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Abstract

This paper studies how inflation expectations are formed, how they are influenced by Inflation-as-a-Bad (IAAB) perceptions, and how these perceptions relate to economic shocks. IAAB perceptions significantly alter inflation expectations, causing spikes, positive bias, and deviations from the Phillips Curve. These perceptions have a distinct impact from canonical properties such as information rigidities, over-reaction, and rationality, which fail to adequately characterize consumer inflation expectations. A model combining rational expectations, information frictions, and consumer heuristics effectively explains the time-variation in the inflation expectations of 365,000 consumers.

JEL classification: E31, D84, E71, E52

Keywords: inflation expectations, inflationary dynamics, aggregate shocks, information rigidities, rationality

1 Introduction

Inflation expectations are important drivers of consumer behaviour, prices and overall economic conditions, influencing factors such as spending decisions, prices, wage setting, and monetary policy (Bernanke, 2007, 2022; Weber et al., 2022). Mishkin and Powell argue that the extent to which overall inflation expectations are anchored has first-order implications for the entire economy (Mishkin, 2007; Powell, 2020). However, although there is a large body of evidence indicating that the price expectations of households are important for their actions, the underlying mechanism for the formation of these expectations remains unclear.

This paper sheds new light on the formation of inflation expectations and the association between expectations and economic shocks, highlighting the importance of inflation as a 'bad' (IAAB) perceptions in intermediating the consumer filtering of economic shocks. I demonstrate that consumers treat aggregate shocks in a materially different manner to readily observable shocks (e.g. oil-prices) and this has significant ramifications for inflation expectations. The premise behind this differential treatment is that consumers can readily observe oil shocks via exchange-rate adjusted petrol prices, whereas it is difficult to ascertain the inflationary expectations of aggregate demand shocks. As such, consumers adopt heuristics associating 'bad' aggregate conditions (e.g. periods of uncertainty and/or negative growth) with high inflation and 'good' aggregate conditions with low inflation, thereby treating inflation and aggregate conditions as if they were negatively correlated. Whereas observable shocks, such as those that directly affect gas prices, induce expectational responses that are consistent with macroeconomic theory, aggregate shocks with uncertain effects on the economy drive a behavioral response associating high inflation to bad macroeconomic outcomes.

The paper makes three primary contributions to the literature. First, in contrast to general or loose statements about IAAB-perceptions, I quantify the impact of IAAB perceptions on beliefs about inflation. IAAB perceptions impact materially on the distribution of inflation expectations, resulting in inflationary spikes, positive bias in expected inflation relative to realized inflation, large shifts in the level of disagreement about future inflation, and expected inflation that periodically deviates sharply from Phillips Curve predictions. In particular, IAAB perceptions are shown to generate sign-dependencies and asymmetries in the impact of shocks that significantly alter the distribution of inflation expectations. In so doing, they generate inflation surprises and large inter-temporal shifts in uncertainty about future inflation, which can impact significantly on household decisions, monetary policy and economic outcomes (Coibion et al., 2021a; Carvalho et al., 2023). IAAB perceptions also introduce positive bias into the expectation formation mechanism, helping to explain the puzzling and ubiquitous presence of positive biases in inflation expectations relative to realized inflation (Andre et al., 2022; D'Acunto et al., 2023).

Second, strong empirical evidence is provided that IAAB perceptions are linked to beliefs about aggregate shocks, with the response of consumers to IAAB-relevant shocks contrasting sharply with the response to typical inflationary shocks. IAAB-related heuristics therefore act as a gateway to better understanding the impact of aggregate income or demand shocks on the formation of consumer inflation expectations. Whereas the response to typical inflationary shocks is heavily characterised by information rigidities, the IAAB-response is faster, asymmetric and induces sharp deviations from the predictions of canonical models of inflation expectations. For example, an unexpected 2% contraction in aggregate demand quickly raises the cross-sectional mean of inflation expectations by 1.6%, whereas an unexpected 2% expansion leads to a minor 0.2% fall in inflation expectations. IAAB-perceptions thereby generate expectations that sharply contradict the Phillips Curve.

The ramifications of IAAB-perceptions extend to the higher-order moments of the cross-section of inflation expectations. In contrast to predictions from canonical models of expectation formation, evidence is provided clearly rejecting the key prediction that shocks generate increased disagreement. Instead, I show that IAAB-perceptions generate state-dependent falls in the level of disagreement in response to unexpected real contractions, but rising disagreement in response to unexpected real expansions. The resulting disagreement differs sharply from that of existing models of expectation formation, and better aligns with the actual time-varying disagreement of consumers.

The presence of an asymmetric reaction of average inflation expectations and disagreement to positive (versus negative) aggregate demand shocks is important, as it strongly rejects previous expectation formation mechanisms. The findings can be contrasted with recent evidence in Fofana et al. (2024), which provides support for the sticky information prediction that both positive and negative shocks raise disagreement. There are, however, salient differences between the latter approach and that adopted in this paper. The first is the presence of data limitations in the surveys they utilize. The Michigan Survey is based on approximately 500 respondents per month, hence limited in its capacity to reflect higher-order cross-sectional moments. The ECB Consumer Expectations Survey and the Survey of Consumer Expectations of US households utilize larger numbers of respondents, but span shorter time periods. (from 2020 for the former and 2013 for the latter). The second is that the relatively short time frame of the latter two surveys renders it difficult to reliably utilize them in econometric analysis. Hence, the local projections undertaken in Fofana et al. (2024) are limited to the Michigan Survey measure of disagreement which, being based on 500 respondents, is likely to provide only a weak representation of the disagreement of US consumers. Fofana et al. (2024) find that disagreement (as measured in the Michigan Survey) rises for both positive and negative shocks (consistent with sticky expectations). The magnitude of the rise, however, is not significantly different to zero, hence it is unclear whether the response is, in fact, positive at all.

Third, I demonstrate that IAAB perceptions are linked to general fears about inflation (Shiller, 1997; Stantcheva, 2024). IAAB perceptions shift upwards in the presence of increased news recall about business profits, supporting the notion that consumers heavily adopt supply side interpretations of inflation, whereby it is believed that firms raise prices in order to support business profits. The latter relationship is also consistent with findings of a significant link between the fear of inflation and the belief that firms are likely to raise prices by more than wages, hence eroding purchasing power (Stantcheva, 2024).

The analysis explicitly examines the capacity of alternative models of expectation formation to match the cross-sectional moments of inflation expectations. I show that alternative expectational frameworks bind the inter-temporal dynamics of the cross-sectional moments of inflation expectations in different ways, such that the cross-sectional moments are informative about expectational parameters and materially assist in distinguishing between alternative models of expectation formation. The cross-sectional distribution of inflation expectations is therefore important for understanding and comparing expectation formation mechanisms.

I therefore propose moment-based methods for evaluating alternative expectation formation mechanisms such as those based on IAAB perceptions, sticky information, diagnostic expectations and rational expectations. Using these methods, the proposed model, which incorporates IAAB perceptions and nests the presence of information rigidities and rational expectations, reliably reflects the time-varying cross-sectional distribution of consumer inflation expectations. In contrast, it is clear that canonical properties such as information rigidities, diagnostic over-reactions, and rationality cannot predict the time-varying distribution of consumer inflation expectations.

To undertake the analysis, a model of the formation of individual price expectations is specified that is characterised by the presence of consumers who interpret inflation as a 'bad'. The model incorporates rational expectations, based on either outdated or updated information, and aggregate shocks that can induce deviations from rationality. These deviations reflect evidence that consumers often employ simple heuristics (viz. Inflation-as-a-Bad) to relate inflation to aggregate economic conditions (Candia et al., 2020; Coibion et al., 2023a; Andre et al., 2022; Aidala et al., 2023). In the absence of IAAB perceptions and information rigidities, the model collapses to rational expectations. The model formalizes the joint impact of IAAB perceptions, information rigidities and rationality on the distribution of inflation expectations, and is used to quantify the inter-temporal response of the distribution of inflation expectations to economic shocks. Evidence from a broader structural VAR is also used to corroborate model predictions.

