When Pessimism Strikes: Sentiment Shocks, and Durable Consumption*

Vladimir Menshikov†

February 2024

Abstract

This paper identifies sentiment shocks from households' inflation expectations by imposing a set of zero and sign restrictions in Structural Vector Autoregression. This shock reflects movements in economic agents' "animal spirits", gives rise to excessive pessimism or optimism about an economic outlook in their minds and rationalizes a departure of households' and firms' expectations from rationality. I quantify aggregate fluctuations triggered by the sentiment shock and find that depressed sentiments lead to a persistent decline in economic activity and an unusual S-shaped dynamics of inflation. One candidate mechanism that can explain these effects, operates through a decline in spending on durable goods. The shock best explains medium run volatility of the unemployment rate, industrial production and consumption, contributes more to short term fluctuations of inflation expectations and accounts for a similar share of variance of realized inflation at both short and medium run frequencies.

Key words: sentiments, shock identification, structural Vector Autoregression, inflation expectations, business cycles, durable consumption

*I am deeply grateful to my primary advisor Christian Matthes for invaluable guidance and continued support throughout the development of this paper, my co-advisors Rupal Kamdar and Todd Walker for fruitful discussions, and participants of the Macro Brown Bag at Indiana University for helpful suggestions.

†Wylie Hall, Department of Economics, Indiana University, 100 South Woodlawn Avenue, Bloomington, IN 47405 USA (email: vlmenshi@iu.edu)

1 Introduction

Every modern macro model is inhabited by forward-looking economic agents whose decision today depends on future outcomes, thus expectations about economic fundamentals influence current economic choices and play a central role in determining equilibria. Researchers typically assume that households and firms have full information and are rational, hence form Full Information Rational Expectations (FIRE). However, as the number of surveys eliciting expectations grows and more data become available, empirical literature documents deviations of agents' measured expectations from the FIRE framework.

Inflation expectations have been given major attention in macroeconomics, thus research has largely focused on this type of expectations. A prominent feature of households' and firms' inflation forecasts[1] is that they are biased upward. D'Acunto et al. (2023) show that households' inflation expectations are systematically higher than those of financial participants. Candia et al. (2023) provide more evidence that households' expectations of inflation exceed those of professional forecasters and deviate significantly from those of firms. In turn, inflation forecasts formed by firms are also subject to a positive bias and vary across different industries, as shown by Savignac et al. (2021). If we consider financial market participants and professional forecasters as most informed and sophisticated agents in the economy and hence treat their inflation expectations rational, inflation forecasts of households and firms are biased upward from the rational counterpart and thus do not satisfy FIRE.

In this paper, I propose to interpret a bias in households' and firms' expectations as caused by sentiments that these agents might hold. Sentiments here should be understood as reflecting "animal spirits" (Keynes, 1936). The latter correspond human instincts and emotions which guide the behavior and ultimately influence economic decisions of individuals. Since psychological aspects and emotions are difficult to predict, I interpret a deviation of agents' economic expectations from rationality as a sentiment shock. An improvement (deterioration) in sentiments gives rise to excessive optimism (pessimism) about an economic outlook in consumers' and firms' mind and hence affects their beliefs. Households and firms have been shown to jointly construct their expectations about economic outcomes (Kamdar, 2019; Coibion et al., 2023; Andre et al., 2022; Candia et al., 2023), thus changes in sentiments, which is equivalent to the sentiment shock, must lead them to simultaneously revise all their expectations.

In a simple New Keynesian model, I formalize a concept of the sentiment shock and introduce it in the form of a deviation of sentimental (nonrational) expectations from fundamental ones. The latter are based only on standard fundamental shocks such as the technology disturbance and thus do not respond to the sentiment shock. The former, on the other hand, represent actual forecasts of households and firms that are vulnerable to emotional and psychological reactions, hence it is sentimental expectations that can move

[1] In this paper, I use the terms "inflation expectations" and "inflation forecasts" interchangeably.

when the sentiment shock arrives. Since animal spirits impact all individual beliefs through emotions, agents' expectations of all variables in the model are sensitive to the sentiment shock. In other words, it hits not a single, but multiple equations where a forward looking behavior plays a role. Agents' choices depend on their expectations, thus macro variables also respond to changes in sentiments. Given the structure of the NK model, I compute IRFs to a variety of shocks and find that a decline in sentiments raises both inflation expectations and realized inflation and leads output gap to fall.

The goal of this paper is to identify the sentiment shock, empirically quantify a degree of aggregate fluctuations generated by this shock and explore its contribution to the business cycle in a Structural Vector Autoregression (SVAR). To identify the shock of interest, I propose new identification schemes which impose a set of zero and sign restrictions on certain variables. Specifically, under baseline identification I place multiple zero restrictions on a response of inflation expectations and consumer prices at different horizons, and sign restrictions on that of probability of real income gains and durable/nondurable consumption. This identification strategy assumes that only households are hit by the sentiment shock, and a zero restriction imposed on consumer prices serves to make sure that firms' inflation forecasts remain unchanged and thus there is no reason for firms to adjust consumer prices.

An alternative identification scheme allows for a possibility of firms holding sentiments and replaces a zero restriction with a sign condition, namely that firms increase consumer prices on impact of the negative shock because the latter worsens firms' sentiments and raises their inflation expectations. Identification implemented in this paper has several distinctive features: it explicitly accounts for the monetary policy's objective to anchor inflation expectations, differentiates responses of durable and nondurable consumption and includes two expectational variables. I identify and estimate the SVAR with the algorithms proposed by Arias et al. (2018), which allows me to examine a resulting business cycle dynamics based on Impulse Response Functions (IRFs) and Forecast Error Variance Decomposition (FEVD).

My findings show that across both identification schemes a negative realization of the sentiment shock (deterioration in sentiments) exerts effects on the real economy: it leads to a persistent increase in unemployment and a fall of industrial production. I uncover one possible channel through which pessimism of agents depresses economic activity: contraction of durable consumption. Since declining sentiments raise pessimism among households and impact their expectations, they anticipate higher inflation and lower real income in the future, which prompts them to cut down spending on durable goods immediately and for a long period into the future. Nondurable consumption reacts differently: having available funds from reducing purchases of big ticket items, households temporarily increase expenditure on nondurable goods and services, for example, buying food or paying an internet bill. A pattern of fluctuations in real variables justifies that what I identify as the sentiment shock is different from other shocks prevalent in macro literature such as the technology or monetary policy disturbances.

I also find an unusual dynamics of inflation that exhibits an S-shape. This is clearly evident in the alternative identification scheme, but even when consumer prices are restricted to remain unchanged on impact, the model favors a conclusion that inflation likely rises. These results confirm that firms might be subject to sentiments just as households are. Intuitively, the negative sentiment shock hits not only households, but also firms because the latter are run by managers who make all within-firm decisions. Depressed sentiments of managers prompt them to feel more pessimistic about future business conditions and expect that demand will shrink while inflation will increase. Following their beliefs, they raise prices today resulting in higher inflation. Households' sentiments also deteriorate, which leads them to reduce expenditure on durables. At a later time, firms face weaker demand for goods and respond to this contraction in consumer spending by lowering prices. Thus, the sentiment shock is able to generate initially accelerating inflation which then reverses and turns into deflation in subsequent periods.

Although a list of variables used in empirical analysis does not include nominal interest rate expectations, my findings point at a possibility that households revise forecasts of nominal rates upward by more than one-to-one in response to a given increase in expected inflation. To make this conclusion, I rely on analysis of survey responses by Coibion et al. (2023) who show that households with higher real interest rate expectations are more likely to reduce purchases of durable goods.

Given responses of macro variables, I measure the trough of a business cycle driven by the sentiment shock. If households' inflation expectations increase in response to a negative one standard deviation sentiment shock, it induces 0.2 percentage point higher unemployment, a decline in industrial production by 0.5–0.6% and in durable consumption by 1.3–1.5%. Computations of FEVD show that the sentiment shock best explains medium run fluctuations of real macro aggregates: 7% in industrial production, 8–9% in the unemployment rate, 9–10% in consumption of durable goods and 6% in nondurable consumption. However, FEVD performed in the model under the alternative identification scheme indicates that the sentiment shock contributes more to short run volatility of inflation expectations: 12–13%. At the same time, it accounts for 11–12% of inflation variance at both short and medium run frequencies.

1.1 Related Literature

This paper builds upon a body of literature which explores how shocks to inflation expectations change dynamics of macro variables. One of the early attempts is Clark and Davig (2011) who differentiate between shocks to long-term and short-term expectations and find that both are inflationary, but authors' measure of economic activity responds in opposite directions depending on long-term or short-term expectations shock. Their identification scheme, however, is a standard recursive one and thus may not be valid.

Adams and Barrett (2023) identify shocks to inflation expectations as departures from the rational benchmark and refer to these shocks as "inflation sentiments". They find that for the US economy a positive inflation expectations shock results in deflation, a reduction of interest rates and a contraction of output. This work is different in that I impose identifying restrictions that explicitly account for the monetary authorities' communication policy aimed at anchoring inflation expectations and the empirically justified response of households to movements in sentiments that operates through durable consumption.

Relying on a similar idea that measured inflation expectations may move away from the rational component, Ascari et al. (2022) build a DSGE model with a shock to short-term inflation expectations and endogenous uncertainty and estimate a SVAR identified with the robust sign restrictions informed by the model. Their findings demonstrate that a positive inflation expectations shock is inflationary and leads to a decline in output and consumption. One drawback of their approach is that they do not give any meaning or interpretation to the shock making it difficult to understand why measured forecasts deviate from rational expectations. Furthermore, researchers use inflation expectations and uncertainty measures by professional forecasters who have been shown to forecast close to actual realized data and thus are unlikely to deviate from rationality. In this paper, I instead focus on households' inflation expectations which have been found to depart from FIRE in multiple dimensions.

This paper is also related to a strand of research that tends to explain business cycles through the lens of sentiments. Angeletos et al. (2018) introduce a shock to higher-order beliefs to macro models which they interpret as waves of optimism and pessimism about the short-run economic outlook. They find that this shock can generate comovement in output, consumption and investment. Maxted (2023) extends a macro-finance model with diagnostic expectations that put relatively more weight on more recent shocks, and shows that it leads to boom-bust investment cycles. In a DSGE model, Barsky and Sims (2012) distinguish between the news shock and animal spirit shock specified as the noise shock to news about productivity and conclude that innovations to consumer confidence identified in their SVAR are more likely to reflect shocks containing information about future productivity. From the empirical perspective, Levchenko and Pandalai-Nayar (2020) identify the nontechnology (demand) shock by orthogonalizing it to surprise and news TFP shocks and maximizing the short-run forecast error variance of an expectational variable. The identified shock accounts for a large fraction of short-term business cycle fluctuations in the US. In this work, I take a different approach since the sentiment shock is non-rational and reflects the bias in agents' expectations.

Although Werning (2022) does not consider any shocks, the passthrough effect of a change in inflation expectations on contemporaneous inflation studied in his paper for a variety of models of firm price setting is relevant to the question whether sentiment shocks moving expectations have any effects on inflation. His findings show that the passthrough effect can be anywhere between zero and an arbitrarily large number depending on a model. However, he does not analyze general equilibrium effects and thus cannot evaluate how shocks to inflation expectations impact aggregate quantities such as output and consumption.

In a related work, researchers evaluate the role of inflation expectations in driving the inflation process focusing on estimation of the New Keynesian Phillips curve with a variety of empirical counterparts of expected inflation. Gali and Gertler (1999) estimate the hybrid Phillips curve for the US using realized values for past and expected inflation as determinants of current inflation and find a greater economic importance of the forward-looking behavior of firms (and hence inflation expectations). Rudd and Whelan (2005) investigate whether the New Keynesian Phillips curve can accurately describe the inflation dynamics and conclude that it cannot account for what is captured by lagged inflation in the reduced form inflation equation, so the role of inflation expectations is questionable. In a follow-up paper, Rudd and Whelan (2006) reexamine the ability of the hybrid Phillips curve to fit the data in a more systematic way and reach a conclusion that the forward looking term related to the real side of the economy does not determine the underlying inflation evolution. The current paper performs a causal analysis and shows that an exogenous variation in inflation expectations driven by sentiments indeed translates to movements in current prices.

A recent paper by Rudd (2022), however, casts doubt on the commonly accepted view that inflation expectations are the main determinant of realized inflation. Upon reviewing the literature he shows that it lacks both the theoretical underpinning and compelling empirical evidence of the central role played by expected inflation, and argues that the expectations mechanism cannot reasonably explain the inflation dynamics.

There is also evidence in literature that empirical expectations improve the model performance. Roberts (1997) shows that using survey inflation expectations which are not perfectly rational, favors the sticky price model. Adam and Padula (2011) find that inflation forecasts from the Survey of Professional Forecasters along with output or unit labor costs as a measure of marginal costs fit the New Keynesian Phillips curve equally well.

Finally, this work connects to a large literature that proposes a variety of identification schemes in empirical models to identify shocks of interest. For monetary policy shocks, Christiano et al. (2005) employs Cholesky identification, Romer and Romer (2004) leverage narrative methods, Uhlig (2005) apply sign restrictions while Gertler and Karadi (2015) and Nakamura and Steinsson (2018) use high-frequency identification. Beaudry and Portier (2006), Barsky and Sims (2011) propose the medium-horizon identification scheme to extract news shocks, Chahrour and Jurado (2022) identify disturbances to technological expectations based on the recoverability concept. In this paper, I identify the sentiment shock by combining zero and sign restrictions.

The remainder of the paper is organized in the following way. Section 2 provides a definition of the sentiment shock and formalizes this concept. Section 3 describes a statistical model and identification of the sentiment shock. Section 4 presents empirical results and discusses their implications. Finally, Section 5 concludes.

2 Sentiment Shocks

Before selecting an identification strategy to identify sentiment shocks, I need to clarify what I mean by "sentiment shocks" and how they can be formalized. Therefore, in subsection 2.1 I discuss the definition of sentiment shocks while in subsection 2.2 I give a theoretical treatment of the ideas from the previous section in a simple New Keynesian (NK) model extended to include the sentiment shock.

2.1 What Is a Sentiment Shock?

Almost every modern macro model features expectations of economic fundamentals, and researchers commonly solve the model within a Full Information Rational Expectations (FIRE) framework. However, empirical literature in recent years has shown that measured expectations of economic agents do not satisfy the FIRE assumption. Economic papers have largely focused on inflation expectations and found some striking features of the latter. In particular, D'Acunto et al. (2023) document that households' inflation expectations persistently exceed those of financial market participants and professional forecasters, and Candia et al. (2023) find that inflation expectations of firms are often higher than what professional forecasters expect. If one considers financial market participants and professional forecasters as agents who are most sophisticated and informed about the economy, their expectations can serve as a proxy for FIRE. It thus implies that expectations of inflation by households and firms systematically deviate from the rational counterpart in the upward direction.

What can explain the bias uncovered from gauging inflation expectations of households and firms? One possible explanation is sentiments which within this paper should be understood in the context of "animal spirits", the term that was coined by Keynes (1936). In this setting, animal spirits refer to human instincts and emotions that guide the behavior and ultimately influence economic decisions of agents. Since the objective of professional forecasters is to make precise economic forecasts, they must be relying only on the available economic data and thus are unlikely to take personal sentiments into account. Households and firms, on the other hand, do not face these constraints and are free to form expectations in any way they deem reasonable, possibly resting upon their feelings. Therefore, variation in sentiments gives rise to excessive pessimism or optimism about the economic outlook in households' and firms' mind, which generates the deviation of their inflation expectations from rationality.

