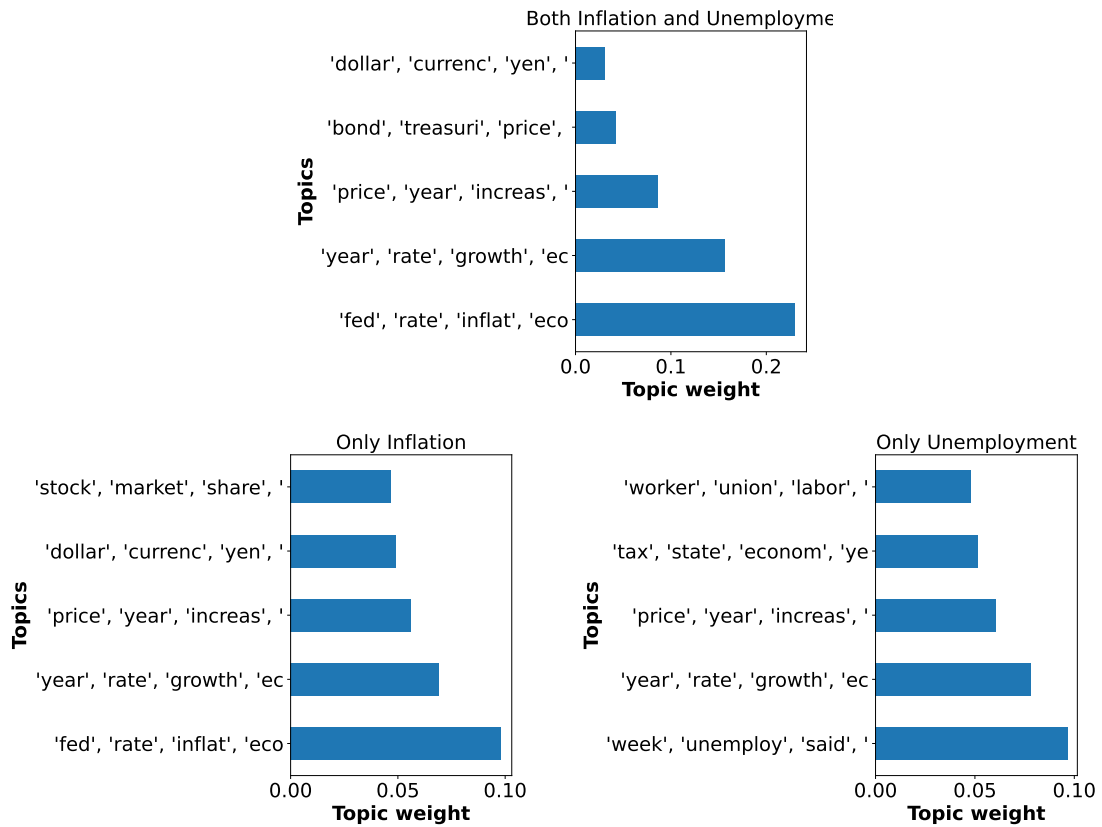
The bar charts plot the top five topics identified by the topic model, in articles that mention both inflation and unemployment and those that only mention inflation or unemployment. Topic weights are between 0-1.