The model is evaluated using an extensive, novel data set of the weighted model-free moments of the cross-section of inflation expectations of approximately 365-thousand

Australian consumers. The moments are linked to information about monthly inflation, inflationary shocks and real economic conditions. Expectations are weighted by reference to time-varying representative weights for each individual, yielding cross-sectional moments that are always representative of the population of consumers. By incorporating IAAB-type perceptions, the proposed model reliably predicts time-variation in the two most important aspects of consumer inflation expectations: (i) the mean of inflation expectations; and (ii) consumer disagreement about inflation expectations.

In linking inflationary dynamics, IAAB perceptions and inflation expectations, the findings augment a significant body of literature on inflationary dynamics and expectation formation (Galı and Gertler, 1999; Cogley and Sargent, 2001; Cogley and Sbordone, 2008; Castelnuovo and Surico, 2010; Nunes, 2010; Coibion and Gorodnichenko, 2011; Bianchi, 2013; Coibion and Gorodnichenko, 2015; Barnichon and Mesters, 2021). The findings also augment the literature on the drivers of beliefs about prices, with factors such as information rigidities, recent shopping experiences, food and oil prices, news and media reports, policy communications, individual income changes and economic knowledge cited as relevant to the formation of consumer inflation expectations (Brock and Hommes, 1997; Mankiw and Reis, 2002; Mankiw et al., 2003; Bachmann et al., 2015; Kaplan and Schulhofer-Wohl, 2017; Das et al., 2020; Bordalo et al., 2020; D'Acunto et al., 2021; Coibion et al., 2021b, 2022). Finally, by evaluating the joint impact of IAAB perceptions and information rigidities on the deviation from rationality, the paper contributes to research on the role of information asymmetries and cognitive limitations on the expectation formation process (Tversky and Kahneman, 1974; Carroll, 2003; De Bruin et al., 2011; Coibion and Gorodnichenko, 2012; Armantier et al., 2013; Malmendier and Nagel, 2016; Cavallo et al., 2017; Weber et al., 2022).

The remainder of the paper is structured as follows. Section 2 discusses canoninal models of inflation expectation formation. Section 3 describes the consumer data used in the paper, with Section 4 presenting initial evidence from a Structural VAR linking real shocks to the cross-sectional moments of inflation expectations. Section 5 presents a new model of the formation of individual inflation expectations that encompasses IAAB perceptions. Moment-based methods are also proposed to estimate the model directly and to contrast it with alternative expectation formation mechanisms. Section 6 concludes the paper.

2 Canonical models of inflation expectations

Consistent with Coibion and Gorodnichenko (2012), consider the following general data generating process for realized inflation

$$\pi_t = (1 - \rho)\mu + \rho\pi_{t-1} + u_t \tag{1}$$

where μ is steady-state inflation, $\rho \geq 0$ is the stickiness of inflation, and u_t is a zero-mean inflationary shock with variance σ_u^2.

In the basic rational expectations framework, the ith agent's conditional inflation expectation is given by

$$\pi_t^{re}(i) = (1-\rho)\mu + \rho\pi_{t-1}. \tag{2}$$

Across n agents, the cross-sectional mean of inflation expectations under the rational expectations framework is

$$E_t\pi_t(i) = \pi_t^{re}(i) \tag{3}$$

where $E_t\pi_t(i)$ denotes an expectation taken over a cross-section of individuals. Accordingly, the rational expectations framework implies that there is no dispersion or disagreement in consumer inflation expectations.

In the sticky and noisy information frameworks, agents, respectively, either: (i) update their information periodically (leading to information rigidities); or (ii) in every period, extract a signal from noisy information. The resulting dynamics for the cross-sectional mean of inflation expectations follow

$$E_t\pi_t(i) = \beta E_{t-1}\pi_{t-1}(i) + (1-\beta)(\pi_t + e_t) \tag{4}$$

where $\beta = 0$ collapses to the rational expectations model. Although the interpretation of e_t differs in each framework, it is clear that the cross-sectional means follow similar dynamics.[1]

In contrast to rational expectations, the sticky and noisy information frameworks generate dispersion amongst consumer expectations. In the former case, dispersion is associated with the slow diffusion of information whereas, in the latter case, dispersion depends on the difficulty associated with distilling the true price signal in the presence of noise. The predicted dispersions for the two frameworks are, respectively:

$$V_t\pi_{t+1|t}(i)_{sticky} = (1-\lambda)\sum_{j=0}^{\infty}\lambda^j(E_{t-j}\pi_{t+1} - E_t\pi_{t+1|t}(i))^2 \tag{5}$$

$$V_t\pi_t(i)_{noisy} = \beta^2 V_{t-1}\pi_{t-1}(i) + P^2\sigma^2 \tag{6}$$

where $0 \leq \lambda \leq 1$ reflects information rigidities and σ^2 is the variance of an idiosyncratic shock uncorrelated with economic conditions. λ is commonly estimated to be approximately 0.75, whereby only 25% of consumers update their information set in a given

[1] e_t is a rational expectation error in the sticky information framework and a shock common to all agents in the noisy information framework.

period.

Although most papers only deal with the mean and dispersion (or variance) of inflation expectations, the sticky information model also makes endogenous predictions about the higher-order cross-sectional moments of expectations. In particular, the predictions stemming from the sticky information framework imply an association between inflationary shocks and the asymmetry and tail properties of the distribution of inflation expectations (see, further, Appendix A). In contrast, the higher-order cross-sectional moments play no endogenous role in either the standard noisy information or rational expectations frameworks. This also holds for variants of the noisy information model (such as diagnostic expectations), which allow for over-reaction (Bordalo et al., 2018, 2020; Angeletos et al., 2021).

Figure 1 shows the theoretical impulse responses of the cross-sectional moments of consumer inflationary expectations to inflationary shocks of -/+2% under the canonical sticky information framework. To generate the response, an economy of 10 thousand agents is simulated, with λ set to 0.75.[2] The latter value accords with the typical estimate of λ in the existing literature. I set the number of simulated periods to $T = 85$, but amending T does not influence the observed patterns. The k-period-ahead impulse response of the relevant cross-sectional moment is the simulated analogue of $\frac{\partial \pi_{t+k|t}(i)_{sticky}}{\partial shock_u}$ defined as the shift in the moment in response to a shock in period $t = 0$ relative to the case where there is no shock.

An interesting property of the sticky information framework that is readily evidenced by Figure 1 is that it generates rich cross-sectional properties that are rarely examined. Relative to the rational expectations model, the presence of sticky information predicts an under-response to shocks. However, the sign of the response is *always* consistent with the sign of the shock. In the hypothetical case of a positive shock, the cross-sectional mean of inflation expectations only partially responds to the shock, thereby exhibiting a smaller increase than warranted by rational expectations. Under sticky information, the cross-sectional variance rises by reference to the magnitude (rather than the sign) of the shock. Consumer disagreement about expected inflation is therefore *independent* of the sign of the shock, with both positive and negative shocks producing greater disagreement about future inflation. There is no cross-sectional dispersion under rational expectations, hence the higher-order moments of cross-sectional inflation expectations are not defined.[3]

[2] For simulation purposes, steady-state inflation is set to 2.5 per cent in line with the mid-point of the central bank's formal 2%-3% inflation target and $\rho = 0.8$ to characterise the stickiness of annual inflation. The variance of u_t is set to unity.

[3] In the sticky information model, the third and fourth moments also respond to shocks. Given the typical $\lambda = 0.75$, the cross-sectional skewness will typically rise immediately following a positive inflationary shock before dissipating. The initial response of the cross-sectional kurtosis is negative, and thereafter exhibits negative autocorrelation (resulting in the presence of over-correction) before convergence.