Human psychological characteristics and emotions are difficult to predict, so it becomes natural to interpret any deviation of households' or firms' inflation expectations from rationality as a sentiment shock. Empirical evidence also gives support to this view: the factor analysis conducted by Kamdar (2019) reveals that the leading component that explains a large proportion of changes in various types of households' expectations looks similar to sentiments. Although inflation forecasts gained the main interest among researchers, some surveys also elicited economic agents' expectations of other variables. The findings of papers studying the response of different expectations to shocks or information provision justify a general conclusion that households and firms tend to form their expectations of most economic outcomes jointly (Coibion et al. (2023), Andre et al. (2022), Candia et al. (2023)). It implies that if their sentiments improve or decline, this change will translate to updating all economic expectations by households and firms. Hence, for identification of sentiment shocks it suffices to look at any type of expectations formed by economic agents.

Since sentiments are driven by people's instincts and emotions, the former are not influenced by outcomes determined within the economy. It thus motivates the following definition of a sentiment shock:

Definition 2.1. A *sentiment shock* is an unanticipated movement in expectations of households or firms that reflects variation in "animal spirits" and is not caused by

1. changes in economic variables such as TFP, output, inflation, financial conditions and

2. changes in monetary or fiscal policy.

It is helpful to refer to the available empirical evidence to explain how sentiment shocks affect different expectations. Kamdar (2019) documents that in the US, households that expect higher inflation also believe that unemployment will increase and their personal financial conditions will deteriorate. Hence, if households' sentiments decline, their inflation and unemployment expectations will rise while expectations of their financial situation will decrease, which is consistent with the earlier finding that people tend to revise jointly all economic expectations.

2.2 Theoretical Framework with Sentiment Shocks

Consider the economy with three fundamental shocks: monetary policy (v_t), technology (a_t), cost-push shock (e_t), and also a new one: sentiment shock (η_t) that simultaneously hits expectations of all variables. For the purpose of this paper, I differentiate between expectations based only on fundamental shocks and expectations based on both fundamental and sentiment shocks. The former expectations will be called "fundamental" while the latter "sentimental".

For simplicity, assume that all shocks are i.i.d. with mean 0 and variance σ_x^2 where $x = \{v, a, e, \eta\}$ with $\sigma_\eta^2 \equiv 1$ as normalization. Let me take inflation as an example to illustrate how fundamental expectations are different from sentimental ones, but the logic will carry on for other variables in a similar fashion. Fundamental expectations are formed based on the history of fundamental shocks only in accordance with FIRE, so I define

$$\mathbb{E}_t \pi_{t+1} \equiv \mathbb{E}(\pi_{t+1} | \mathcal{F}_t), \tag{1}$$

using the rational expectation operator $\mathbb{E}_t$. $\mathcal{F}_t$ is the sigma-algebra generated by random innovations corresponding to fundamental shocks up to period t and represents the information available at t to make a fundamental forecast of inflation at $t+1$ given by

$$\mathcal{F}_t \equiv \sigma\left(v_s, a_s, e_s \mid s \leq t\right). \tag{2}$$

When the sentiment shock hits economic agents, it causes sentimental expectations to deviate from fundamental forecasts, which captures the bias observed in measured expectations of households and firms. Thus, I define sentimental expectations of inflation

$$\widetilde{\mathbb{E}}_t \pi_{t+1} \equiv \mathbb{E}_t \pi_{t+1} - \sigma_{\pi,\eta} \eta_t, \tag{3}$$

where the expectation operator with a tilde sign ($\sim$) is used to make a distinction. $\sigma_{\pi,\eta}$ is an inflation-specific parameter representing the (absolute) on-impact response of sentimental expectations of inflation to a unity realization of the sentiment shock because the latter may move expectations of one economic variable differently from those of other variables. Note that the shock enters (3) with a minus sign in accordance with empirical evidence that higher optimism of households and firms (higher η_t) drives down inflation expectations.

The following timeline of how households and firms form expectations is helpful to reconcile the ideas presented above. Suppose at stage 1, each agent gets access to past economic data from which the history of fundamental shocks can be extracted, and computes expectations of economic variables relying exclusively on mathematical skills and that history. Each agent acts like a computational machine, and this stage produces fundamental expectations.

At the next stage, agents process the available information and the forecasts they previously formed through their mind. Since humans are subject to emotions, all the information they take as input, including that about future economic outcomes, will be processed through their current emotional state. Therefore, if sentiments are high, households and firms are optimistic about the future and will revise their stage-1 fundamental expectations of inflation downward and those of future financial conditions upward. On the other hand, if they are pessimistic about the prospects of the economy and sentiments stand at a low level, agents will revise their stage-1 forecasts in the opposite direction. Households and firms are also free to acquire information from alternative sources. Since internet articles, TV programs, magazines all provide views of experts and other individuals on the current and future state of the economy, it also contributes to sharing their sentiments with households and firms. As a result, stage 2 generates the departure of sentimental expectations from fundamental ones.

Let me now consider a log-linearized three equation NK model extended to include the sentiment shock. This version of the model closely follows Gali (2008). The expectations entering the equilibrium dynamics are sentimental since households and firms' decision making relies on actual forecasts they form. Thus, I replace the usual expectation operator by one with a tilde sign such that the Euler equation, Phillips curve and monetary policy rule become

$$\hat{y}_t = \widetilde{\mathbb{E}}_t \hat{y}_{t+1} - \frac{1}{\gamma}\left(\hat{i}_t - \widetilde{\mathbb{E}}_t \pi_{t+1}\right) - \psi_{ya} a_t \tag{4}$$

$$\pi_t = \beta \widetilde{\mathbb{E}}_t \pi_{t+1} + \kappa \hat{y}_t + e_t \tag{5}$$

$$\hat{i}_t = \phi_\pi \pi_t + \phi_y \hat{y}_t + v_t \tag{6}$$

where $\hat{y}$ is output gap, π is inflation, and $\hat{i}$ is a deviation of nominal interest rate from the steady state. Following the definition of sentimental expectations of inflation and a similar one for output gap, I have

$$\widetilde{\mathbb{E}}_t \pi_{t+1} = \mathbb{E}_t \pi_{t+1} - \sigma_{\pi,\eta} \eta_t \tag{7}$$

$$\widetilde{\mathbb{E}}_t \hat{y}_{t+1} = \mathbb{E}_t \hat{y}_{t+1} + \sigma_{y,\eta} \eta_t \tag{8}$$

where $\sigma_{y,\eta}$ measures the on-impact response of sentimental expectations of output gap to a unity sentiment shock. Note that higher sentiments raise expectations of output, hence the sentiment shock enters (8) with a positive sign.

If one eliminates sentimental expectations using (7)–(8) in (4)–(5), I obtain

$$\hat{y}_t = \mathbb{E}_t \hat{y}_{t+1} + \sigma_{y,\eta} \eta_t - \frac{1}{\gamma}\left(\hat{i}_t - \mathbb{E}_t \pi_{t+1} + \sigma_{\pi,\eta} \eta_t\right) - \psi_{ya} a_t \tag{9}$$

$$\pi_t = \beta(\mathbb{E}_t \pi_{t+1} - \sigma_{\pi,\eta} \eta_t) + \kappa \hat{y}_t + e_t. \tag{10}$$

As is evident from the equations above, the monetary policy rule is affected by the sentiment shock, but only indirectly via responses of inflation and output gap to the shock. The direct impact will be present as long as the central bank responds to expected inflation as opposed to its current value. If one compares this model with a standard NK framework, it can be seen that the sentiment shock enters both the Euler equation as well as the Phillips curve while either the technology or cost-push shock enters only one of those conditions. The positive or negative response of output gap to innovation in sentiments is determined by the relative magnitudes of coefficients $\sigma_{y,\eta}$ and $-\frac{1}{\gamma}\sigma_{\pi,\eta}$ depending on a particular value of γ, the intertemporal elasticity of substitution.

The crucial difference is that the sentiment shock does not move the fundamental part of expectations denoted by $\mathbb{E}_t(\cdot)$, but makes sentimental expectations of economic aggregates over– or underreact. Since shocks are i.i.d., all fundamental expectations are zero, so (7)-(8) can be rewritten

$$\widetilde{\mathbb{E}}_t \pi_{t+1} = -\sigma_{\pi,\eta} \eta_t \tag{11}$$

$$\widetilde{\mathbb{E}}_t \hat{y}_{t+1} = \sigma_{y,\eta} \eta_t. \tag{12}$$

It clearly shows that based on the history of fundamental shocks, agents should expect zero inflation and output gap, but the sentiment shock η_t creates an upward or downward bias in their forecasts.

Parameter	Meaning	Value	Calibration criteria
β	Discount factor	0.9926	3% annual interest rate
γ	Risk aversion	1	Standard in macro literature
φ	Inverse Frisch elasticity	1	Standard in macro literature
$1-\alpha$	Labor share	2/3	Standard in macro literature
θ	Probability of keeping the price	2/3	Average duration of 3 quarters
ε	Elasticity of substitution	10	Profits are 10% of GDP
ϕ_π, ϕ_y	Interest rate sensitivity	1.5, 0.5/4	Taylor (1993)
ρ_a, ρ_e, ρ_v	Persistence of shocks	0.9, 0.9, 0.5	Standard in macro literature
$\sigma_a, \sigma_e, \sigma_v$	Standard deviation of shock innovations	0.45, 0.14, 0.24	Smets and Wouters (2007)
ρ_η	Persistence of sentiment shock	0.5	Average persistence
$\sigma_{\pi,\eta}$	On-impact effect on inflation expectations	0.0350	Stan. dev. of cost-push shock / 4
$\sigma_{y,\eta}$	On-impact effect on output gap expectations	0.1125	Stan. dev. of technology shock / 4

Table 1: Parameter calibration in the NK model with sentiment shocks.

To illustrate the responses of macro variables to the sentiment shock and compare those with other fundamental shocks, I calibrate the NK model with sentimental expectations defined above and solve for the equilibrium assuming all shocks evolve according to a separate AR(1) process with persistence ρ_s and innovation term $\varepsilon_s \sim \mathcal{N}(0, \sigma_s^2)$ where $s \in \{a, e, v, \eta\}$ denotes a specific shock. Given the solution, I compute IRFs of three macro quantities – inflation, output gap and nominal interest rate – as well as sentimental expectations of inflation[2] to each shock at a time.

I keep calibration standard for non-sentimental parameters. Since the sentiment shock may affect on impact inflation and output gap expectations differently, I normalize standard deviation of the sentiment shock $\sigma_\eta \equiv 1$ and calibrate on-impact parameters $\sigma_{\pi,\eta}$ and $\sigma_{y,\eta}$ directly. Since I am interested in qualitative responses of sentimental expectations and do not aim to specifically match the empirical evidence in this exercise, I set the on-impact response of inflation expectations $\sigma_{\pi,\eta} = \sigma_e/4$ and that of expected output gap $\sigma_{y,\eta} = \sigma_a/4$. All calibrated parameter values are given in Table 1.

IRFs are displayed in Figure 1. If a positive sentiment shock hits the economy (sentiments improve), agents expect lower inflation in the future, by construction. The responses of actual

[2] Since most empirical papers study expected inflation of households and firms, I also focus on the responses of these expectations.

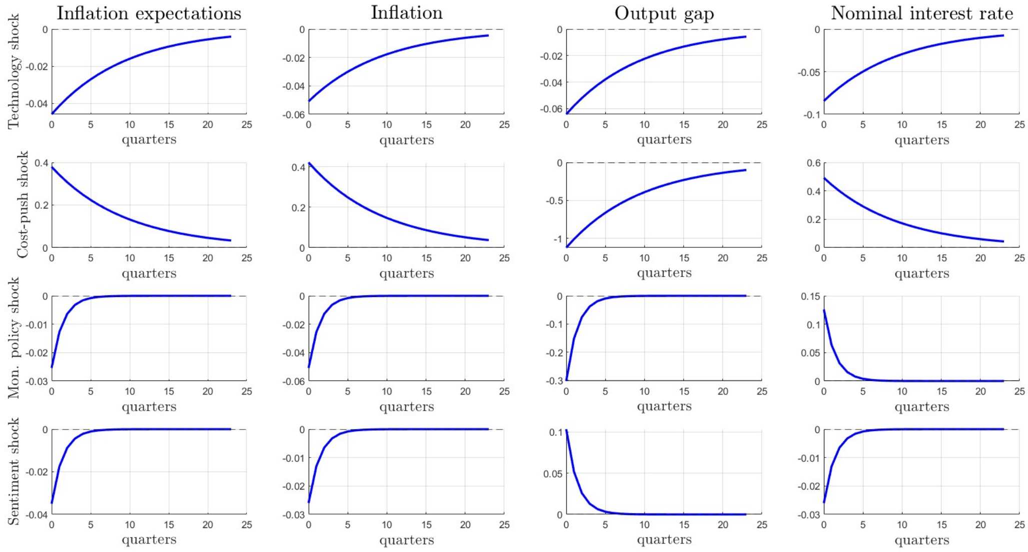

Figure 1: IRFs of (sentimental) inflation expectations and three macro variables to four shocks in the NK model augmented with the sentiment shock.

inflation and output gap though are determined by the solution of the model and thus may take any sign. It follows from Figure 1 that inflation also decreases together with expectations in response to elevated sentiments: firms become more optimistic about the prospect of the economy and business conditions and choose to cut their prices. High sentiments together with lower prices encourage households to raise demand for goods and services which results in the economy's output exceeding its potential level (a positive response of output gap). The central bank places a higher weight on inflation, thus interest rates go down, which boosts demand even further.

Qualitatively, the responses to a favorable cost-push shock look similar: both inflation expectations and inflation decrease, output gap increases while interest rates fall. It implies that to identify the sentiment shock, one would need to impose additional sign restrictions on other expectational variables to differentiate it from the cost-push shock.

3 Identification of Sentiment Shocks

This section is devoted to the identification strategy for the sentiment shock. In subsection 3.1, I outline a SVAR model employed in the identification and subsequent empirical analysis, and in subsection 3.2, I discuss specific identifying restrictions I impose in SVAR.

3.1 Statistical Model

The identification and empirical analysis of macroeconomic effects of sentiment shocks is based on the SVAR model with p lags

$$A_0 y_t = \sum_{i=1}^{p} A_i y_{t-i} + c + \varepsilon_t \tag{13}$$

where y_t is an $n \times 1$ vector of endogenous economic variables at time t, A_i is lag i matrix of parameters, $1 \leq i \leq p$, A_0 determines the contemporaneous dynamics of variables contained in y_t and is assumed invertible. An $n \times 1$ vector ε_t represents structural shocks such that j-th entry in ε_t is a structural shock corresponding to j-th variable in y_t. Assume also that in the cross-section, structural shocks are uncorrelated with one another and each have unit variance: $\varepsilon_t \sim (0, I_n)$ for any t.