Figure 14: Key Words in Different Inflation-Unemployment Narratives
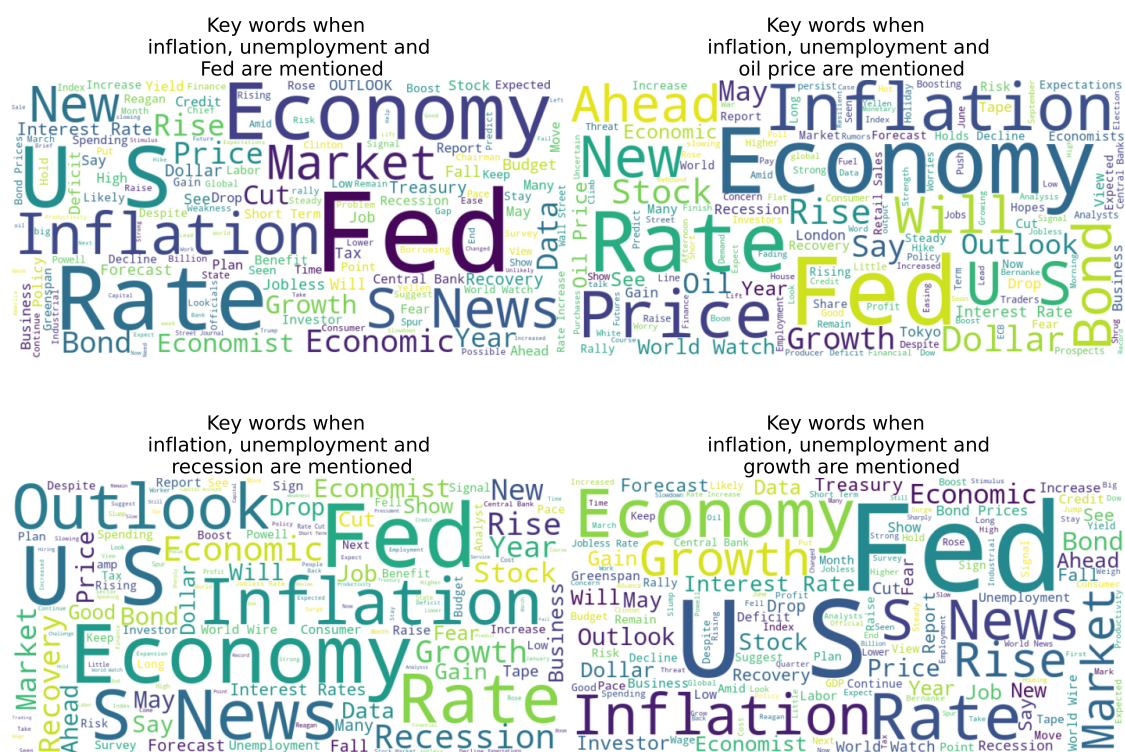
The figure plots the 100 most frequently used words in news articles that mention inflation, unemployment and one of the four economic topics: Fed, oil price, recession, and growth, respectively.

Figure 15: Sentiment in Inflation-Unemployment News
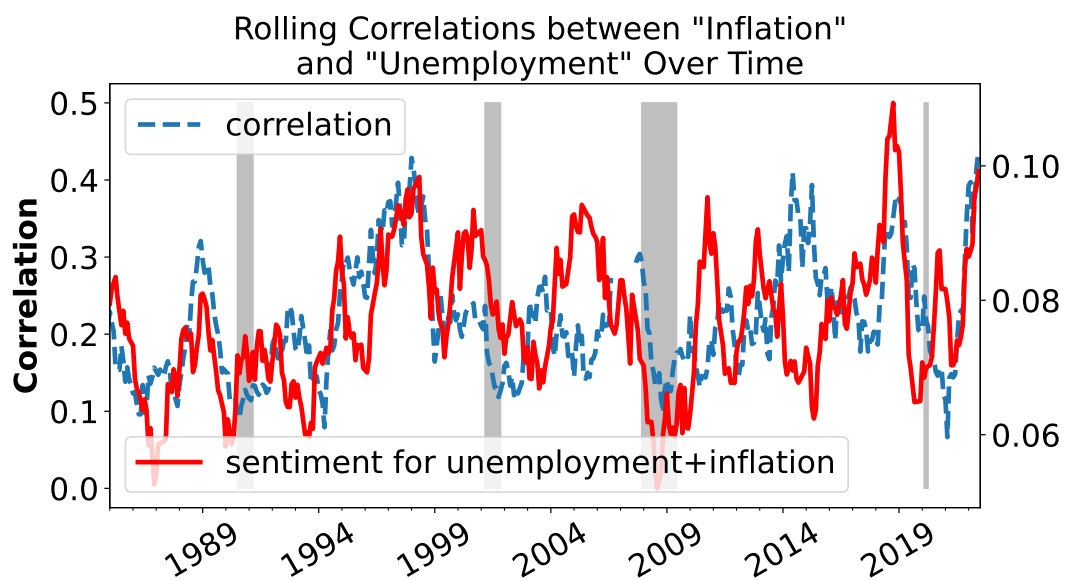
On the left axis is the average within-article correlation coefficients between frequencies of "inflation" and "unemployment" for a rolling window of 2 years. In the right axis is the average sentiment score of articles mentioning both terms.