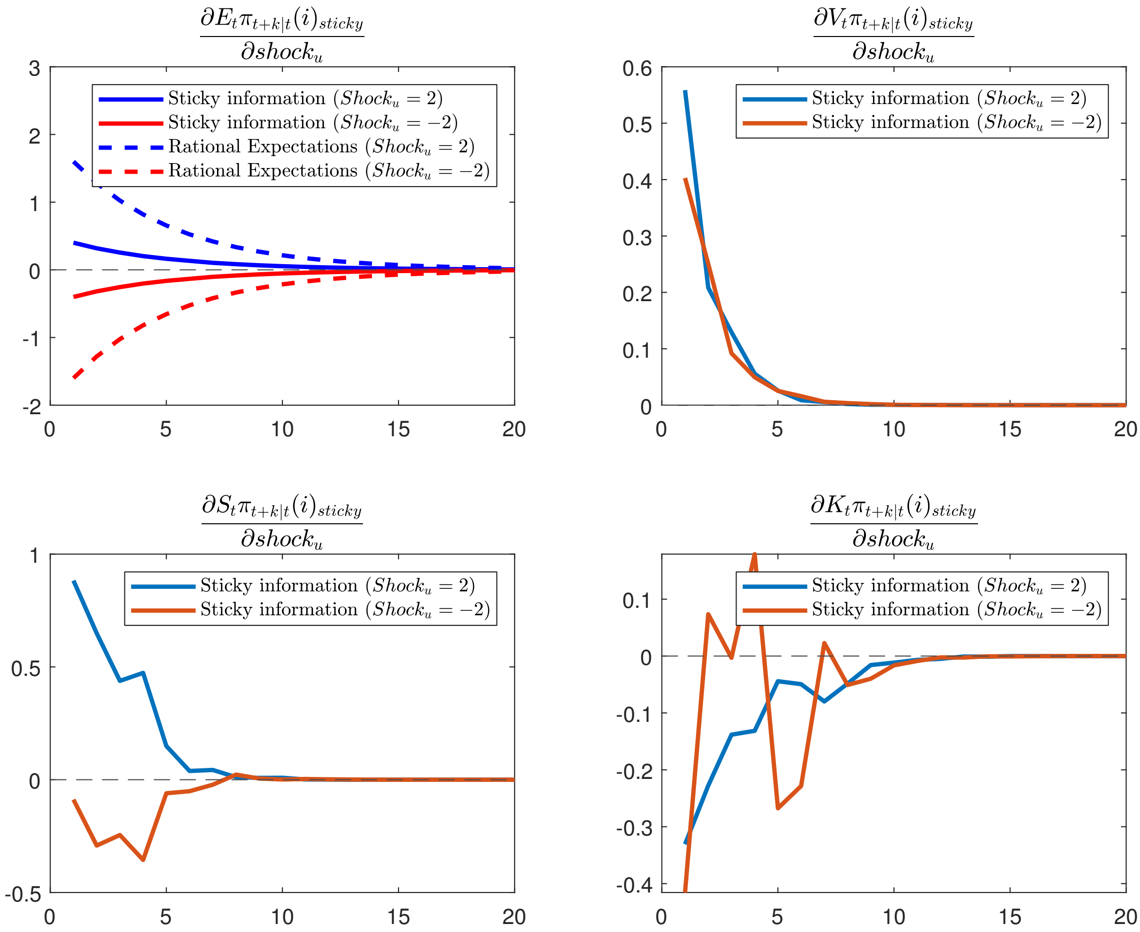

Figure 1: Predicted impulse responses of the cross-sectional mean, variance, skewness and kurtosis of inflation expectations (denoted $E_t\pi_t(i)$, $V_t\pi_t(i)$, $S_t\pi_t(i)$ and $K_t\pi_t(i)$ respectively) to $-/+2\%$ inflationary shocks u_t under the canonical sticky information and rational expectations models. The sticky information response is based on the typical rigidity parameter of $\lambda = 0.75$ such that 25% of consumers update their information sets in each period.

3 Construction of model-free cross-sectional moments

Given the different cross-sectional predictions of models of inflation expectations, it is not possible to reliably evaluate alternative models without first constructing reliable empirical analogues of the cross-sectional properties of inflation expectations. For example, even if the cross-sectional mean of inflation expectations is consistent with the sticky information prediction, this does not imply the satisfaction of the sticky information model (since the predicted higher-order cross-sectional moments may be entirely inconsistent with observed cross-sectional moments). Similarly, it is not possible to evaluate the model proposed in Section 5, and reliably contrast it with alternative expectation formation mechanisms, without considering the extent to which its predictions about the higher-order cross-sectional moments match observed cross-sectional moments.

To evaluate alternative expectational specifications, I therefore construct model-free moments of the cross-section of inflation expectations (from 1995 to 2022). To construct these moments, inflation expectations data are obtained from the Melbourne Institute's Consumer Attitudes, Sentiments and Expectations in Australia survey. The survey is a repeated cross-sectional survey undertaken each month. A key benefit of the survey is the large number of respondents surveyed in every period; at least 1200 respondents (for a population of approximately 25 million) have been surveyed in each month over the period 1995 to 2022. This is critical for the analysis since it enables the construction of accurate model-free moments of the cross-section of inflation expectations for each month over the entire period of interest. Two other important aspects of the survey are that: (i) it relies on a combination of phone interviews and online surveys to ensure targeting of different consumers; and (ii) representative weights are available for every respondent over the entire time period.

Different types of questions have been used in research to measure consumer expectations about inflation. One type asks consumers to think about how prices change (for example, in the Michigan Survey of Consumer Expectations), while another type asks consumers to give numerical values of inflation (for example, the New York Fed's Survey of Consumer Expectations). The analysis in this paper relies on the wording adopted in the Michigan Survey:[4]"*By what percentage do you think prices will have gone up (down) by this time next year?*"

To construct the monthly cross-sectional moments, individual responses about expected percentage price changes are collected from approximately 365 thousand consumers over the period January 1995 to December 2022. Survey weights for each respondent are also utilized. The survey weights are based on household-level decomposition data from the Australian Bureau of Statistics and reflect (time-varying) heterogeneity across factors such as gender, age and location. The weights ensure that the cross-sectional moments are representative of the entire population in every time period. The representative moments can be contrasted with the monthly sample size of 500 used to construct cross-sectional moments for the US in Fofana et al. (2024).

The monthly weighted cross-sectional mean, variance, skewness and kurtosis measures are then directly constructed using the individual survey responses and the associated respondent-specific weights. Before constructing the moments, a negligible proportion of individuals are excluded who report absolute levels of inflation that exceed 100. The truncation bounds of -20 to 50 used in Reiche and Meyler (2022) have also been adopted with unchanged results.

For the cross-sectional mean and variance measures, both untrimmed and trimmed

[4]The issue of appropriate wording has also been considered for the Consumer Attitudes, Sentiments and Expectations in Australia survey used here. In addition to the standard question about the percentage price changes of the goods consumers buy, an additional question has been periodically added to the survey relying on the term 'inflation' in order to determine its impact on survey responses. The primary difference in the impact of the wording is a lower response rate for the inflation question.

weighted measures are considered. Although trimming is not appropriate for the weighted cross-sectional skewness and kurtosis (as extreme values are material for obtaining reliable estimates of both moments), I adopt 10% trimmed versions of the weighted cross-sectional mean and variance measures. The latter trimming helps to identify key trends in the data (20% trimming has also been employed with similar results). However, to ensure that the results are invariant to trimming, I also repeat the analysis with the untrimmed moments, reporting similar results.

The resulting moments, denoted $\pi^e_{1t}, \pi^e_{2t}, \pi^e_{3t}$ and π^e_{4t}, provide representative model-free depictions of the monthly variation in the cross-sectional properties of inflation expectations. These moments are the *direct* empirical analogues of the theoretical cross-sectional moments underpinning canonical models of inflation expectations. Moreover, because the moments are constructed using population weights, they are inherently reflective of the population-wide moments in each time period. Figure 2 shows the monthly moments from 1995 to 2022, highlighting sharp changes in the cross-sectional properties of inflation expectations during periods of significant economic shocks such as the economic downturn in the early 2000s, the Global Financial Crisis, the European debt crisis and COVID. The changes are not limited to the cross-sectional mean of inflation expectations, and extend to other cross-sectional moments, thereby reflecting shifts in both the mean of inflation expectations and disagreement about future inflation during key periods.