Let me define $A_+ \equiv (A_1, \ldots, A_p, c)$ and $x_t \equiv (y'_{t-1}, \ldots, y'_{t-p}, 1)'$, then (13) can be compactly written as

$$A_0 y_t = A_+ x_t + \varepsilon_t. \tag{14}$$

If I left-multiply (14) by A_0^{-1}, I obtain a reduced-form VAR

$$y_t = B x_t + u_t \tag{15}$$

where $B \equiv A_0^{-1} A_+$ and $u_t \equiv A_0^{-1} \varepsilon_t$ is the reduced-form shock. The VAR (15) is identified and can be estimated from data, so the covariance matrix of u_t is given by

$$\text{Var}(u_t) = A_0^{-1} (A_0')^{-1} \equiv \Sigma. \tag{16}$$

The matrices (A_0, A_+) are structural parameters while the matrices (B, Σ) are reduced-form parameters.

It is clear that the on-impact response of endogenous variables in y_0 is fully determined by (the inverse of) A_0, and the subsequent evolution of $\{y_t\}$ follows the endogenous dynamics in (15) governed by reduced-form parameters B. Thus, identifying structural shocks and their effects on the economy is equivalent to identifying the matrix A_0^{-1}. However, it is a well-known result in SVAR literature (Sims, 1980) that (16) provides less restrictions on A_0 than the number of unknown parameters, so additional identifying restrictions need to be imposed.

3.2 Discussion of Identifying Restrictions

Since the sentiment shock moves all types of expectations households and firms have about the economy, in this paper I focus specifically on inflation expectations of households to identify the shock of interest for two reasons. Firstly, the literature documents that households are those whose expectations exhibit the largest deviation from those of professional forecasters, so using households' forecasts gives a higher chance of identifying the true sentiment shock. Secondly, surveys most often elicit inflation expectations, and there is a long time series for households while surveys aimed at firms are typically conducted only several times in a specific year and do not satisfy the consistency requirement.

Without loss of generality, assume that inflation expectations are ordered first in y_t. To identify the sentiment shock, I will thus need to identify only the first column of A_0^{-1}, the responses of endogenous variables to the unit sentiment shock on impact. In doing so, I propose the identification strategy that combines both zero and sign restrictions on responses of certain variables at different horizons, which I refer to as "baseline identification".

Let me start with discussion of zero identifying restrictions. Firstly, I impose zero restrictions that speak to the response of monetary authorities to the sentiment shock. It has become a common practice nowadays for the central bank to develop the communication strategies that explain the reasoning for their policy choices, for example, the forward guidance of long-term nominal interest rates targeted at financial markets. Managing inflation expectations has also been considered an essential part of the communication policy such that the central bank strives to "anchor" inflation expectations of households and firms at some low level. If the central bank is successful in this regard, it enables to fully control the real interest perceived by economic agents and hence more effectively deal with the effects of business cycle shocks. When a negative sentiment shock suddenly raises households' inflation expectations and diverts them from the central bank's target, this scenario creates a possibility of de-anchored expectations and calls for the central bank to take action via communication channels with the goal of restoring the anchored state.

Denote the impulse response function of a variable x to a structural shock s at horizon h as $\text{IRF}(x, s, h)$, then the identifying restriction 1 is

$$\text{IRF}(\text{inflation expectations}, \varepsilon_\eta, h) = 0,\ h \in [H_1, H_2], \tag{17}$$

where ε_η is the sentiment shock. Condition (17) says that following the realization of the shock, the central bank delivers proper communication messages to make sure that inflation expectations of households and firms are re-anchored by horizon H_1. Since there is no guarantee that expectations will be tied to the anchor forever, restriction (17) holds only up to some finite horizon H_2.

When performing an empirical analysis, I need to specify the values of horizons H_1 and H_2. Since the Federal Reserve[3] has not explicitly announced the period by which it believes to achieve the goal of anchoring inflation expectations since the U.S. economy entered the high inflation environment in 2022, and to the best of my knowledge, the empirical literature

[3]This paper studies the effects of the sentiment shock in the U.S. economy, thus I focus on the Federal Reserve in this part.

does not have relevant findings to inform about this aspect of the communication policy, I rely on the results which suggest how the forward guidance is performed. Specifically, Swanson and Williams (2014), Hanson and Stein (2012) argue that the Federal Reserve pursues the forward guidance policy at a two year horizon, and Gurkaynak et al. (2005) provide the empirical evidence for this view, thus I assume that the Federal Reserve aims to anchor inflation expectations by horizon $H_1 = 24$. I use the monthly frequency data in the SVAR analysis, hence 24 horizons correspond to a two year outlook.

Specifying horizon H_2 determines the duration of successful anchoring. For this matter, I am guided by the findings of Coibion et al. (2022) suggesting that inflation expectations of households treated with the monetary policy communication are indistinguishable from those of households in the control group six months after information provision. Since they find a statistically significant difference in expectations of the groups three months after treatment and no effects six months after treatment, I take the average of those monthly horizons to determine the duration of inflation expectation anchoring, which rounds to five months and gives $H_2 = 28$.

Secondly, I restrict the response of consumer prices. Inflation expectations are relevant to firms' economic choices, in particular, when setting prices, they take those expectations into account (Coibion et al., 2020). The sentiment shock causes households' inflation expectations to deviate from the initial level, but firms cannot easily observe these changes in households' beliefs. It may take time for firms to recognize that consumers now hold higher expectations of inflation, and adjust their pricing policy accordingly at a later date.

Alternatively, even if firms happen to know that households' inflation expectations have risen, and are ready to change prices within the period of shock realization, they might not be able to do so because of nominal price rigidity.[4] If one thinks of price stickiness in Calvo (1983) fashion, there will be at least one firm being able to reset the price and immediately respond to an increase in households' inflation expectations, thus inflation will not be zero. This notwithstanding, it will have small effects on an aggregate price level since other firms keep prices unchanged, and the zero restriction on the response of consumer prices serves a good approximation. Therefore, up to horizon H_3 following the sentiment shock, firms do not alter consumer prices that households face while shopping, and the identifying restriction 2 is

$$\mathrm{IRF}(\text{consumer prices}, \varepsilon_\eta, h) = 0, \;\; h \in [0, H_3]. \tag{18}$$

To minimize the potential distortion arising from imposing zero restrictions, I set $H_3 = 0$, which implies that prices are unresponsive to the sentiment shock on impact only. I do not restrict the responses at further horizons to let data inform the subsequent dynamics of consumer prices.

Next, I discuss a set of sign identifying restrictions all of which are imposed only on

[4] For a survey of empirical evidence of price rigidity and approaches to incorporating it in macro models, see Nakamura and Steinsson (2013).

impact. The first sign restriction relflects the idea that since households and firms jointly form their expectations in all dimensions, the sentiment shock realization must influence not only inflation forecasts, but also expectations of other outcomes relevant to economic behavior. To sharpen identification of the shock of interest, I need to include another series of expectations and sign its response in the way consistent with empirical evidence. With respect to the latter, I rely on the findings of Kamdar (2019) who studies expectations of U.S. households derived from the MSC and the New York Fed's Survey of Consumer Expectations and documents that households who expect higher inflation also believe that unemployment will rise. The factor analysis performed in the paper shows that the leading component may be interpreted as sentiments: pessimistic (optimistic) households expect that inflation, real income, unemployment will increase (decrease) and a personal financial position as well as general business conditions will deteriorate (improve).

The MSC, which is the source of information on households' expectations for this paper, contains continuous measures of expectations only for inflation, with other variables being categorical, which prevents me from including a measure of other expectations of households to capture joint movements in beliefs driven by sentiments. To bypass this restriction, I select the series of probability of real income gains which is estimated by the same respondent reporting inflation expectations in the survey. The negative sentiment shock triggers a more pessimistic outlook of the economy, raises inflation expectations and reduces the probability of real income gains, in accordance with how a decline in sentiments influences households' expectations. Hence, the identifying restriction 3 is

$$\text{IRF}(\text{probability of real income gains}, \varepsilon_\eta, h) > 0,\ h = 0. \tag{19}$$

Note that following the definition of the sentiment shock in (3), a negative innovation (decline in sentiments) reflects higher pessimism among households, and they anticipate a lower probability of real income gains, thus the sign in the restriction (19) is positive.

Secondly, I put signs on the response of consumption characterising the households' behavior when their sentiments change. Consumption is one of the most fundamental choices households make, and also represents a large portion of aggregate output. The theory proposes a number of channels through which higher inflation expectations may affect consumption decisions in opposite directions. On the one hand, an increase in expectations of inflation makes future purchases of goods more expensive and reduces the real interest rate, from the households' perception. As a result, current consumption rises. On the other hand, higher expected inflation erodes the real value of nominal assets and income and gives rise to negative wealth/income effects dampening current consumption. Furthermore, households associate higher future inflation with a bad economic situation (Kamdar, 2019), which may force them to cut down on current spending.

The theory does not provide a clear answer to the question of how movements in inflation expectations change consumption of households. Thus, I employ empirical facts to inform my sign identifying restrictions. Coibion et al. (2022) ran a randomized control trial experiment in the U.S. in which they elicited 12 month ahead households' inflation expectations before and after the provision of different pieces of information about monetary policy announcements. Since in this setting an information treatment is randomly assigned, it enables them to make causal conclusions, and they find that an exogenous rise in inflation expectations leads households to increase their purchases of nondurable goods and services, but reduce spending on durables. This type of behavior is consistent with the sentiment-based interpretation: when households' sentiments dwindle, they become more pessimistic about the future state of the economy and prefer to delay the purchases of expensive big-ticket items instead using their savings to buy more essential nondurable goods and services. Following the findings above, I impose the identifying restrictions 4 and 5, respectively,

$$\text{IRF}(\text{nondurable consumption}, \varepsilon_\eta, h) < 0,\ \ h = 0, \tag{20}$$

$$\text{IRF}(\text{durable consumption}, \varepsilon_\eta, h) > 0,\ \ h = 0. \tag{21}$$

Finally, I need to ensure that a positive sentiment innovation causes inflation expectations to decrease, thus I impose the normalizing identifying restriction 6

$$\text{IRF}(\text{inflation expectations}, \varepsilon_\eta, h) < 0,\ \ h = 0, \tag{22}$$

and the response in subsequent horizons is determined endogenously in VAR. Table 2 summarizes all the restrictions imposed to identify the sentiment shock, which constitutes my baseline identification scheme.

Identifying Restriction	Variable	Type of Restriction	Horizons
1	Inflation expectations	Zero	[24, 28]
2	Consumer price inflation / index	Zero	0
3	Probability of income gains	Positive	0
4	Nondurable consumption	Negative	0
5	Durable consumption	Positive	0
6	Inflation expectations	Negative	0

Table 2: Baseline identification scheme: summary of identifying restrictions for the sentiment shock in SVAR analysis.

4 Aggregate Fluctuations Triggered by Sentiment Shocks

In this section, I identify and quantify the aggregate effects of the sentiment shock in a SVAR framework. Firstly, I provide a description of the data and estimation procedures in subsection 4.1 and then discuss the results of the empirical analysis in subsections 4.2 and 4.3 considering different identification.

4.1 Data and Estimation Technique

The frequency of the data I use is monthly, and I follow the monetary policy literature Coibion (2012), Gertler and Karadi (2015), Ramey (2016) in selecting a standard set of macro aggregates: the industrial production index, the consumer and producer inflation rates / price indices, the unemployment rate and the federal funds rate[5]. Indices enter the model in log levels. My preferred baseline specification of the VAR uses inflation rates since the central bank typically responds to changes in inflation rather than a price level, nevertheless, I also estimate the VAR with price indices instead to check robustness of the results[6].

For the purpose of identifying the sentiment shocks, I extend the standard set of variables with the median one year ahead inflation expectations and the mean probability of real income gains. I also include real durable and nondurable consumption entering the VAR in log levels. My baseline specification considers the sample period which starts in December 1997 and ends in December 2022.

I estimate the SVAR given in (13) with $p = 12$ lags in the Bayesian approach and use the importance sampling method following the algorithms proposed in Arias et al. (2018). They allow me to identify the SVAR given the zero and sign restrictions summarized in Table 2. As suggested in Arias et al. (2018), I select the uniform-normal-inverse-Wishart distribution as the prior over the orthogonal reduced-form parameterization to estimate the VAR and set the values of hyperparameters as in Canova and Ferroni (2022). The algorithms transform a draw over the reduced-form parameterization to a draw over the structural parameterization, which produces the posterior distributions of IRFs and FEVD at each horizon.

4.2 Empirical Investigation: Baseline Identification

I start the empirical analysis with the baseline specification of the VAR described above and implement the baseline identification scheme with the corresponding restrictions outlined in Table 2. To characterize aggregate fluctuations, I look at IRFs of the variables in response to a negative one standard deviation realization of the sentiment shock.

[5]Description of the data used and their sources is provided in Appendix section A.

[6]Appendix section B presents additional robustness exercises, and I show that the main findings remain valid.

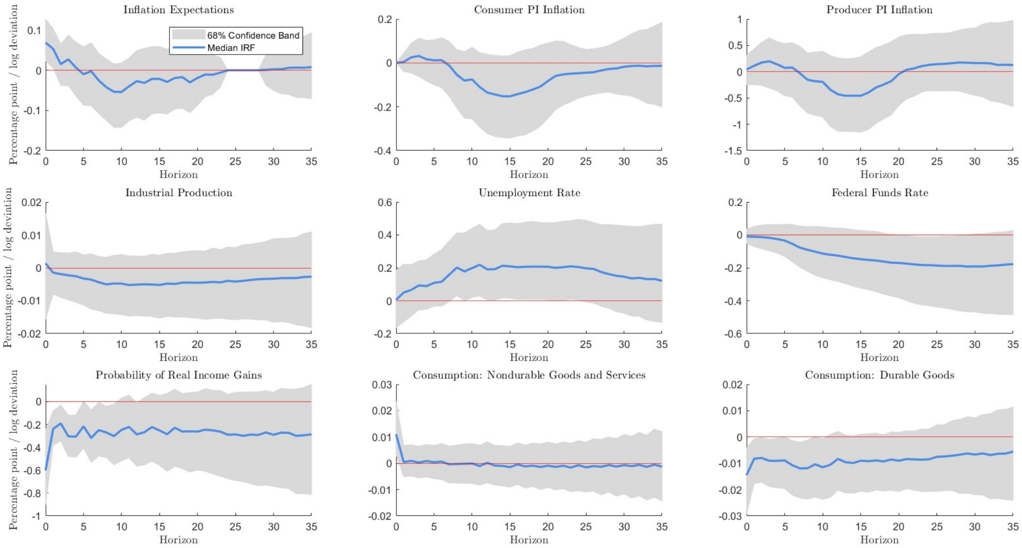

Figure 2: IRFs to the negative sentiment shock. Baseline identification scheme, restrictions are summarized in Table 2. Sample period runs from December 1997 to December 2022. A blue line depicts the median response, shaded area shows 68% confidence bands.

Figure 2 plots median IRFs (blue lines) and 68% confidence bands (in grey) for each variable up to horizon 35, with a horizon corresponding to a month. A negative sentiment shock raises inflation expectations on impact by almost 0.07 percentage point, but the effect is not persistent and they return to an initial level by horizon 4. Expectations do not stay there, however, and continue to fall reaching the trough of -0.05 percentage point around horizon 10. Although the confidence band does include a value of zero, one should take into account that IRFs are random objects and responses are correlated across horizons, thus their joint distribution over certain horizons is more informative of the dynamics of a variable.

Table 3 presents calculated probabilities that responses of variables take a certain sign over a specified fraction of given horizons. In particular, it shows that the response of inflation expectations is negative over at least 2 out of three periods at horizons 9–11 with probability of more than 75%. It justifies that households are likely to expect lower-than-initial inflation after their inflation forecasts increase in response to a sentiment shock. Expectations return to a pre-shock level thereafter following the anchoring effect of monetary policy. The expected probability of real income gains declines sharply on impact by almost 0.6 percentage point and likely remains depressed across all horizons, as Table 3 suggests. Specifically, the probability that expected probability of income gains has decreased over at least 13 periods at horizon 10 and further, is approximately 85%. Its persistent negative response indicates that this series helps identify the variation in households' sentiments.

Variable	Sign of Response	Horizons	Probability that responses satisfy sign over		
			One horizon	50% of horizons	100% of horizons
Inflation expectations	Negative	[9, 11]	86.86	76.85	61.1
Probability of income gains	Negative	[10, 35]	98.71	84.63	34.84
Durable consumption	Negative	[0, 35]	100	91.39	16.19
Unemployment rate	Positive	[10, 25]	97.8	89.44	57.42
Industrial production	Negative	[10, 25]	98.11	79.79	19.49
CPI inflation	Positive	[0, 5]	89.27	65.67	14.57
CPI inflation	Negative	[10, 20]	92.26	78.58	47.17
Fed funds rate	Negative	[3, 35]	96.7	83.62	41.67

Table 3: Probabilities that responses take a certain sign over a specified fraction of given horizons. Responses of variables to the negative sentiment shock in the SVAR employing the baseline identification scheme, restrictions are summarized in Table 2. Sample period runs from December 1997 to December 2022. Calculated probabilities are in percentages.

The sentiment shock also exerts real effects on the economy. Durable consumption decreases on impact by almost 1.5% and remains below an initial level up to 36 months following a shock realization with probability of over 90%. The response of nondurable consumption is drastically different: it rises by 1.1% immediately after the sentiment shock arrives, but there is no evidence that households change their expenditure on nondurables at horizons 1 and later relative to a steady state.

The unemployment rate does not respond momentarily to the negative sentiment shock, but rather increases gradually. It reaches the plateau around horizon 10 hovering around 0.2 percentage point for 15 months and reverts back after that. Table 3 confirms this finding: unemployment rate is above an initial level for most of horizons 10–25 with almost 90% probability. Industrial production dynamics also signals recessionary effects, with the trough of -0.5% at horizon 11. If I consider the same range of horizons 10–25 at which the unemployment rate stands at the highest point, the estimated probability that industrial production falls for at least 8 out of 16 periods at the specified range is nearly 80%. These calculations prove that unemployment is high at the time when industrial production declines. Additionally, the responses of these two indicators of economic activity justify that what I identify as the sentiment shock is different from a negative supply shock because the latter causes industrial production and the unemployment rate to, respectively, fall and increase instantly while I find slow-moving responses of those variables.

To get a sense of the depth of the business cycle driven by sentiments, I evaluate the magnitude of the peak or trough median response of macro aggregates. IRFs from Figure 2 suggest that a peak increase in unemployment rate per one percentage point change in the sentiment shock is 3.2 percentage points. One standard deviation shock leads to a decline of 0.5% in industrial production and 1.1% in durable consumption around horizon 10, which translates to a decline of 7.6% and 16.7%, respectively, per one percentage point increase of the shock.

Turning to inflation rates, I find that per Figure 2, there is some evidence of the positive response for 6 months after the shock, and Table 3 estimates this probability for the CPI inflation rate to be 65%. Subsequently, both inflation measures dip below an initial level and take the lowest value approximately at horizon 15: -0.15 percentage points for CPI and -0.46 percentage points for PPI. Calculations give support to this observation: if I focus on horizons 10–20 around the trough, then the probability that CPI inflation responds mostly negatively is nearly 80%. Nominal interest rates largely do not move in the first couple of months, but later exhibit a sluggish downward trend, as indicated in Table 3. The fact that I do not observe an abrupt change in interest rates, confirms that the sentiment shock I identify using the variation in inflation expectations is separate from a usual monetary policy shock.

Given the dynamics of macro variables depicted in IRFs, how can one interpret the aggregate response of the economy to the sentiment shock? A negative realization of the shock erodes households' sentiments in a way that they turn more pessimistic about the future economic conditions and expect higher inflation along with higher unemployment and lower real personal income. The revision of households' expectations directly translates into consumption behavior. Durable goods are expensive items which households typically cannot purchase making a one time payment. In order to be able to afford purchases of durables, they have to get approved for a loan and make regular smaller payments into the future. If households anticipate their income in real terms to contract, they realize they will likely be unable to pay out the main body of the loan and accrued interest and thus give up their planned purchases of big-ticket items. Now that they have available funds following the decision not to spend on consumer durables, households increase the expenditure on nondurable goods and services such as grocery shopping, restaurants, internet services given that they also expect prices to go up.

There is a chance that firms slightly increase prices shortly after a shock realization, which may indicate that firms either appear to become aware of higher inflation expectations of households or turn more pessimistic due to a decline in their own sentiments raising their inflation forecasts. Since the demand for expensive durable goods shrinks all across the economy for a long time while the effect of increased consumers' spending on nondurables is transitory, firms respond by setting lower prices upon observing the buyers' economic activity fall. If the share of durable good production is relatively large in the economy, households' lower spending on these goods forces firms to lay off their workers involved in either selling durable items in stores or the manufacturing process. As a result, the unemployment rate gradually rises, and upon receiving this recessionary signal, the central bank cuts interest rates with a delay.

Variable	Horizon				
	1 month	6 months	1 year	2 years	5 years
Inflation expectations	7.89 (0.84, 26.66)	7.72 (2.89, 16.32)	8.22 (3.62, 16.79)	7.36 (3.34, 14.83)	5.2 (1.73, 12.43)
CPI inflation	0.0 (0.0, 0.0)	3.21 (0.96, 8.8)	5.47 (1.98, 13.98)	7.08 (2.45, 17.52)	5.85 (1.87, 14.29)
PPI inflation	3.48 (0.31, 12.52)	5.92 (1.71, 16.71)	7.69 (2.89, 17.06)	7.68 (3.1, 16.75)	6.36 (2.23, 14.66)
Industrial production	3.18 (0.28, 14.75)	5.45 (1.87, 14.59)	6.57 (2.69, 14.94)	6.97 (2.93, 15.45)	5.64 (1.7, 13.56)
Unemployment rate	5.52 (0.51, 23.04)	6.26 (1.98, 16.41)	8.09 (2.86, 20.92)	9.0 (2.97, 22.12)	6.82 (2.08, 16.64)
Federal funds rate	5.68 (0.52, 22.7)	5.76 (1.0, 21.29)	7.3 (1.45, 24.36)	8.96 (1.94, 25.59)	7.34 (2.01, 19.33)
Prob. of real income gains	23.02 (3.99, 51.62)	20.16 (7.54, 35.75)	17.05 (7.34, 30.13)	12.83 (5.63, 24.53)	7.1 (2.33, 17.18)
Nondurable consumption	3.45 (0.3, 16.16)	5.14 (1.87, 14.48)	5.76 (2.51, 13.51)	5.98 (2.55, 13.11)	5.19 (1.58, 12.63)
Durable consumption	5.37 (0.43, 21.67)	8.05 (2.35, 22.35)	9.71 (3.45, 23.17)	9.12 (3.61, 19.83)	6.4 (1.97, 16.02)

Table 4: Forecast Error Variance Decomposition (FEVD) for the sentiment shock in the SVAR employing the baseline identification scheme, identifying restrictions are summarized in Table 2. Sample period runs from December 1997 to December 2022. Table shows median values in percentages with 68% confidence bands.

Table 4 presents FEVD for the sentiment shock under the baseline identification scheme at different horizons ranging from 1 month to 5 years. The sentiment shock explains around

7–8% of variance of households' inflation expectations up to 1–2 year horizon and only 5% at 5 years following a shock realization. The contribution to volatility of two measures of economic activity gets larger at longer horizons: the shock accounts for 5.5% of fluctuations in the unemployment rate and 3% of those in industrial production at horizon of 1 month, and the figures increase to 9% and 7%, correspondingly, 2 years after the shock. A similar pattern is observed for both types of household expenditure: a fraction of variance of nondurable and durable consumption due to the sentiment shock rises from 3.5% and 5% at 1 month horizon to almost 6% and 9–10% at horizons of 1–2 years, respectively.

The shock of interest best explains short-run movements in probability of real income gains: the value of 23% at 1 month declines to 7% at 5 years. The share of variance of two inflation rates and the federal funds rate attributed to the sentiment shock tends to be higher at longer horizons: for example, it equals, respectively, 7–8% and 9% 1–2 years after the shock as opposed to 3% and 6% at 1 month frequency.

These findings reveal that shocks causing variation in households' sentiments are more likely to drive medium run aggregate fluctuations in unemployment rate, industrial production, consumption and prices, but are equally important for volatility of inflation expectations in short and medium terms.

Inflation itself is an important factor in decision making of households and firms, but may also influence economic decisions by perturbing real interest rates via the Fisher equation. Economic theory predicts that consumption and, therefore, saving choices depend on expected real interest rates via an Euler equation, as illustrated in (4). Following this mechanism, central banks seek to influence economic behavior of households and firms by setting nominal rates, and also pay close attention to agents' inflation expectations because the latter is an integral component of expected real interest rates.

Since households have been shown to jointly revise all their expectations, the sentiment shock is likely to induce a response of not only inflation forecasts, but also beliefs of nominal interest rates, which implies that expected real interest rates may move as well. If one could observe real interest rate expectations and how they respond to the shock, it could also shed light on how households update expected nominal rates assuming they follow the Fisher equation. However, I cannot track households' beliefs of interest rates to draw conclusions, so I instead rely on empirical findings of Coibion et al. (2023) who, within a randomized control trial experiment, provide households with information about past, current and future policy rates as well as inflation and trace the effects of forecast revisions on economic choices. In particular, they document a causal relationship between perceived interest rates and consumption: households expecting higher real market rates are less likely to purchase durable goods in the next six months. They do not find any robust evidence that expected real rates have effects on nondurable consumption.

Their results make sense if one accounts for the fact that households commonly apply for loans to be able to finance their expenditure on durable goods, so real interest rates play a big role in their ability to afford those expensive goods, not inflation alone. According to my empirical analysis, the negative sentiment shock leads to an increase in inflation expectations and a persistent decline in spending on big ticket items. For these aggregate responses to be consistent with the survey-based findings of Coibion et al. (2023), households must revise forecasts of nominal interest rates upward by more than those of inflation such that expected real rates rise. This resembles the Taylor rule of monetary authorities: the central bank pushes up nominal interest rates by more than one-to-one in response to higher inflation to cool down the economy with higher real market rates. The empirical evidence available for households lends support to this view (Carvalho and Nechio (2014), Drager and Lamla (2015)).

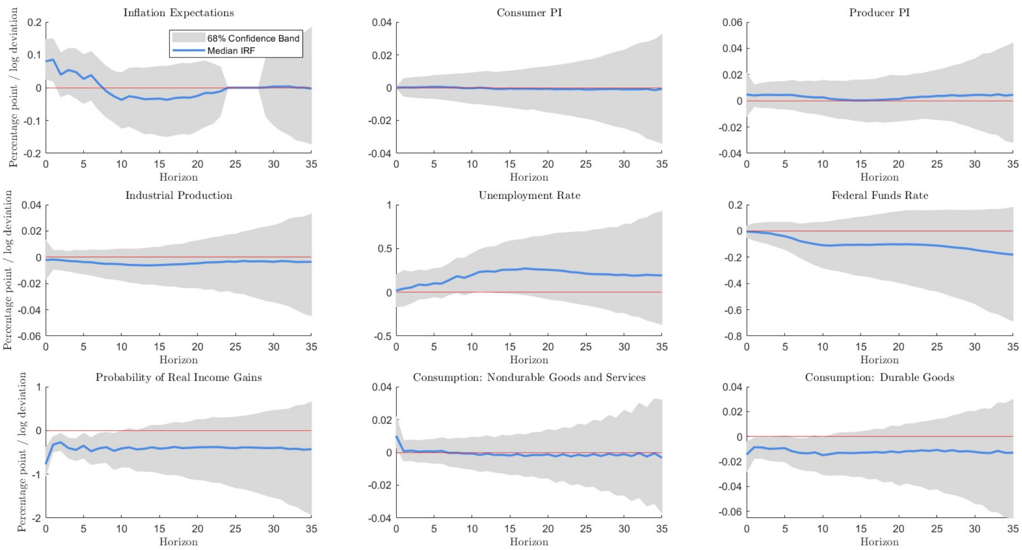

Figure 3: IRFs to the negative sentiment shock. Baseline identification scheme, restrictions are summarized in Table 2. Price indices are included in VAR in place of inflation rates. Sample period runs from December 1997 to December 2022. A blue line depicts the median response, shaded area shows 68% confidence bands.

The baseline specification of the VAR includes inflation rates – direct measures of how fast prices grow or fall, and in the literature there is no strict guidance whether researchers should use price levels or a rate of change in levels. To explore whether the main results go through, I reestimate the SVAR employing the baseline identification scheme, but replace inflation rates with price indices in logs. Figure 3 plots IRFs.

Overall, main conclusions are maintained in this modified specification. A negative realization of the sentiment shock generates a gradual increase in the unemployment rate reaching the peak of 0.27 percentage points at horizon 17, which implies the maximum increase of the unemployment rate per one standard deviation of the shock is almost 3.4. Industrial production tends to fall and is at the trough at horizons 10–15, around the time when the unemployment rate reaches its peak values. Durable consumption remains compressed for all horizons, this is especially clear up to horizon 10. As in the baseline specification, households spend more on nondurable goods and services only in the period of a shock arrival since nondurable consumption jumps up on impact and its median response stays at zero afterwards. Households' inflation expectations switch around horizon 8 from being above to being below the original level, just as we saw it in Figure 2. I also confirm the prior findings that the response of the probability of real income gains is persistently negative and interest rates decrease.

Evolution of price indices, however, is different from the pattern of inflation rates in the baseline specification. There is basically no response of CPI although the dynamics of PPI indicates a possible slight increase if one judges by the median.

4.3 Alternative Identification: Do Firms Share Households' Sentiments?

This paper relies on inflation expectations of households to identify movements in sentiments. The goal of imposing a zero identifying restriction on the response of consumer prices is to reflect the idea that households' expectations influenced by sentiments are formed in their mind and thus not directly observable by firms, so there is nothing that would encourage firms to change their economic behavior. In other words, firms respond to the shock through adjustment of prices and employment only upon recognizing with a delay that households expect higher inflation and worse economic conditions.

However, it excludes the possibility that firms can be exposed to sentiments similarly to households. In fact, firms are hierarchical structures in which individual managers make decisions on the pricing and production strategies possibly basing them on sentiments which affect all the expectations. Savignac et al. (2021) provide the empirical evidence that inflation expectations of a particular manager from French firms depend on the position he or she holds. Therefore, the way price setting choices respond to movements in managers' sentiments is determined by the level of the firms' decision-making.