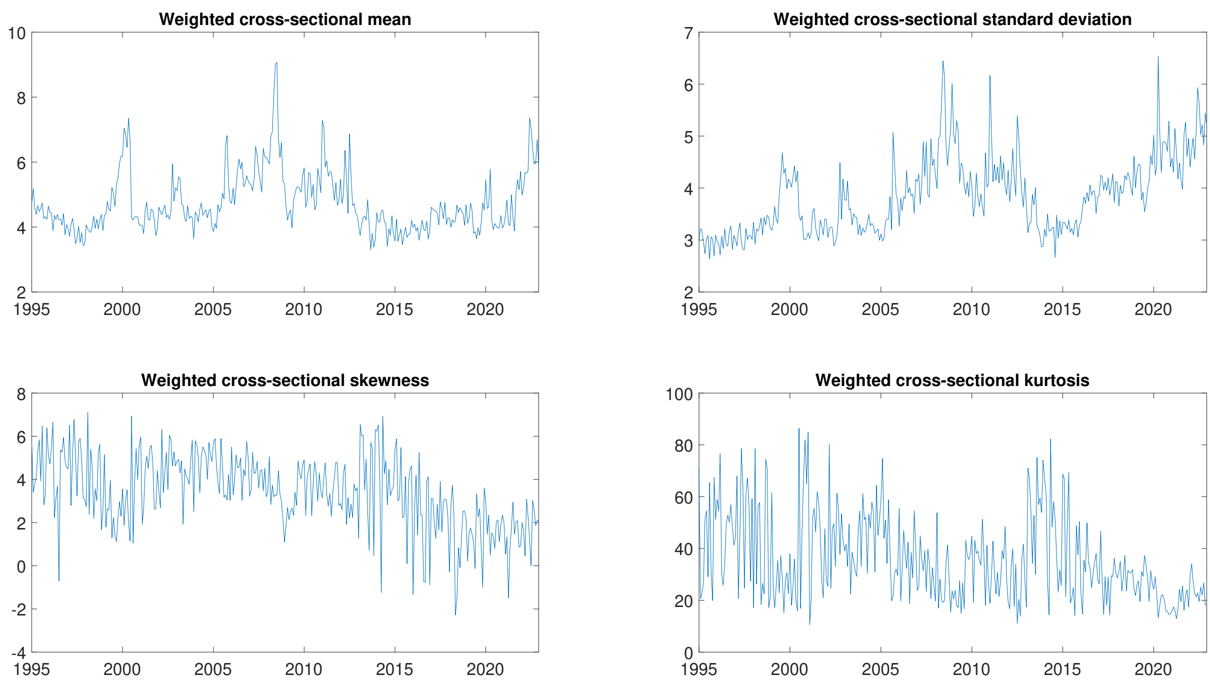

Figure 2: Empirical population-weighted cross-sectional moments of consumer year-ahead inflation expectations

4 Initial results from a Structural-VAR

In this section, a structural-VAR is estimated to examine key predicted features in the underlying data. In the next section, a model combining sticky information with IAAB perceptions is proposed, together with a moment-based method for directly estimating the parameters of the structural model and comparing the proposed expectation formation process to alternative expectational frameworks.

4.1 Data for identifying exogenous shocks

The proposed SVAR incorporates the time-varying cross-sectional mean, variance, skewness and kurtosis of inflation expectations, being the empirical counterparts of the theoretical cross-sectional moments that characterise the predictions of both the proposed model and the sticky information model. The SVAR relies on oil-specific and aggregate demand shocks to understand the propagation of alternative shocks on the cross-sectional distribution of inflation expectations. It is noted that, as shown in Section 2, the evaluation of alternative models of inflation expectations requires consideration of multiple cross-sectional moments, and cannot be undertaken using only the cross-sectional mean.

The contrasting choice of oil-related and aggregate shocks follows from extensive evidence that both realized inflation and the first moment of inflation expectations are highly influenced by oil-related shocks (Coibion and Gorodnichenko, 2015; Wong, 2015; Kilian and Zhou, 2022). These shocks are readily observable by consumers and hence provide a basis for examining the impact of typical inflationary shocks. In contrast, real aggregate shocks that are uncorrelated with oil-related shocks are broader in nature and reflect general economic activity. These two shocks are also incorporated in the structural model, and are discussed further in Section 5. The two sets of shocks in the SVAR are, by construction, uncorrelated.

Identification of the shocks follows Kilian (2009), Kilian and Murphy (2014) and Baumeister and Hamilton (2019) in using data pertaining to global oil supply, oil demand and aggregate demand. Oil supply data (denoted $\Delta prod_t$) is based on changes in monthly world crude oil production provided by the U.S. Energy Information Administration (EIA). Oil demand data (denoted $\Delta price_t$) is based on real US-dollar denominated oil prices constructed by deflating the global WTI spot price using U.S. CPI. Finally, global demand data (denoted rea_t) is based on the global industrial production measure described in Baumeister and Hamilton (2019). The latter measure is derived using a combination of the OECD's index of monthly industrial production and the production of six additional major countries (Brazil, China, India, Indonesia, the Russian Federation and South Africa), reflecting approximately 75% of the IMF WEO estimate of global GDP.[5]

[5] Global oil production data are from the U.S. Energy Information Administration website (`https://www.`

All three variables are measured in growth rates as 100 times the log-difference of their monthly values.

4.2 Structural VAR specification

Consider a structural VAR for $y_t = \left(\Delta prod_t, rea_t, \Delta price_t, \Delta rer_t, \pi^e_{1t}, \pi^e_{2t}, \pi^e_{3t}, \pi^e_{4t}\right)'$, where the first three dependent variables are the global oil supply, global aggregate demand and global oil demand variables described above, Δrer_t is 100 times the change in the real (USD/AUD) exchange rate in period t,[6] and the final four variables are the period t cross-sectional moments of consumer year-ahead inflationary expectations described in Section 3. The variables are observed on a monthly basis over the period January 1995 to December 2022 and the model is given by

$$Ay_t = c + \sum_{i=1}^{P} B_i y_{t-i} + \epsilon_t \tag{7}$$

$$\epsilon_t \sim MVN(0, I_N) \tag{8}$$

where ϵ_t is an serially uncorrelated multivariate normal process with a identity variance-covariance matrix I_N.

The contemporaneous propagation of the shocks ϵ_t is determined by A

$$A = \begin{bmatrix} 1 & & & & & & & \\ a_{21} & 1 & & & & & & \\ a_{31} & a_{32} & 1 & & & & & \\ a_{41} & a_{42} & a_{43} & 1 & a_{45} & a_{46} & a_{47} & a_{48} \\ a_{51} & a_{52} & a_{53} & a_{54} & 1 & a_{56} & a_{57} & a_{58} \\ a_{61} & a_{62} & a_{63} & a_{64} & a_{64} & 1 & a_{67} & a_{68} \\ a_{71} & a_{72} & a_{73} & a_{74} & a_{75} & a_{76} & 1 & a_{78} \\ a_{81} & a_{82} & a_{83} & a_{84} & a_{85} & a_{86} & a_{87} & 1 \end{bmatrix}. \tag{9}$$

In accordance with Kilian (2009), the parameter restrictions in the upper 3-by-3 block of A imply a vertical supply curve for crude oil in the short run. This restriction is consistent with recent evidence based on monthly data that the short-run oil supply elasticity is close to zero (Braun, 2023). The specification for A allows for contemporaneous global oil supply, world aggregate demand and real oil price effects on the moments of Australian

eia.gov/). WTI spot price and U.S. CPI data are from the FRED database website (codes POILWTIUSDM and CPIAUCSL respectively). World oil production data are from Baumeister's website (https://sites.google.com/site/cjsbaumeister/datasets).

[6]The real USD/AUD exchange rate is constructed using U.S. CPI data from the FRED database (code: CPIAUCSL) and Australian headline CPI data from the Australian Bureau of Statistics (with the quarterly index linearly interpolated to monthly).

inflation expectations but reasonably omits the converse effects. The fourth row accommodates exchange rate effects between the global US-dollar denominated variables and Australian inflation expectations.

The matrix A is specified in a manner that is deliberately agnostic about the shock structure for the four moments of inflation expectations such that the results are invariant to the ordering of these moments. y_t is therefore subject to the following shock structure

$$e_t = A^{-1} \begin{bmatrix} oil\_supply\_shock_t \\ aggregate\_demand\_shock_t \\ oil\_demand\_shock_t \\ . \\ . \\ . \\ . \end{bmatrix} = A^{-1}\epsilon_t \tag{10}$$

where e_t are the reduced form errors for y_t.

4.3 Estimating the effects of aggregate demand shocks on the cross-sectional moments of expectations

The SVAR specification yields aggregate demand shocks, which can be readily contrasted with oil-specific demand shocks. The two sets of shocks provide natural empirical counterparts for examining typical inflationary shocks and real economy-wide shocks. The focus is primarily on the impulse responses for aggregate demand shocks, but oil-specific demand shocks are also considered in order to facilitate a comparison.[7] Appendix B shows the impulse responses for the oil production, aggregate demand and oil price variables in response to oil supply, aggregate demand and oil-specific demand shocks.

The sticky information model predicts that the sign of the response of the first and third cross-sectional moments will follow the sign of the shock, whereas the sign of the response of the cross-sectional variance will not depend on the sign of the shock. Accordingly, the cross-sectional mean of inflation expectations is predicted to rise with a positive shock, with the cross-sectional variance predicted to rise for both positive and negative shocks. The model proposed in Section 5 rejects the latter properties and predicts that both the sign and magnitude of responses will differ by reference to the type of shock. In particular, I demonstrate that, in the presence of IAAB perceptions, positive aggregate shocks *reduce* inflation expectations and disagreement (thereby reducing the

[7] The SVAR also estimates oil-supply shocks, although recent evidence indicates that oil price activity is primarily a function of oil-demand shocks, with oil-supply shocks explaining only a relatively small proportion of oil-price activity (Braun, 2023).

cross-sectional mean and variance), but raise the cross-sectional skewness and kurtosis.

Figure 3 shows the response of the cross-sectional moments of consumer inflation expectations to (+1 standard deviation) aggregate demand shocks and oil-specific demand shocks. The results are based on an SVAR(10). However, the SVAR model is estimated with every lag structure from the SVAR(6) to the SVAR(12) to evaluate the sensitivity of the results to the choice of lag. Across alternative lag structures, material differences are not observed in either the estimated shocks or the impulse responses of the four cross-sectional moments of inflation expectations. The figure is based on the adoption of 10% trimmed weighted cross-sectional mean and variance measures of inflation expectations. However, I repeat the analysis using only the untrimmed weighted cross-sectional moments with similar results (Appendix C).

In contrast to canonical models, the estimated impulse response function for the cross-sectional mean indicates that consumers reduce their inflation expectations following an aggregate demand shock, but raise their inflation expectations following an oil demand shock.

A second key characteristic of canonical models of expectation formation lies in the response of the cross-sectional variance to aggregate demand shocks. With sticky expectations, both positive and negative shocks lead to increased cross-sectional variance. With noisy information, the cross-sectional variance is characterised by its autoregressive dynamics, rather than fundamental shocks (Coibion and Gorodnichenko, 2012). Both predicted properties are clearly rejected in the estimated impulse responses, with the variance of inflation expectations falling in response to the positive aggregate demand shock, but rising in response to the oil-demand shock.

A third characteristic of canonical models is the tail behaviour of the cross-sectional moments. In the presence of sticky information, the cross-sectional kurtosis falls as disagreement rises. With noisy or rational expectations, the higher-order moments are unresponsive to shocks. The estimated impulse responses reject such predictions, with the cross-sectional kurtosis rising and disagreement declining in response to the aggregate shock. Moreover, in stark contrast to the impulse responses stemming from aggregate demand shocks, Figure 3 shows that the cross-sectional mean, variance, skewness and kurtosis all rise in response to oil-specific demand shocks.

Overall, the SVAR highlights two fundamental responses of consumer inflation expectations that depend on shock type, identifying sharply contrasting responses to aggregate and oil-specific demand shocks. The results support the presence of a dichotomous response structure, characterized by contrasting responses to oil-specific shocks (being the quintessential type of inflationary shock) and aggregate shocks. In contrast to the clear and persistent rise in inflation expectations for the positive oil-demand shock, the cross-sectional mean of inflation expectations falls in response to a positive aggregate demand shock. In sharp contradiction of canonical predictions, the cross-sectional variance falls following a positive aggregate demand shock but rises following a positive oil-specific demand shock. Consequently, the level of disagreement about future inflation falls in response to aggregate demand shocks, rejecting a key prediction of the sticky information paradigm.

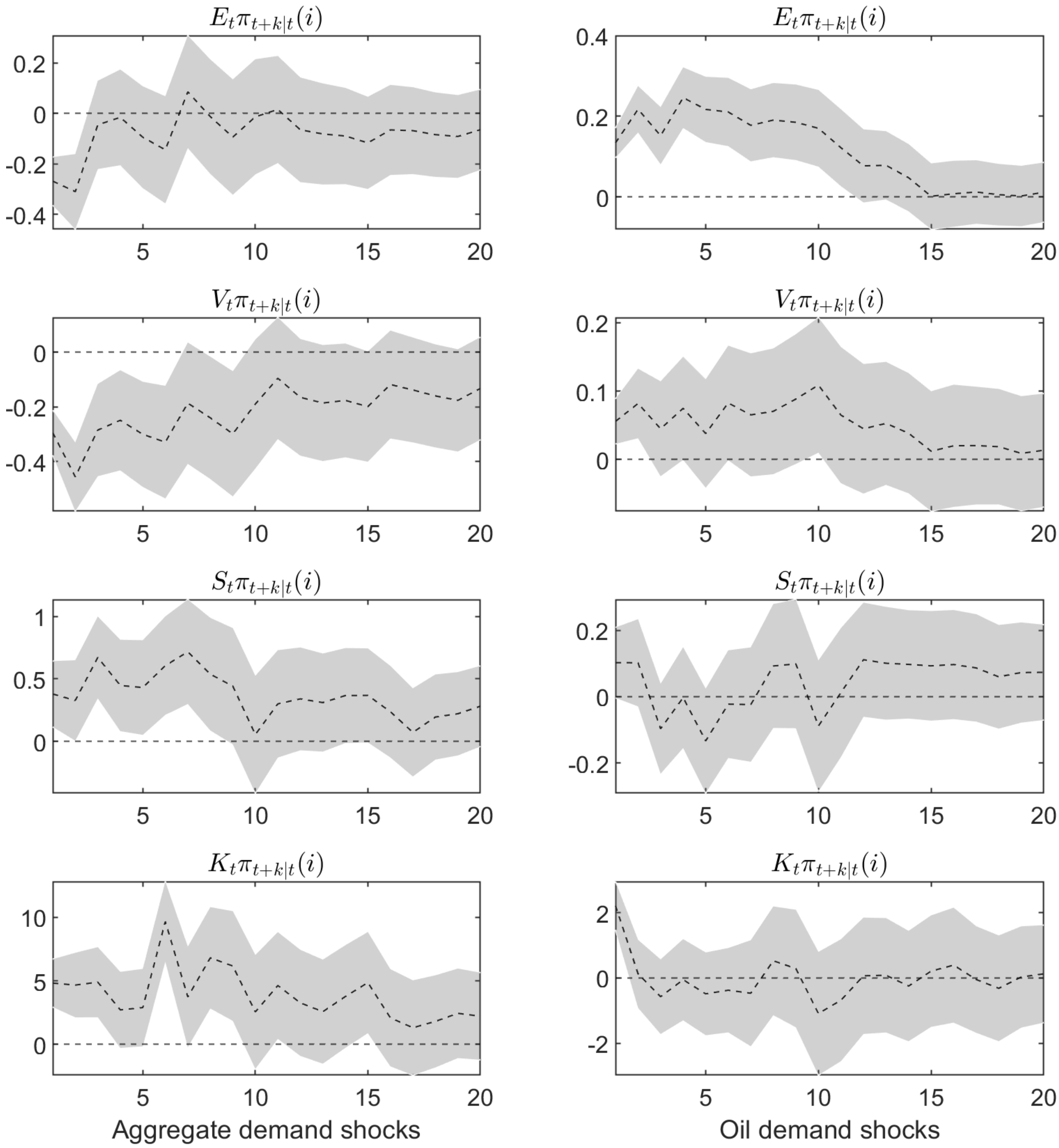

Figure 3: Mean response (with 90% CI) to 1-std. dev. aggregate-demand (left column) and oil-demand (right column) shocks.