Empirical literature finds that firms use their inflation expectations when making business decisions. Coibion et al. (2018) demonstrate that across firms in New Zealand, lower inflation expectations lead them to reduce investment and employment, but the negative effect on prices and wages does not have the statistical significance. In the survey of Italian firms, Coibion et al. (2020) document that firms with higher inflation forecasts tend to raise prices in the next two quarters and cut employment in the next six quarters following information treatment. Authors also explore what drives firms' responses to higher expected inflation, and their analysis shows that an increase in inflation expectations causes firms to believe in a worse aggregate economic situation and a decline in their own business conditions.

As research presented above suggests, firms are likely to be subject to sentiments expecting worse economic outcomes and higher inflation, just like households are. If this is the case, a negative realization of the sentiment shock should make firms' managers more pessimistic about the economic outlook, raise their inflation expectations and thus encourage them to increase actual prices immediately. Furthermore, the NK model augmented with the sentiment shock and discussed in subsection 2.2, also predicts that realized inflation will be higher if agents' sentiments decline, as is shown in Figure 1 plotting IRFs. In order to allow for this possibility and examine whether the SVAR model corroborates this idea, I employ the alternative identification scheme: it imposes restrictions as in Table 2 except that I replace the zero identifying restriction (18) with the sign restriction on consumer prices

$$\text{IRF}(\text{consumer prices}, \varepsilon_\eta, h) < 0, \;\; h = 0. \tag{23}$$

All identifying restrictions that are included in this alternative identification scheme are summarized in Table 5.

Identifying Restriction	Variable	Type of Restriction	Horizons
1	Inflation expectations	Zero	[24, 28]
2	Consumer price inflation / index	Negative	0
3	Probability of income gains	Positive	0
4	Nondurable consumption	Negative	0
5	Durable consumption	Positive	0
6	Inflation expectations	Negative	0

Table 5: Alternative identification scheme: summary of identifying restrictions for the sentiment shock in SVAR.

I estimate the baseline specification of the SVAR and focus on IRFs when a negative one standard deviation sentiment shock hits both households and firms.

Figure 4 plots median IRFs and 68% confidence bands around them. The response of inflation expectations follows a pattern very similar to that under the baseline identification scheme. Specifically, they increase on impact by 0.08 percentage point, return to an initial level at horizon 5, continue to fall further reaching the lowest point of almost -0.07 percentage

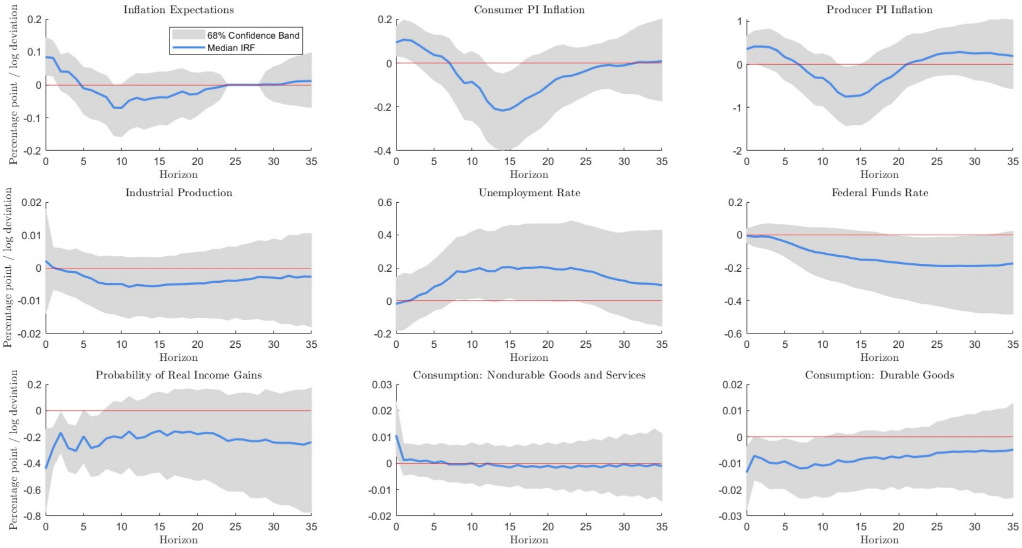

Figure 4: IRFs to the negative sentiment shock. Alternative identification scheme, restrictions are summarized in Table 5. Sample period runs from December 1997 to December 2022. A blue line depicts the median response, shaded area shows 68% confidence bands.

point around horizon 10 and rise back to a steady state thereafter. According to estimates from Table 6, the probability that inflation expectations decrease most periods at horizons 9–11 is over 80%. Under alternative identification, I also find that households expect lower-than-initial inflation shortly after their forecasts rise. The probability of real income gains lowers on impact and the main mass of distribution of responses at horizons 9 and further stays in the negative domain, which Table 6 confirms. This piece of evidence gives support to the view that the identified shock worsens households' economic expectations and can be interpreted as the sentiment shock.

The effects on real quantities are qualitatively similar to ones obtained under the baseline identification scheme. Figure 4 shows a persistent negative response of durable consumption which decreases by 1.3% in the very first period, and it remains so up to horizon 35 with probability 90%. As was the case under baseline identification, consumption of nondurable goods and services goes up on impact by 1% and non-zero effects at further horizons disappear. The shape of the response of unemployment is similar in that it enters the plateau at horizon 10 and levels off around 0.2 percentage point for 15 months with 90% probability. Industrial production reaches the trough of -0.6% and the probability that its response is negative in most periods across horizons 10–25 is given by more than 80%.

IRFs from Figure 4 help quantify the extent of aggregate fluctuations due to changes in sentiments. One percentage point sentiment shock results in the peak increase in un-

Variable	Sign of Response	Horizons	Probability that responses satisfy sign over		
			One horizon	50% of horizons	100% of horizons
Inflation expectations	Negative	[9, 11]	91.19	83.05	69.08
Probability of income gains	Negative	[9, 35]	98.59	78.1	26.16
Durable consumption	Negative	[0, 35]	100	90.53	15.32
Unemployment rate	Positive	[10, 25]	98.16	89.51	54.45
Industrial production	Negative	[10, 25]	98.73	82.01	19.68
CPI inflation	Positive	[0, 5]	100	90.5	56.71
PPI inflation	Positive	[0, 5]	92.77	83.63	56.86
CPI inflation	Negative	[10, 20]	96.0	86.4	52.4
PPI inflation	Negative	[10, 20]	95.04	82.04	39.07
Fed funds rate	Negative	[3, 35]	96.95	84.65	40.13

Table 6: Probabilities that responses take a certain sign over a specified fraction of given horizons. Responses of variables to the negative sentiment shock in the SVAR employing the alternative identification scheme, restrictions are summarized in Table 5. Sample period runs from December 1997 to December 2022. Calculated probabilities are in percentages.

employment rate by 2.4 percentage points and decline of 6.9% and 16% at the trough in, respectively, industrial production and durable consumption.

The key difference from the baseline identification scheme lies in IRFs of inflation. Responses of both measures exhibit an S-shape: CPI and PPI inflation rates increase by 0.1 and 0.4 percentage point at the peak, correspondingly, and then dip below an initial inflation level reaching -0.2 and -0.7 percentage point at the lowest around horizon 15, afterwards it converges back to a steady state. As is evident from Table 6, the probability of positive fluctuations over at least 3 months at horizons 0–5 is 84–90% while inflation falls over at least 6 months at the frequency of 10–20 horizons with probability 82–86% depending on which price index is considered. Imposing a positive response of inflation on impact reveals high volatility in the rate at which prices change.

How can one reconcile these responses with those depicted in Figure 2 and discussed earlier? I propose the following economic interpretation. A negative sentiment shock now hits not only households, but also firms' managers leading them to think more pessimistically about a future economic and business environment and expect higher inflation. Since firms believe that future demand will shrink, and also have direct control over prices of their products, higher inflation expectations turn into higher (consumer and producer) prices today as businesses take advantage of yet strong consumer demand. Households also share the pessimistic view of the economy anticipating their real income to decrease and thus reduce their spending on big-ticket items. At the same time, they temporarily buy more of nondurable goods and services using saved money they had planned to spend on durables. The strength of a decline in demand for big-ticket items might be amplified by prices growing even faster than in the steady state. As time passes, firms observe weaker consumer demand for durable products, which prompts them to lower prices or at least limit the pace of price increases. Hence, the sentiment shock is able to generate accelerating inflation in initial periods followed by disinflation at further horizons.

The sentiment shock has the property of the self-fulfilling prophecy: before the shock arrives, there are no fundamental forces that push the economy closer to a recession. The mere belief of households and firms' managers driven by sentiments that economic conditions will deteriorate, triggers the response of real macro aggregates such as consumption and induces a contraction of economic activity.

Table 7 presents estimates of FEVD due to the sentiment shock under the alternative identification scheme for a range of different horizons from 1 month to 5 years. The shock of interest explains about 12–13% at 1–3 months and around 10–11% at 4–12 months of the volatility in inflation expectations, and the share declines to 5.5% at 5 years. Under the alternative scheme, the shock's contribution turns out to be greater in short and medium run, as can be seen from comparing Tables 7 and 4. The volatility of industrial production and unemployment rate accounted for by the sentiment shock is slightly lower, but the pattern from baseline identification is preserved: it tends to increase at medium term horizons, with values of 7% and 8%, correspondingly, at 2 years, but then contracts to 5.5–6.5% at long run horizon of 5 years. The figures for two types of consumption are comparable across both identification schemes such that a greater fraction of variance explained by the shock happens to be in medium run. In particular, around 4% and 5% of fluctuations in, respectively, nondurable and durable consumption 1–3 months after the shock, and its explanatory power rises to nearly 6% and 10% 1 year after.

The share of the variance of probability attributed to the sentiment shock is not as high as what I obtained with the baseline identification scheme in Table 4, yet is sizeable and rises to 16% around 6 month horizon further decreasing to 7%. Under alternative identification,

Variable	Horizon				
	1 month	6 months	1 year	2 years	5 years
Inflation expectations	11.48 (1.48, 34.69)	10.16 (3.95, 21.48)	10.2 (4.69, 19.3)	8.48 (4.01, 16.46)	5.56 (1.86, 12.8)
CPI inflation	10.98 (1.18, 34.04)	9.49 (3.0, 23.04)	8.72 (3.82, 17.84)	9.7 (3.74, 21.1)	6.5 (2.19, 15.18)
PPI inflation	11.24 (1.18, 36.92)	10.05 (2.74, 27.64)	10.6 (4.36, 20.64)	9.96 (4.27, 20.12)	7.2 (2.56, 15.94)
Industrial production	3.28 (0.26, 15.39)	5.13 (1.76, 13.94)	6.53 (2.61, 14.93)	6.93 (2.87, 15.37)	5.53 (1.73, 13.76)
Unemployment rate	4.96 (0.48, 19.97)	5.19 (1.83, 13.04)	7.1 (2.58, 17.93)	8.02 (2.76, 20.81)	6.52 (1.97, 16.29)
Federal funds rate	4.96 (0.48, 21.7)	5.64 (1.07, 19.9)	6.9 (1.48, 23.97)	8.79 (1.92, 25.6)	7.3 (1.91, 18.86)
Prob. of real income gains	12.45 (1.27, 38.59)	15.67 (6.32, 31.36)	13.74 (6.23, 26.18)	10.33 (4.7, 20.86)	6.6 (2.1, 15.68)
Nondurable consumption	3.24 (0.28, 15.76)	5.06 (1.76, 13.93)	5.79 (2.46, 13.21)	5.82 (2.59, 12.62)	5.08 (1.6, 12.5)
Durable consumption	4.57 (0.4, 19.57)	7.97 (2.29, 21.92)	9.47 (3.36, 22.21)	8.69 (3.36, 19.49)	6.37 (1.94, 14.95)

Table 7: Forecast Error Variance Decomposition (FEVD) for the sentiment shock in the SVAR employing the alternative identification scheme, identifying restrictions are summarized in Table 5. Sample period runs from December 1997 to December 2022. Table shows median values in percentages with 68% confidence bands.

I find differences in the shape and magnitude of contribution to volatility in inflation across horizons. The pattern uncovers two peaks at 1–2 and 17 months: while for CPI both reach the level of 11%, peak values for PPI are 11.5–12%, afterwards explained shares decline steadily. These horizons closely match those at which inflation responses are at the peak or trough, as IRFs in Figure 4 show and discussed above. Finally, the sentiment shock generates 5–9% of variation in the Federal funds rate depending on a horizon.

Variance decomposition under the alternative identification scheme confirms previous results that the sentiment shock is more likely to explain medium run aggregate fluctuations in indicators of economic activity (unemployment rate and industrial production) and consumption of both durables and nondurables. However, findings suggest there are also differences: it accounts for a higher share of variance in inflation expectations and inflation measures, and the cross-horizon pattern of contribution to volatility in the latter enjoys two peaks while it was single-peaked under baseline identification.

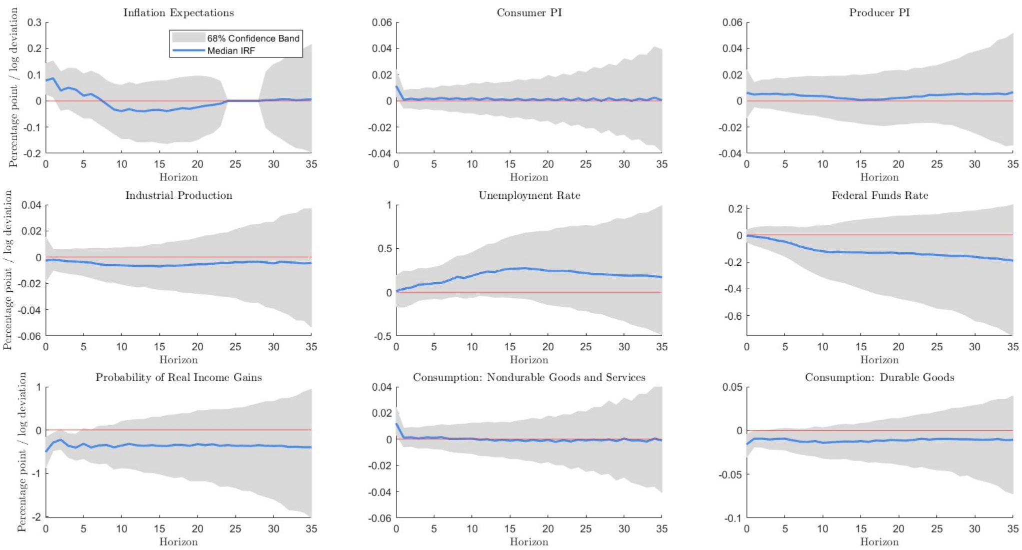

Figure 5: IRFs to the negative sentiment shock. Alternative identification scheme, restrictions are summarized in Table 5. Price indices are included in VAR in place of inflation rates. Sample period runs from December 1997 to December 2022. A blue line depicts the median response, shaded area shows 68% confidence bands.