5 An model of expectation formation incorporating Inflation-as-a-Bad heuristics

The proposed model of expectation formation augments the sticky information model with features that are consistent with recent evidence that consumers view inflation as a 'bad'. In particular, the model posits that consumers will typically rely on rational expectations, using either old or updated information. However, when there is an aggregate shock, some consumers will deviate from rationality. In terms of the latter, Candia et al. (2020) and Coibion et al. (2023a) provide evidence that consumers become more optimistic about real economic conditions when their inflation expectations fall. Conversely, households who expect higher inflation tend to expect worse economic conditions. Andre et al. (2022) provide evidence that consumers use basic heuristics to form relationships between inflation and wider/aggregate economic conditions.[8] In so doing, they see inflation as a bad and associate it with negative general economic outcomes. Stantcheva (2024) also provides evidence that consumers have a fear of inflation.

Denote the data generating process for realized inflation as $\pi_t = f(\cdot)$, where $f(\cdot)$ continues to be the AR(1) process specified for the canonical model in Eq. 1. Steady-state inflation is therefore given by μ and inflation stickiness is given by ρ. In the canonical model above, agents are potentially influenced by inflationary shocks u_t. These shocks continue to exist in the proposed model.

Assume that there are N agents in a T-period economy. A proportion of agents $1-\lambda$ update their beliefs about inflation in any given period. If agent i belongs to the updating group at time t, then they observe π_t and form expectations about inflation at time $t+1$ using Eq. 2 based on the observed π_t. Conversely, λ represents the proportion of agents who do not update their information. These agents form inflation expectations using Eq. 2 subject to substituting their previous estimate of inflation in place of the observed π_t. This process yields the sticky-information inflation expectations $\pi_t^{sticky}(i)$, $i = 1, 2, ..., N$.

Assume also the presence of a second set of real shocks v_t that are not present in the canonical model. These shocks are motivated by extensive empirical evidence that some agents associate negative aggregate conditions with higher inflation, hence treating inflation as a 'bad'. As a practical distinction between the two types of shocks, consider that u_t represents oil price shocks and v_t represents real aggregate demand shocks. The shocks can also be distinguished in terms of what Broadbent refers to as 'pure demand shocks', which consumers can be more certain about (Broadbent highlights oil prices as a classic example), and other types of demand shocks (Broadbent, 2022).[9]

[8] Aidala et al. (2023) provide evidence of supply-side consumer interpretations of inflation.

[9] Broadbent notes "[t]he response to a pure demand shock...is rather different in this respect. We can be less uncertain about its effects, there's less reason to wait till they actually come through and one would therefore expect a more immediate reaction."

The shock process v_t is uncorrelated with u_t, and reflects broader economic conditions than those for inflationary shocks u_t

$$v_t = N(0, \sigma_v^2). \tag{11}$$

For estimation purposes, shocks v_t are identified as real aggregate demand shocks that are orthogonal to typical oil-price shocks u_t . Positive values of v_t therefore reflect positive economy-wide shocks, with negative values of v_t indicating negative economy-wide shocks. As v_t becomes increasingly negative, a larger proportion of agents become pessimistic about overall economic conditions and deviate from Eq. 2 altogether.

Agents do not deviate from the rational expectation solely because they fail to update their beliefs about π_t (viz. due to sticky information) but also because they no longer adopt a process consistent with $f(\cdot)$ when forming expectations. In effect, their uncertainty about the impact of the negative economy-wide shock overrides their rational or quasi-rational[10] sticky expectation.

The deviation from the sticky information based expectation is represented as a parameter-restricted affine transformation of $\pi_t^{sticky}(i)$. Other representations are also feasible, but the affine representation provides a simply, tractable heuristic for understanding the deviation from sticky (hence rational, albeit with possibly old information) expectations. Pursuant to this transformation, for a sufficiently negative v_t, agents that see inflation as a 'bad' raise their sticky price expectation $\pi_t^{sticky}(i)$, thereby elevating the cross-sectional mean of inflation expectations. Accordingly, in period t, a proportion p_t of agents form expectations using

$$\pi_t(i) = \begin{cases} \kappa + \pi_t^{sticky}(i) & \text{with probability } p_t \\ \pi_t^{sticky}(i) & \text{otherwise} \end{cases} \tag{12}$$

where $\kappa \geq 0$.

The proportion of agents p_t who deviate from $\pi_t^{sticky}(i)$ is given by

$$p_t = \frac{1}{1 + \exp\left[-\gamma_0((-v_t) - \gamma_1)\right]} \tag{13}$$

where $\gamma_0 > 0$ and $\gamma_1 \in \Re$ are parameters governing the sensitivity of agents to v_t. As v_t becomes increasingly negative, a larger proportion of agents become pessimistic about overall economic conditions and deviate from $\pi_t^{sticky}(i)$. I note that the logistic function has been widely used in modelling economic dynamics (Granger and Teräsvirta, 1993; Auerbach and Gorodnichenko, 2012; Caggiano et al., 2014).

The resulting model incorporates the effects of both the failure to update information

[10] The term quasi-rational is used to denote the fact that consumers continue to use $f(\cdot)$ to form inflation expectations, even if they rely on stale information about actual inflation.

(hence sticky information) and the notion of inflation as a 'bad'. It also nests both the conditional and unconditional sticky information and rational expectation models. In particular, if $\kappa = 0$ the model collapses to the sticky information model and agents make predictions based on $\pi_t^{sticky}(i)$ at all time periods. If $\kappa \neq 0$ but $p_t = 0$, the model collapses to the sticky information model at time t but allow for deviations from the sticky information model at other time periods. If $\lambda = 0$, then $\pi_t^{sticky}(i) = \pi_t^{re}(i)$ in Eq. (12), with a proportion p of consumers reacting to shocks v_t in a manner consistent with inflation as a bad and the remainder forming rational expectations. Furthermore, if both $\kappa = 0$ and $\lambda = 0$, the model collapses to the standard rational expectations model.

Figures 4 and 5 show simulated impulse responses of the cross-sectional moments of inflation expectations to inflationary and real aggregate shocks shocks u_t and v_t respectively.[11] In line with the shocks for the sticky information and rational expectations models presented in Figure 1, shocks of $u_t = -/+2\%$ and $v_t = -/+2\%$ are adopted.

If I impose $v_t = 0$ over the simulation period, the impulse responses with respect to u_t are, by construction, identical to the sticky information model (since the model collapses to the sticky information model). However, to provide a better understanding of how the contemporaneous presence of IAAB perceptions influences the impact of a typical shock on the time-varying cross-sectional distribution of inflation expectations, I calculate the impulse responses for a shock to u_t whilst allowing for non-zero aggregate demand shocks. I note that, when computing the impact of a shock to u_t, the values of the aggregate demand shocks are the same both with and without the shock to u_t (hence the latter shock is the only difference between simulations). However, by allowing for non-zero values of v_t (which are orthogonal to u_t), the wider effects of the presence of IAAB perceptions (viz. their effect on the impact of typical shocks over and above their direct effect via aggregate shocks) can be demonstrated.

Consistent with the sticky information model, consumers continue to under-respond to *typical* shocks u_t, resulting in a cross-sectional mean of inflation expectations that is substantially smaller than the magnitude of the shock. Similar to the sticky information prediction, the cross-sectional dispersion of inflation expectations also rises with the magnitude of the shock to u_t. Consequently, for the first two cross-sectional moments, readily observable shocks, such as those for oil prices, induce expectational responses that are consistent with the predictions from the sticky expectations framework.

The responses of the cross-sectional skewness and kurtosis to u_t under the IAAB model, however, differ from those based on the sticky information model.[12] The pres-

[11] To construct the impulse responses, I set $\kappa = 5$ in line with the $\kappa \geq 0$ restriction, whereby IAAB perceptions raise expected inflation. I also set $\gamma_0 = 0.75$ and $\gamma_1 = 4.0$ such that the proportion of consumers forming IAAB perceptions rises with increasingly negative shocks. σ_v^2 is set to unity. The remaining parameters are the same as those used to generate the impulse responses in Section 2 (viz. steady-state inflation of 2.5 per cent, $\rho = 0.8$ and $\sigma_u^2 = 1$). I note that adopting different values for γ_0 and γ_1 influences the simulated impulse responses but does not change the overall interpretation.

[12] In contrast to sticky information predictions, the cross-sectional skewness does not depend on the sign

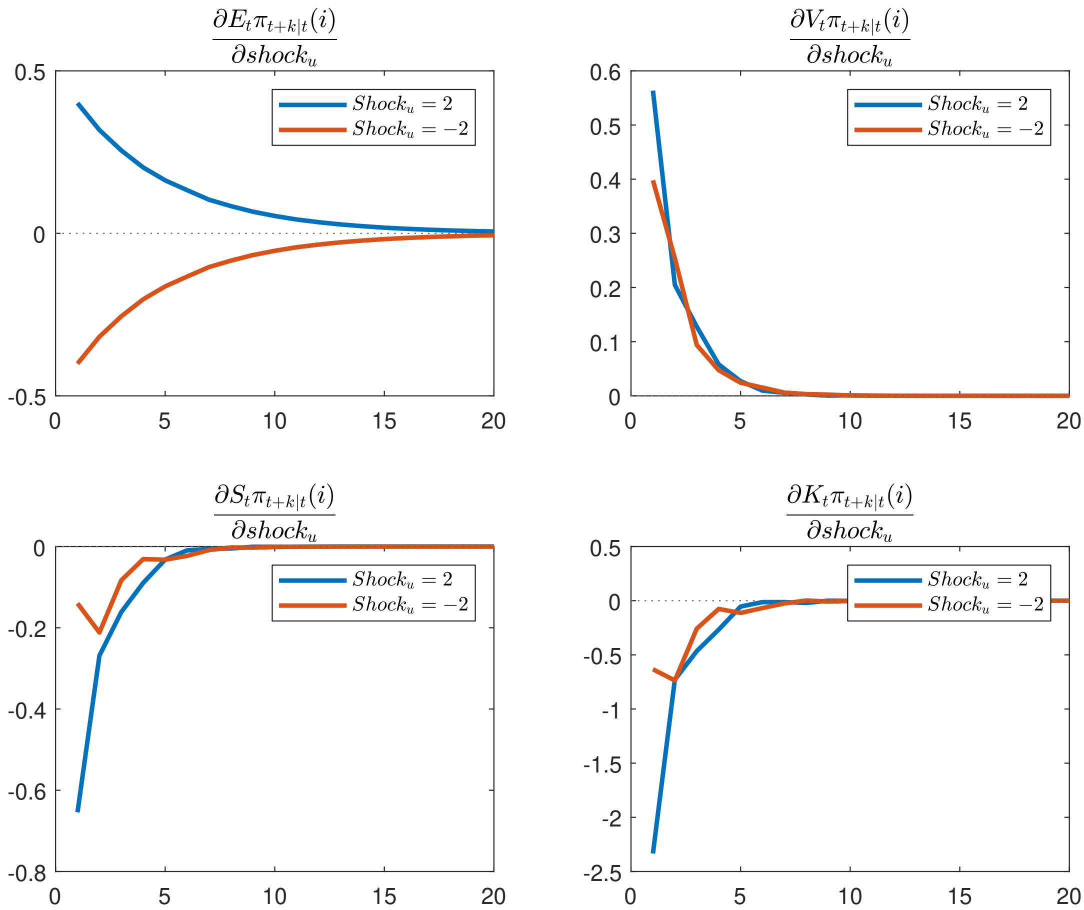

Figure 4: Predicted impulse response of the cross-sectional mean, variance, skewness and kurtosis of inflation expectations (denoted $E_t\pi_t(i)$, $V_t\pi_t(i)$, $S_t\pi_t(i)$ and $K_t\pi_t(i)$ respectively) to a $-/+2\%$ shock to typical inflationary shocks u_t under the IAAB model. The response is based on the typical rigidity parameter of $\lambda = 0.75$ such that 25% of consumers update their information sets in each period.

ence of IAAB perceptions therefore alters the higher-order cross-sectional moments of inflation expectations. The impulse responses for the cross-sectional skewness and kurtosis show lower levels of autocorrelation relative to the sticky information model, and converge to zero considerably faster than that implied by sticky information. A typical oil price shock, for example, has a larger immediate impact on the tails of the cross-sectional distribution of inflation expectations (relative to the sticky information model), but the impact of the shock on the tails of the distribution is less persistent (subsisting for around five periods, compared to around 10 periods for the sticky information model and zero periods for rational expectations). This is because some consumers continue to form expectations that deviate from the sticky expectation $\pi_t^{sticky}(i)$, even when the magnitude of v_t is small

The impact of real aggregate demand shocks v_t is clearly distinct from that of typical shocks u_t, and it is in this impact that the IAAB model primarily differs from the sticky ex-

of u_t, with cross-sectional skewness falling for both positive and negative shocks.