I also verify whether the main findings from Figure 4 remain unchanged if I substitute price indices for inflation rates. To do so, I estimate the SVAR relying on the alternative identification scheme with a positive response of consumer prices. Figure 5 plots results with a modified specification, blue lines are median IRFs and grey area represents 68% confidence bands up to horizon 35.

A negative sentiment shock raises inflation expectations, but the effect is short-lived, and they go down quickly. Expectations decline relative to a steady state at horizon 7, reach the trough of -0.04 percentage point 6 months later and start their return to a pre-shock level from horizon 16. However, it is harder to discern a dip of inflation forecasts now. The probability that expectations of inflation respond negatively in 4 or more periods when considering a wider range of horizons 10–16 is only 66% as compared to 83% in the specification with inflation rates.

I observe a gradual increase in unemployment and a subsequent fall. There are several differences in its dynamics across specifications though. Firstly, the peak value is now 0.27 percentage point, so unemployment rises by one third more than in the model with inflation rates. Secondly, unemployment does not enter the plateau, instead it monotonically increases, gets highest at horizon 17 and declines thereafter. Although confidence bands are wider, the probability that unemployment rate rises at least in 8 periods at horizons

10–25 remains high and equals almost 85%. The specification with price indices also shows persistent negative effects of the sentiment shock on durable consumption. It contracts on impact by 1.6%, the trough point, and although the depth of a fall shrinks in the next couple of months, a decline of durable consumption reaches 1.4% at horizons 10–11, close to the trough value. Across all horizons 0–35, expenditure on big ticket items decreases in 18 or more periods with probability of around 85%.

Similarly to the baseline specification, the response of industrial production is negative, however, the trough of -0.7% becomes larger in absolute value and happens at horizon 15. There is a 75% chance that industrial production goes below a steady state in most periods at horizons 10–25. Notice that the moment of the biggest contraction in industrial production (horizon 15) is well aligned with the period of highest unemployment – horizon 17. This observation justifies that both measures of economic activity are good at characterising the same business cycle. Behavior of nondurable consumption follows that in the specification with inflation: it jumps up by 1.2% at horizon 0 and is back to an initial level one month after the shock.

The probability of real income gains responds negatively on impact and continues to hover below a steady state across all horizons. The chances that this happens in 18 or more months at horizons 0–35, are estimated at over 80%. Figure 5 also provides evidence that the central bank takes actions and reduces interest rates. The main difference across specifications comes from responses of price indices. CPI is restricted to increase on impact by construction, but it does not induce further interesting dynamics: IRF is basically zero from horizon 1 and on. PPI seems to be above a steady state value up to horizon 10, but deviation is very small and confidence bands are wide. If I take the range of horizons 0–10, then PPI goes up at least in 6 periods only with 69% probability.

The findings pertaining to real effects of the sentiment shock are preserved in the specification with price indices. On the other hand, the S-shape dynamics of inflation disappears, and neither CPI nor PPI move in a meaningful way in response to the shock.

5 Conclusion

Expectations of households and firms have been found to be biased away from those of professional forecasters and thus deviate from the FIRE framework. What can account for this departure of expectations from rationality?

I propose an explanation that sentiments cause a bias in measured expectations of agents. Sentiments should be understood as reflecting “animal spirits” in households’ and firm managers’ mind that turn them excessively optimistic or pessimistic about the prospect of the economy, which influences their forecasts and thereby economic choices.

This paper employs a new identification scheme within the SVAR to identify unanticipated shifts in sentiments – the “sentiment shock” – from households’ inflation expectations.

It explicitly takes account of the central bank's strategy to anchor these expectations and a differentiated response of durable and nondurable consumption and also includes two expectational variables. I study the properties of a business cycle triggered by this shock and find that it has long-lived effects on unemployment, industrial production and durable consumption along with a non-trivial evolution of inflation. One candidate channel that has a potential to explain how shifts in sentiments may cause changes in economic activity, operates through a contraction of households' spending on durable goods.

Since the sentiment shock is shown to generate effects on real and nominal quantities, there is need to develop a theory to formalize the way pessimism or optimism can drive aggregate fluctuations. It requires researchers to introduce bounded rationality into agents' behavior when building macro models with expectations because this paper along with other studies reveals real effects of nonrational sentiment shocks and confirms prior empirical findings that measured expectations of households and firms may not fully satisfy FIRE. This goal represents an avenue for future research.

References

Adam, K. and M. Padula (2011) "Inflation Dynamics and Subjective Expectations in the United States," *Economic Inquiry*, 49 (1), 13–25.

Adams, J. and P. Barrett (2023) "Shocks to Inflation Expectations," *Working Paper*.

Andre, P., C. Pizzinelli, C. Roth, and J. Wohlfahrt (2022) "Subjective Models of the Macroeconomy: Evidence from Experts and a Representative Sample," *Review of Economic Studies*, 89, 2958–91.

Angeletos, G.-M., F. Collard, and H. Dellas (2018) "Quantifying Confidence," *Econometrica*, 86 (5), 1689–726.

Arias, J., J. Rubio-Ramirez, and D. Waggoner (2018) "Inference Based on Structural Vector Autoregressions Identified with Sign and Zero Restrictions: Theory and Applications," *Econometrica*, 86 (2), 685–720.

Ascari, G., S. Fasani, J. Grazzini, and L. Rossi (2022) "Endogenous Uncertainty and the Macroeconomic Impact of Shocks to Inflation Expectations," *Working paper*.

Barsky, R. and E. Sims (2012) "Information, Animal Spirits, and the Meaning of Innovations in Consumer Confidence," *American Economic Review*, 102 (4), 1343–77.

Barsky, R.B. and E.R. Sims (2011) "News Shocks and Business Cycles," *Journal of Monetary Economics*, 58 (3), 273–89.

Beaudry, P. and F. Portier (2006) "Stock Prices, News, and Economic Fluctuations," *American Economic Review*, 96 (4), 1293–1307.

Calvo, G. (1983) "Staggered Prices in A Utility-Maximizing Framework," *Journal of Monetary Economics*, 12 (3), 383–98.

Candia, B., Y. Gorodnichenko, and O. Coibion (2023) "The Macroeconomic Expectations of Firms," *Handbook of Economic Expectations*, 321–53.

Canova, F. and F. Ferroni (2022) "A Hitchhiker's Guide to Empirical Macro Models," *Working paper*.

Carvalho, C. and F. Nechio (2014) "Do People Understand Monetary Policy?" *Journal of Monetary Economics*, 66, 108–23.

Chahrour, R. and K. Jurado (2022) "Recoverability and Expectations-Driven Fluctuations," *Review of Economic Studies*, 89 (1), 214–39.

Christiano, L.J., M. Eichenbaum, and C.L. Evans (2005) "Nominal Rigidities and the Dynamic Effects of a Shock to Monetary Policy," *Journal of Political Economy*, 113 (1), 1–45.

Clark, T. and T. Davig (2011) "Decomposing the Declining Volatility of Long-term Inflation Expectations," *Journal of Economic Dynamics & Control*, 35, 981–99.

Coibion, O. (2012) "Are the Effects of Monetary Policy Shocks Big or Small?" *American Economic Journal: Macroeconomics*, 4 (2), 1–32.

Coibion, O., D. Georgarakos, Y. Gorodnichenko, and M. Weber (2023) "Forward Guidance and Household Expectations," *Journal of the European Economic Association.*

Coibion, O., Y. Gorodnichenko, and S. Kumar (2018) "How Do Firms Form Their Expectations? New Survey Evidence," *American Economic Review*, 108 (9), 2671–713.

Coibion, O., Y. Gorodnichenko, and T. Ropele (2020) "Inflation Expectations and Firm Decisions: New Causal Evidence," *The Quarterly Journal of Economics*, 135 (1), 165–219.

Coibion, O., Y. Gorodnichenko, and M. Weber (2022) "Monetary Policy Communications and Their Effects on Household Inflation Expectations," *Journal of Political Economy*, 130 (6), 1537–84.

D'Acunto, F., U. Malmendier, and M. Weber (2023) "What Do the Data Tell Us about Inflation Expectations?" *Handbook of Economic Expectations*, 133–61.

Drager, L. and M. Lamla (2015) "Disagreement a la Taylor: Evidence from Survey Microdata," *Macroeconomics and Finance Series 2015-03, University of Hamburg, Department of Socioeconomics.*

Gali, J. (2008) *Monetary Policy, Inflation, and the Business Cycle: an Introduction to the New Keynesian Framework and Its Applications*: Princeton University Press.

Gali, J. and M. Gertler (1999) "Inflation Dynamics: A Structural Econometric Analysis," *Journal of Monetary Economics*, 44 (2), 195–222.

Gertler, M. and P. Karadi (2015) "Monetary Policy Surprises, Credit Costs, and Economic Activity," *American Economic Journal: Macroeconomics*, 7 (1), 44–76.

Gurkaynak, R., B. Sack, and E. Swanson (2005) "Do Actions Speak Louder than Words? The Response of Asset Prices to Monetary Policy Actions and Statements," *International Journal of Central Banking*, 1 (1), 55–93.

Hanson, S. and J. Stein (2012) "Monetary Policy and Long-Term Real Rates," *Finance and Economics Discussion Series (FEDS) Discussion Paper 2012–46*.

Kamdar, R. (2019) "The Inattentive Consumer: Sentiment and Expectations," *Working paper*.

Keynes, J.M. (1936) *The General Theory of Employment, Interest and Money*: Kessinger Publishing, LLC.

Levchenko, A. and N. Pandalai-Nayar (2020) "TFP, News, and "Sentiments": The International Transmission of Business Cycles," *Journal of the European Economic Association*, 18 (1), 302–41.

Maxted, P. (2023) "A Macro-Finance Model with Sentiment," *Review of Economic Studies*, 90 (5).

Nakamura, E. and J. Steinsson (2013) "Price Rigidity: Microeconomic Evidence and Macroeconomic Implications," *Annual Review of Economics*, 5, 133–63.

——— (2018) "High-Frequency Identification of Monetary Non-Neutrality: the Information Effect," *The Quarterly Journal of Economics*, 133 (3), 1283–1330.

Ramey, V. (2016) "Macroeconomic Shocks and Their Propagation," *Handbook of Macroeconomics*, 2A, 71–162.

Roberts, J. (1997) "Is Inflation Sticky?" *Journal of Monetary Economics*, 39 (2), 173–96.

Romer, C.D. and D.H. Romer (2004) "A New Measure of Monetary Policy Shocks: Derivation and Implications," *American Economic Review*, 94 (4), 1055–84.

Rudd, J. (2022) "Why Do We Think that Inflation Expectations Matter for Inflation? (And Should We?)," *Review of Keynesian Economics*, 10 (1), 25–45.

Rudd, J. and K. Whelan (2005) "New Tests of the New-Keynesian Phillips Curve," *Journal of Monetary Economics*, 52 (6), 1167–81.

——— (2006) "Can Rational Expectations Sticky-Price Models Explain Inflation Dynamics?" *The American Economic Review*, 96 (1), 303–20.

Savignac, F., E. Gautier, Y. Gorodnichenko, and O. Coibion (2021) "Firms' Inflation Expectations: New Evidence from France," *Banque de France Working Paper 840*.

Sims, C. (1980) "Macroeconomics and Reality," *Econometrica*, 48 (1), 1–48.

Smets, F. and R. Wouters (2007) “Shocks and Frictions in US Business Cycles: A Bayesian DSGE Approach,” *American Economic Review*, 97 (3), 586–606.

Swanson, E. and J. Williams (2014) “Measuring the Effect of the Zero Lower Bound on Medium– and Longer–Term Interest Rates,” *American Economic Review*, 104 (10), 3154–85.

Taylor, J. (1993) “Discretion vs Policy Rules in Practice,” *Carnegie Rochester Conference Series on Public Policy*, 39, 195–214.

Uhlig, H. (2005) “What Are the Effects of Monetary Policy on Output? Results from an Agnostic Identification Procedure,” *Journal of Monetary Economics*, 52 (2), 381–419.

Werning, I. (2022) “Expectations and the Rate of Inflation,” *Working Paper*.

Appendices

A Data

Description of the data used in the VAR is given in Table 8.

Variable	Source	Reference	Further details / Transformation
Inflation expectations	MSC	Table 32: Expected Change in Prices During the Next Year	Median
Probability of real income gains	MSC	Table 16: Probability of Real Income Gains During the Next 5 Years	Mean
Consumer price index	St. Louis FED	CPIAUCSL	Logs
Consumer price inflation	St. Louis FED	CPIAUCSL_PC1	Percent change from year ago
Producer price index	St. Louis FED	PPIACO	Logs
Producer price inflation	St. Louis FED	PPIACO_PC1	Percent change from year ago
Industrial production	St. Louis FED	INDPRO	Logs
Unemployment rate	St. Louis FED	UNRATE	Percent
Federal funds rate	St. Louis FED	FEDFUNDS	Percent
Nondurable consumption	St. Louis FED	PCEND, PCES	PCE on nondurable goods and services summed up together and deflated by PCE price index (PCEPI)
Durable consumption	St. Louis FED	PCEDG	PCE on durable goods deflated by PCE price index (PCEPI)

Table 8: Description of data used in the VAR. MSC stands for Michigan Survey of Consumers.

B Robustness Checks

In section 4 I have found that the negative sentiment shock leads to an increase in the unemployment rate, a persistent decline in durable consumption and inflationary/deflationary effects under two identification schemes. These results may be dependent on a particular specification of the VAR, so I perform a series of robustness checks in this section to verify that conclusions continue to qualitatively hold true. I consider different samples (extending a baseline one to start in 1978 or excluding a period of a COVID pandemic), an alternative measure of consumer price inflation and removing zero restrictions on the response of inflation expectations in identification.

B.1 Extended Sample

The original sample period running from December 1997 to December 2022 is constrained by the availability of probability of real income gains. If I exclude it from a list of variables in the VAR, it enables me to extend the sample to January 1978. I estimate the SVAR based on the period from January 1978 to December 2022 using inflation rates and rely first on the baseline identification scheme summarized in Table 2 in which the sign restriction on the response of probability is not enforced.

Figure 6 presents the median IRFs and 68% confidence bands around them. If I start with similarities with previous results, the first thing to note is that when the negative sentiment shock hits the economy, the unemployment rate gradually increases, as was the case in the original sample, and remains elevated between horizons 10 and 25. The peak response, however, is now almost three times lower: a 1.3 percentage point increase per one percentage point sentiment shock as opposed to almost 3.5 in the baseline specification. A contraction of durable consumption becomes more persistent: the condition that a probability of a negative response at a given horizon is at least 84%, is satisfied up to horizon 25 for this longer sample while it holds only up to horizon 10 if estimated on data starting in December 1997. Industrial production is likely to fall slowly and remain in the negative domain until horizon 35.

The main difference arising from an extended sample is that the inflation expectations response does not dip into negative values, but instead monotonically returns to zero following an initial increase. Judging by median responses, I do not find pronounced negative effects on price inflation around horizons 10–20.

Next, I explore how extending the sample to January 1978 changes the response of the economy under the alternative identification scheme summarized in Table 5 where the sign restriction on the probability is excluded. I again include inflation rates in VAR rather than price indices such that any differences stem from increasing the sample size. As Figure 7 shows, the unemployment rate rises, but not as sharply as with the original sample at horizons 0–7, and reaches highest levels (based on median) later around horizon 25. There

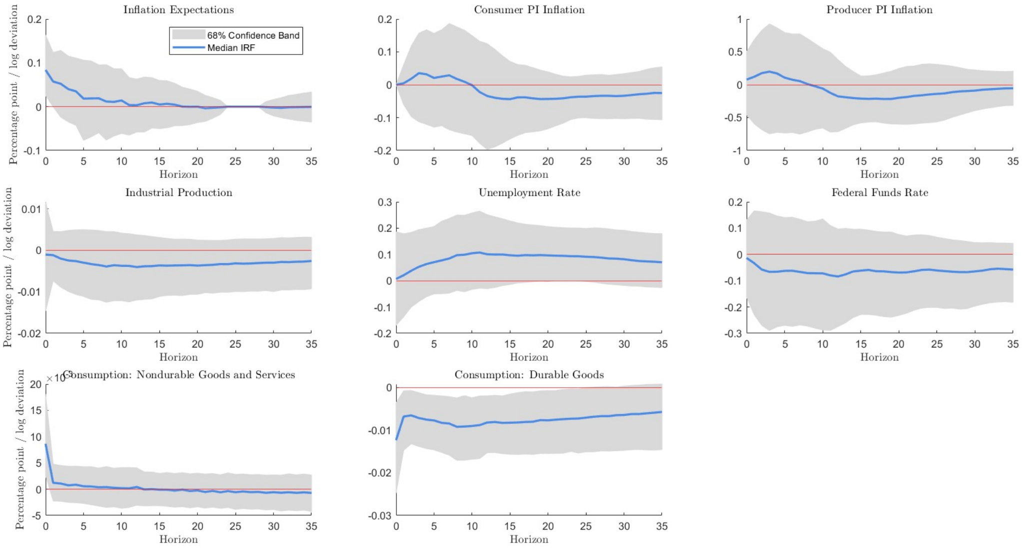

Figure 6: IRFs to the negative sentiment shock. Baseline identification scheme, restrictions are summarized in Table 2, but the sign restriction on the response of probability is not enforced since the variable is excluded. Sample period runs from January 1978 to December 2022. A blue line depicts the median response, shaded area shows 68% confidence bands.

is no discernible plateau when unemployment is at its peak, instead it tends to decline soon after it reaches the maximum. A greater degree of persistence in negative effects on durable good spending is also evident here, similarly to Figure 6: more probability mass in the distribution of responses is concentrated around the median, as illustrated by tighter confidence bands in Figure 7.

I also find that positive effects of the sentiment shock on inflation expectations live longer. In the VAR estimated over the period 1978–2022, expectations increase on impact and steadily decline afterwards while in the baseline specification, forecasts initially go up, but then quickly fall and dip below a starting value around horizon 10. The fact that households do not expect prices to fall when the sample starts in 1978, is consistent with excessively high inflation rates and expectations in late 1970s – early 1980s when deflation was not recorded. Nevertheless, the model still generates an S-shaped pattern in responses of inflation: after both inflation measures increase, they reverse and turn negative starting with horizon 17–18. If one looks at median responses, the trough is more than two times smaller in absolute value compared with that in the original sample, yet the main mass of the distribution lies in the negative domain, which confirms that the S-shaped dynamics of inflation is present in this specification as well.

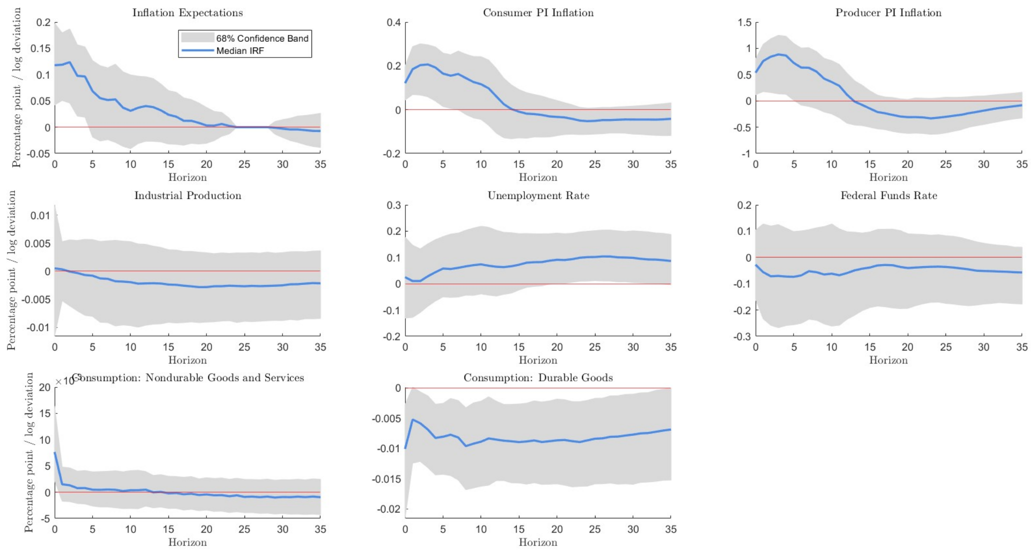

Figure 7: IRFs to the negative sentiment shock. Alternative identification scheme, restrictions are summarized in Table 5. A sign restriction on the response of probability is not enforced since the variable is excluded. Sample period runs from January 1978 to December 2022. A blue line depicts the median response, shaded area shows 68% confidence bands.

B.2 Excluding a COVID Period

The baseline sample ends in December 2022 and thus covers three years after the COVID pandemic started. Since both inflation expectations and inflation rate in US skyrocketed during this time, I explore how and whether main results are affected if the COVID period is excluded from the sample. In doing so, I estimate the baseline specification of SVAR on data from December 1997 to December 2019.

IRFs under the baseline identification scheme are illustrated in Figure 8. The response of inflation expectations becomes more persistent as they increase roughly by 0.07 percentage point on impact and remain elevated in 4 or more periods until horizon 6 with 90% probability. Starting with the next period, they decrease and return to an initial level by horizon 12, so I do not find a dip of inflation expectations below a steady state, and probability of a decline at horizons 9–11 is only 58%. A negative response of probability of income gains is favored by this specification, the chance of its decrease in most months at horizons 10–35 is over 85%.

The unemployment rate rises steadily and reaches the peak of nearly 0.15 percentage point (a reduction by one fourth from the baseline specification) at horizon 22. There is no plateau where unemployment hovers around some level, it instead declines monotonically to

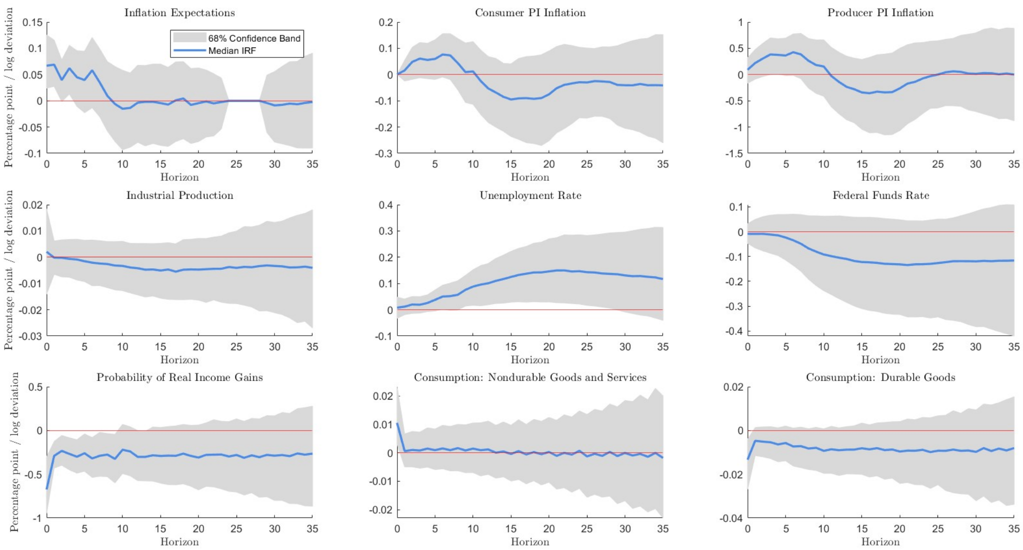

Figure 8: IRFs to the negative sentiment shock. Baseline identification scheme, restrictions are summarized in Table 2. Sample period excludes COVID and runs from December 1997 to December 2019. A blue line depicts the median response, shaded area shows 68% confidence bands.

a steady state. The rate of unemployment clearly goes up in most periods at horizons 10–30, the probability of which is nearly 90%. Figure 8 shows that durable consumption falls by 1.3% on impact, and the depth of its fall levels off in the range 0.8-1% in periods afterwards. An event that consumption of durable goods decreases in most periods across horizons 0–35 happens with probability of 90%. The pattern of a response of industrial production has not changed dramatically: it still shows a downward trend, with the trough point being -0.6% at horizon 17, and if one takes a horizon range 10–30, the same as for unemployment, the probability that industrial production contracts at least in 11 periods is estimated to be 77%. Similarly to the case with the baseline sample, consumption of nondurables increases on impact and no response is observed thereafter.

Despite a zero on impact restriction on CPI inflation, the model generates an S-shaped response of both inflation measures. CPI and PPI inflation increases by up to 0.08 and 0.42 percentage point, respectively, until horizon 6 such that probabilities of positive responses at horizons 0–8 are around 82%. They both then dip reaching the trough of -0.09 percentage point at horizon 15 for CPI and -0.36 at horizon 16 for PPI inflation, stay around these values for 4-5 months and ultimately move toward a steady state. If focusing on horizons 10–20, calculations show that CPI inflation responds negatively at least in 6 periods with 75% probability and PPI inflation does so with 69% probability.

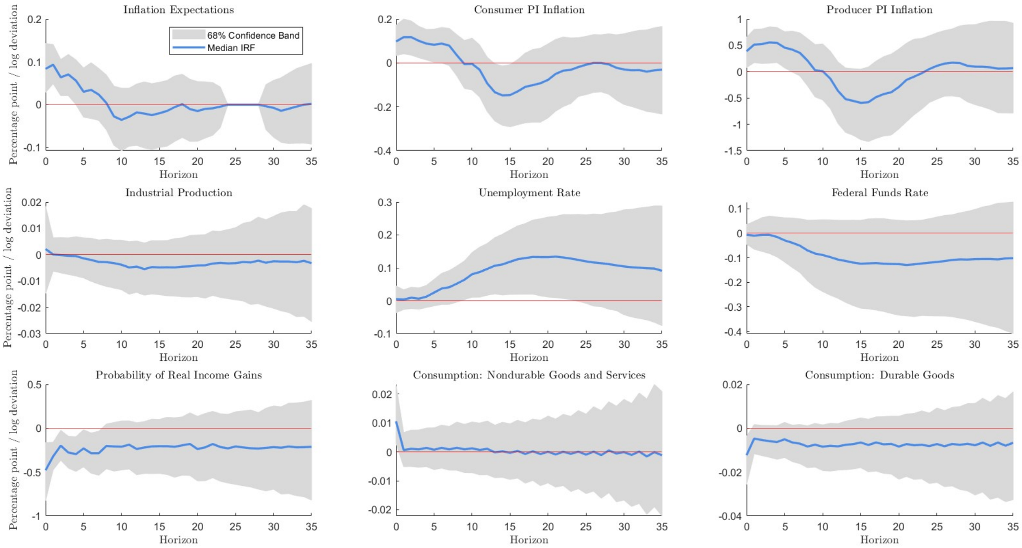

Figure 9: IRFs to the negative sentiment shock. Alternative identification scheme, restrictions are summarized in Table 5. Sample period excludes COVID and runs from December 1997 to December 2019. A blue line depicts the median response, shaded area shows 68% confidence bands.

Figure 9 presents IRFs when the alternative identification scheme is used. Inflation expectations go up by 0.08 percentage point on impact, but with no substantial persistence. Their return to a steady state is more sluggish though such that expectations reach an initial level at horizon 8 which is 3 months later than when estimated on a full sample. The model also indicates that expected inflation declines below a steady state with the trough of -0.04 percentage point at horizon 10, but it is harder to justify this dynamics: inflation forecasts decrease only with 69% probability over horizons 9–11 as compared to 83% when COVID time is included. The response of probability of income gains follows a pattern seen before and remains negative at horizons 9–35 with almost 80% probability.

Unemployment starts to increase with a lag and gets at the highest level of 0.13 percentage point at horizon 21. It implies that if a sample covers COVID months, a response of unemployment becomes more volatile: its maximum deviation from a steady state increases from 0.13 to 0.2 percentage point. Figure 9 illustrates the plateau at which unemployment sits for 7 months before it falls gradually. It also clearly shows that the unemployment rate rises at least in 8 periods over horizons 10–25, and the probability of this event equal to almost 90% justifies this claim. The largest negative effect on consumption of durable goods happens on impact – a 1.2% contraction, and in each subsequent period it stays 0.5–0.8% below a steady state value. With probability of 87% its response in most periods at horizons

0–35 is negative. Relative to a baseline sample including a COVID pandemic, industrial production dynamics does not exhibit major distinctions: it falls and hits a -0.6% trough 13 months after the shock, negative effects in 8 or more periods at horizons 10–25 are likely with 82% probability. I do not observe anything new in fluctuations of nondurable consumption.

An S-shaped pattern is again detected in responses of inflation rates. CPI inflation goes up at horizons 0–8 with 91% probability, the peak is achieved at 0.12 percentage point at horizon 2, and it hits the bottom of -0.15 percentage point at horizon 14. This dip is probable in 6 or more periods from horizons 10–20 with 82% chance. When focusing on PPI inflation, probability that it responds positively at same horizons 0–8 is close to 91%. It peaks at 0.56 percentage point at horizon 3 and reaches a low at -0.59 percentage point 12 months later. A decline in PPI inflation over horizons 10–20 occurs with probability slightly below 80%.

To sum up, excluding a COVID period from a sample leads to minor changes in results. A negative sentiment shock still has sizeable effects on unemployment, durable consumption and industrial production although the former does not hover around peak values for a long time. It triggers a response of inflation that follows an S-pattern. I also find a more persistent rise in inflation expectations for the first few months after the shock, especially under the baseline identification scheme. On the other hand, the evidence of a dip of inflation forecasts is less clear.

B.3 Core CPI Inflation

The baseline specification includes CPI inflation rates in VAR, but these are known to be volatile because they account for changes in food and energy prices. Some central banks also prefer to exclude volatile prices from consideration when analysing inflation dynamics. I reestimate the SVAR model of the baseline specification except that CPI inflation is replaced with core CPI inflation, which is based on all goods and services less food and energy. The sample period is fixed and runs from December 1997 to December 2022.

I start with the baseline identification scheme, results are presented in Figure 10. IRFs from this specification are consistent with those under a baseline one. Inflation expectations rise on impact and also decline below an initial level around horizon 10. Unemployment rate increases steadily and levels off at 0.2 percentage point, but this occurs 5 months later than under the baseline – at horizon 15. The negative response of durable consumption becomes even more persistent such that at least 84% mass of distribution of responses is in the negative domain up to horizon 15. There are no major differences across specifications in evolution of industrial production or nondurable consumption.

Core CPI inflation responds in a similar fashion to CPI inflation although there are some slight changes. The trough point now shifts several months later to horizon 18 and its magnitude in absolute terms is reduced from -0.15 to -0.07 percentage point, which is in line with what one should expect if most volatile prices are excluded. The response of core CPI inflation is more long-lived and remains negative from the trough until horizon 35 for

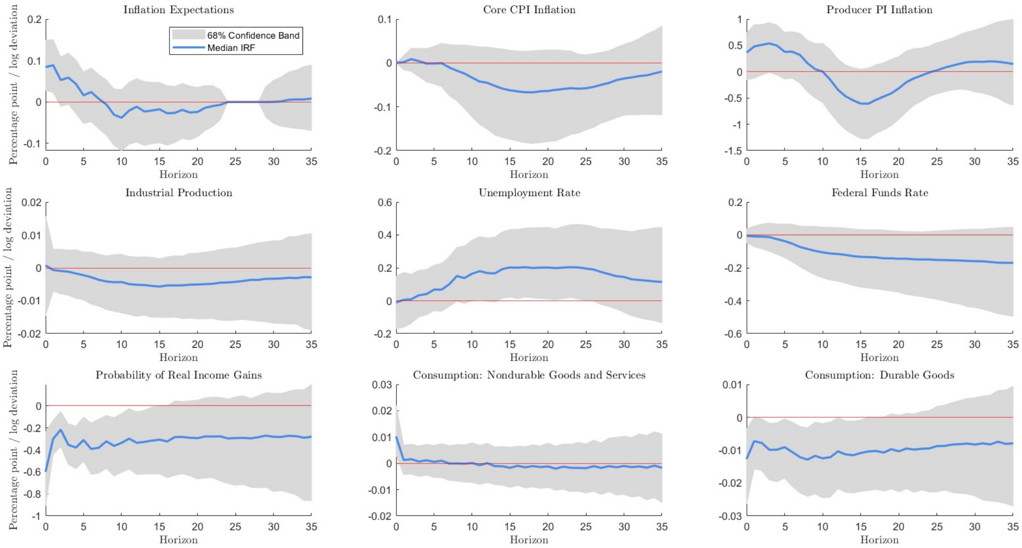

Figure 10: IRFs to the negative sentiment shock. SVAR model with core CPI inflation. Baseline identification scheme, restrictions are summarized in Table 2. Sample period runs from December 1997 to December 2022. A blue line depicts the median response, shaded area shows 68% confidence bands.

most months with probability of almost 80%. Although the baseline identification scheme does not restrict either consumer or producer prices to increase in response to a negative sentiment shock, the specification based on core CPI provides evidence that dynamics of PPI inflation exhibits an S-pattern. Specifically, producer inflation rises for a few months and gets the highest level of over 0.5 percentage point at horizon 3 staying above an initial level with probability of more than 80% between horizons 0 and 6. It then starts a downward trend and after PPI inflation reaches the trough of -0.6 percentage point 16 months after the shock, goes back to zero. If I consider a horizon range of 10–20, an event that producer inflation falls relative to a steady state, occurs with probability around 80%.

Under the alternative identification scheme, main findings continue to hold although dynamics of inflation changes, as can be seen from Figure 11. Response of inflation expectations is positive for a few months and turns negative around horizon 10, but now there is no immediate convergence back to a steady state, as it was the case in the specification with CPI inflation. Rather, inflation expectations hover at -0.04 percentage point below the steady state until horizon 18 and then go back when anchoring by the central bank takes effect. The probability of a negative response at most horizons of the 10–18 range is estimated to be nearly 75%. Unemployment rate appears to decline on impact, but begins to rise thereafter and reaches the plateau at -0.19 percentage point at horizon 15 which is 5 months later than

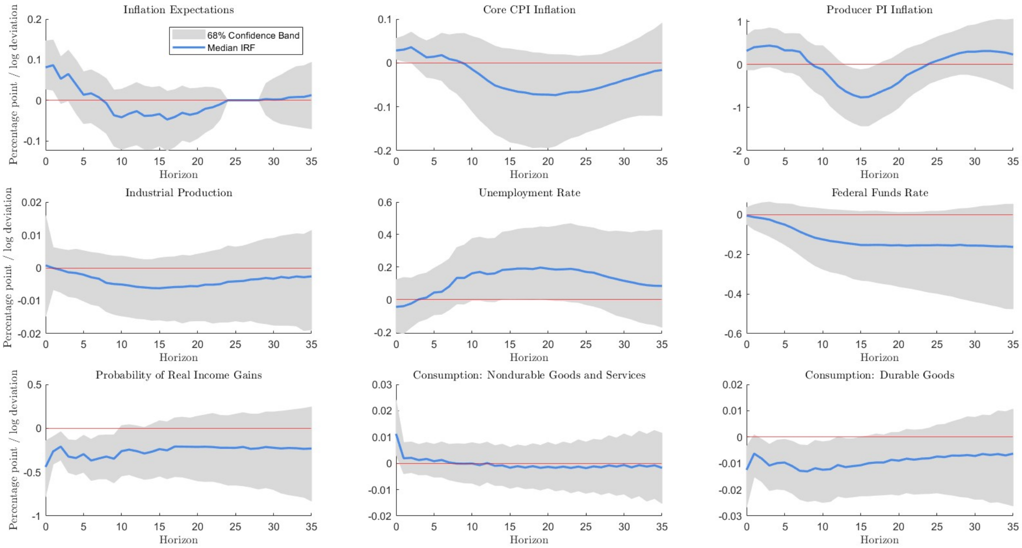

Figure 11: IRFs to the negative sentiment shock. SVAR model with core CPI inflation. Alternative identification scheme, restrictions are summarized in Table 5. Sample period runs from December 1997 to December 2022. A blue line depicts the median response, shaded area shows 68% confidence bands.

in the specification using CPI inflation. The response of unemployment is positive in most periods over horizons 15–25 with probability of more than 85%. Durable consumption decreases such that effects are more persistent: if the largest fall of 1.3% in the baseline occurs on impact, the trough of similar -1.3% with core CPI inflation is recorded at horizon 8. The probability that households cut down expenditure on durable goods at 0–35 horizons, is high – over 90%. Regarding nondurable consumption and industrial production, their responses are broadly similar when using any of two measures of consumer price inflation.

Main differences arise in IRFs of core CPI inflation measure. It goes up on impact and the peak of 0.04 percentage point is reached at horizon 2. Since core CPI inflation is slow moving, its response crosses zero level at horizon 9 – 2 months later than CPI inflation, and continues to fall with the trough of -0.07 percentage point at horizon 21 – 7 months later than CPI inflation. Negative effects are not as easily seen as those in the baseline specification, yet the probability of a decline in core CPI inflation at horizons 15–25 is roughly 80%. PPI inflation responds in a way similar to what was obtained in the baseline specification: peak and trough are, respectively, 0.4 and -0.8 percentage point and observed at roughly the same horizons, and the probability of a decline over horizons 10–20 exceeds 85%. Therefore, both inflation measures follow an S-shaped response, and the changes I found in evolution of core CPI inflation rate are accounted for by excluding most volatile prices from price index.

B.4 Removing Zero Restrictions on Inflation Expectations

Both identification schemes impose zero restrictions on a response of inflation expectations at horizons 24–28 to capture anchoring effects of monetary policy communication. To verify how results depend on enforcing the zero response of inflation forecasts, I completely remove these restrictions from both identification schemes and estimate SVAR with the baseline specification over the period December 1997 to December 2022.

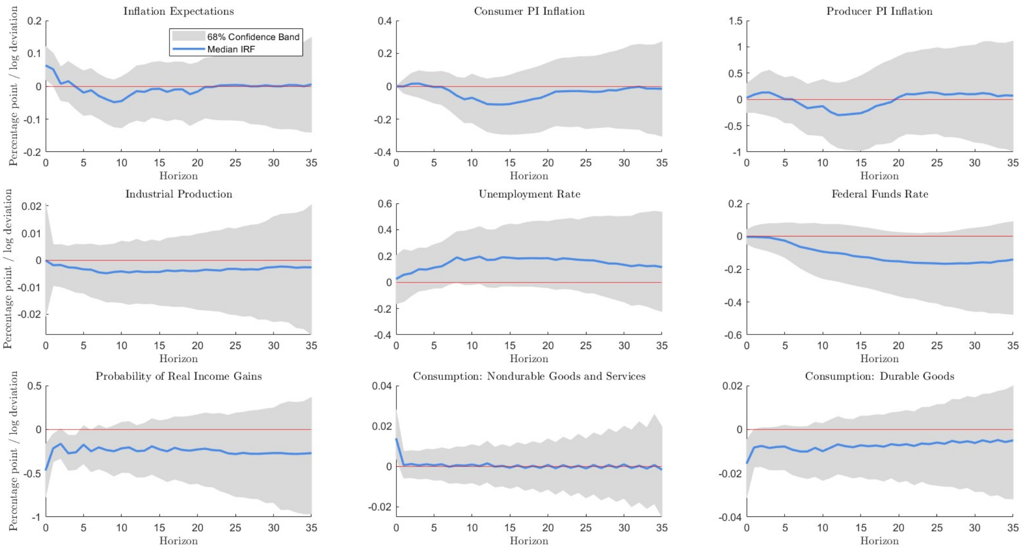

Figure 12: IRFs to the negative sentiment shock. Baseline identification scheme, restrictions are summarized in Table 2 except that zero restrictions on inflation expectations are removed. Sample period runs from December 1997 to December 2022. A blue line depicts the median response, shaded area shows 68% confidence bands.

Figure 12 presents IRFs to a negative sentiment shock under a modified baseline identification scheme. The response of inflation expectations resembles one under the baseline: they increase on impact and quickly start to fall, with the lowest level of approximately -0.05 percentage point below a steady state value around horizon 10. They return to an initial level by horizon 27 – close to horizon 24 when the anchoring effect is assumed to take place in identification schemes, and continue to stay there afterwards. Although the response is unrestricted at horizon 1 and on, it looks like the central bank is indeed able to anchor inflation expectations.

Unemployment rate behaves similarly to its dynamics under the baseline such that it starts increasing gradually and upon reaching the level close to 0.19 percentage point at horizon 11, lingers there for another 12 months. The probability of unemployment rate staying above a steady state level at horizons 10–20 is slightly below 85%. Removing zero restrictions leads to less persistence in a response of durable consumption. Calculating probability corroborates this conclusion: the probability that the sentiment shock has negative effects on durable consumption at horizons 0–35 is down from 90% under the baseline identification to 85%. Industrial production again declines softly, and the trough point happens to be around -0.5%, the same level that was seen before. I do not find any differences in evolution of nondurable consumption. Analysis implies that responses of real quantities are minimally affected.

IRFs of inflation rates provide less pronounced evidence of S-shaped dynamics largely because of wider confidence bands. Even though a zero restriction is imposed on the response of CPI inflation on impact, there are signs that both measures rise for a few months once the shock realises. Specifically, CPI and PPI inflation increase at least in 3 periods over horizons 0–5 with probability around 60% and 65%, respectively. After that, they both dip below zero, and CPI inflation reaches the trough at horizon 14 while PPI inflation does so earlier: this moment shifts from horizon 15 to 12. The magnitude of the trough has also decreased by one third. There is almost a 75% and 63% chance for, respectively, CPI and PPI inflation that they become lower at least in 6 periods over horizons 10–20.

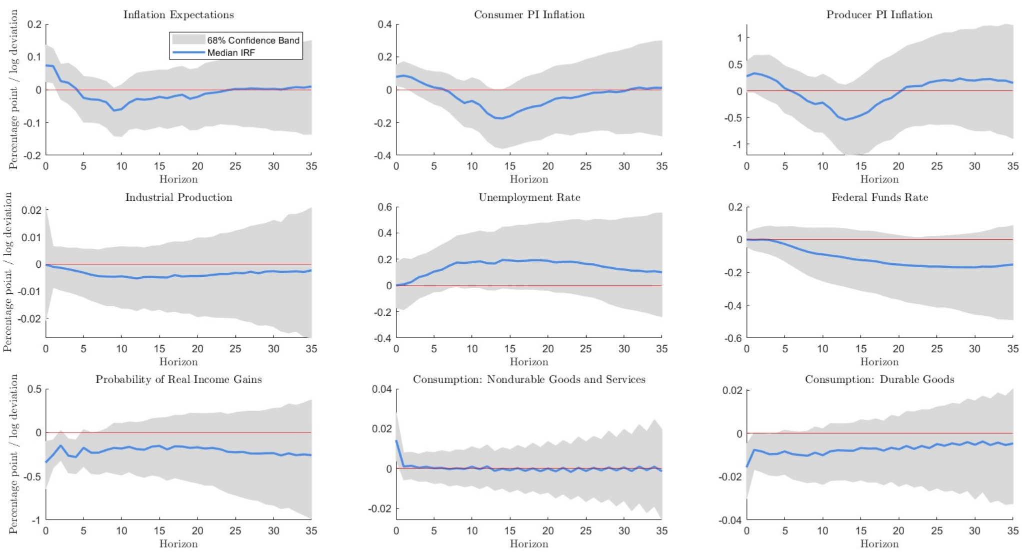

Figure 13: IRFs to the negative sentiment shock. Alternative identification scheme, restrictions are summarized in Table 5 except that zero restrictions on inflation expectations are removed. Sample period runs from December 1997 to December 2022. A blue line depicts the median response, shaded area shows 68% confidence bands.

I also remove zero restrictions on inflation forecasts from the alternative identification scheme and estimate the baseline specification of SVAR. Figure 13 plots IRFs to the negative sentiment shock. As we can see, inflation expectations increase on impact by 0.07 percentage point, and since the response is not persistent, they return to a steady state value already by horizon 4. Inflation forecasts decline further and reach the lowest level of -0.06 percentage point below the steady state at horizon 9. Their response remains negative in 2 or more periods at horizons 8–10 with probability over 80%, almost identical to an estimate under the alternative identification scheme. The response gets back to zero by horizon 25. Note that the moment when inflation forecasts arrive at the steady state agrees well with a horizon 24 used in the alternative identification to specify a period in which inflation expectations become anchored.

Responses of real macro variables qualitatively remain the same. After a gradual rise, unemployment levels off at 0.17–0.19 percentage point from horizon 8 to 24 and subsequently falls. It rises above the steady state over this range of horizons with probability of 85%. Consumption of durable goods is down by 1.5% upon the shock arrival and contracts relative to an initial level up until horizon 35 with nearly 85% probability. The trough of the response of industrial production is -0.5% and occurs 12 months after the shock hits, the probability that it declines across horizons 8–24 is close to 75%. An increase of nondurable consumption by 1.4% is recorded on impact and it is not different from a steady state value at later horizons.

When turning to inflation rates, a similar conclusion can be made that their dynamics also exhibits an S-shape that was uncovered with zero restrictions imposed. CPI inflation peaks at 0.09 percentage point and dips to the lowest level of -0.17 percentage point, PPI inflation shows the same pattern with corresponding figures of 0.33 and -0.55 percentage point. Distribution of responses conveys information about probabilities: the chances of CPI and PPI inflation rising at least in 3 periods over 0–5 horizons are, respectively, 87% and 79% while they fall in 6 or more periods over horizons 10–20 with 80% and 73% probability. To sum up, removal of zero restrictions on inflation expectations does not change evolution of variables in a meaningful way.