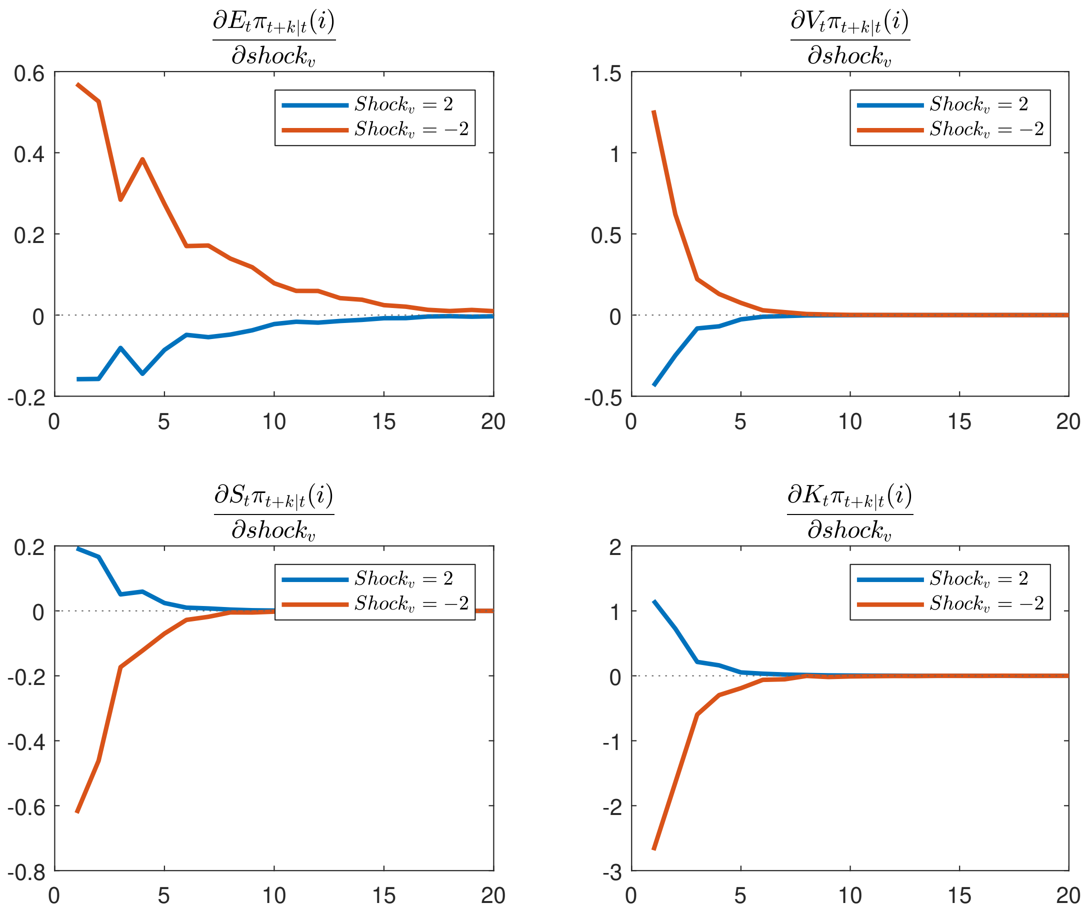

Figure 5: Predicted impulse response of the cross-sectional mean, variance, skewness and kurtosis of inflation expectations (denoted $E_t\pi_t(i)$, $V_t\pi_t(i)$, $S_t\pi_t(i)$ and $K_t\pi_t(i)$ respectively) to a $-/+2\%$ shock to real aggregate demand shocks v_t under the IAAB model. The response is based on the typical rigidity parameter of $\lambda = 0.75$ such that 25% of consumers update their information sets in each period.

pectations paradigm. Consistent with the treatment of inflation as a bad, consumers raise their expectations when $v_t < 0$. Hence the cross-sectional mean of inflation expectations rises with negative shocks to v_t, but falls with positive shocks to v_t. The impact of shocks to v_t is therefore the opposite of that for u_t (and therefore the opposite of that predicted by models based on the presence of sticky or noisy information). Moreover, in contrast to the sticky information or noisy expectations predictions, the cross-sectional disagreement about inflation depends on the sign of the aggregate shocks v_t; negative aggregate shocks raise the level of consumer disagreement about future inflation, whereas positive shocks reduce the level of disagreement.

The expectation formation process is therefore uniquely characterised by two sources of disagreement. The first source is about typical inflationary shocks u_t, which raise disagreement about expected inflation irrespective of the sign of u_t. The second source depends on the sign and size of aggregate shocks v_t, which increase (decrease) the level of disagreement when $v_t < 0$ ($v_t > 0$). The evolution of the cross-sectional skewness and kurtosis to aggregate shocks v_t is also sign dependent (whereas the responses of the cross-sectional skewness and kurtosis to typical shocks u_t are not).

A key feature of the proposed model is the sign-dependence of expectations on v_t, with all cross-sectional moments exhibiting a shock-dependent path that varies for positive and negative aggregate shocks. The sign of v_t is important not only for the sign of the impulse responses, but also for the size of the responses. In the presence of IAAB perceptions, negative aggregate shocks have a much larger impact on inflation expectations than positive aggregate shocks of the same magnitude. The model therefore accommodates adverse over-reaction to negative aggregate shocks. For example, the absolute response of the cross-sectional mean is much larger for negative shocks than positive shocks, as is the level of disagreement (with consumers more likely to disagree about the impact of negative shocks than positive shocks), leading to large differences in the expectation formation process relative to canonical models of expectation formation.[13]

5.1 Estimating the structural model

The IAAB model and alternatives such as the sticky information model yield predictions about the cross-sectional moments of inflation expectations. Since the predictions from the expectational frameworks govern the inter-temporal dynamics of the cross-sectional moments, an estimator based on the comparison of actual and predicted cross-sectional moments is sensible from both a theoretical and statistical perspective.

While it is possible to obtain estimates of the information rigidity parameter using regression specifications of the form

$$\pi^e_{1t} = c + \rho\lambda\pi^e_{1,t-1} + (1-\lambda)\pi^{re}_t + e_t, \tag{14}$$

such specifications do not account for information that is embedded in other cross-sectional moments, such as π^e_{2t}, π^e_{3t} and π^e_{4t}. Moreover, such specifications are uninformative about other expectational parameters such as those pertaining to IAAB perceptions.

To account for higher-order cross-sectional information that is present in the data, model parameters are estimated, and model comparison is undertaken, using a method of moments approach based on solving for

$$\arg\min_{\lambda,\kappa,\gamma_0,\gamma_1} \sum_{t=1}^{T} e_t'\Sigma^{-1}e_t \tag{15}$$

where e_t is a column vector containing the residuals between the actual moments

[13] Similar sign-dependent properties are also observed for the cross-sectional skewness and kurtosis, with consumers substantially more likely to form extreme inflation expectations following a negative aggregate shock that a positive shock of the same size.

$\pi^e_{1t}, \pi^e_{2t}, \pi^e_{3t}$ and π^e_{4t} and the predicted moments $\hat{\pi}^e_{1t}, \hat{\pi}^e_{1t}, \hat{\pi}^e_{1t}, \hat{\pi}^e_{1t}$. Σ is a matrix containing the unconditional variances of the actual moments on its diagonal.[14]

To understand the difference between estimates based on Eq. (14) and those based on Eq. (15), the basic information rigidity parameter λ is estimated for the sticky information model using both approaches. Using the former approach, I obtain a rigidity of $\hat{\lambda} = 0.743$ for Australian consumers, which is effectively identical to the typical 0.75 estimate of the information rigidity of US consumers. This estimate of rigidity, however, does not minimize Eq. (15). When the latter is minimized for the sticky information model, thereby accounting for information in other cross-sectional moments, $\hat{\lambda} = 0.820$, indicating materially greater information rigidities.

To estimate the parameters of the proposed model using Eq. (15), monthly estimates of annual realized inflation π_t and aggregate demand shocks v_t are required. The former are used to generate the dynamics of realized inflation in Eq. (1) and the latter are used to determine the shocks in Eq. (13). For annual realized inflation, year-end inflation is obtained from the Melbourne Institute Monthly Inflation Gauge over the period August 2003 to December 2022. Monthly aggregate demand shocks v_t over the same time period are obtained from the SVAR model estimated in Section 4. The correlation between the two sets of shocks is -0.034 ($p = 0.599$) hence the two sets of shocks are effectively orthogonal to each other.[15] To account for two extreme outliers in v_t during COVID, v_t is first standardized before setting its values in March 2020 and April 2020 to -3. During these two months, aggregate shocks reached unprecedented levels (of approximately -8 and -5 times the standard deviation of v_t respectively). This approach is equivalent to that adopted in Lenza and Primiceri (2022), whereby variance shifts are imposed during COVID in order to facilitate parameter estimation.

The unconditional mean and stickiness of realized annual inflation are set to their least squares estimates ($\rho = 0.95$ and $\mu = 2.5$). The variance coefficient σ^2_u is set to 0.35 using the variance of the least-squares residuals from the estimation of Eq. (1) on realized inflation. Without loss of generality, the unconditional mean of π^e_{1t} is set to 2.5% prior to estimation.

The minimization of the moment-based estimator in Eq. (15) yields $\hat{\lambda} = 0.85$, indicating significant rigidities with respect to updating information about inflationary shocks u_t. For comparison, the estimate of λ using Eq. (15) for the standard sticky information

[14] The minimization of Eq. 15 using Σ yields consistent but mildly inefficient estimates of the model parameters. To alleviate this, a two-step estimation process is also considered whereby, in the second-step, estimation of the parameters is undertaken after replacing Σ with the variance-covariance of the estimated residuals. The resulting estimated cross-sectional moments and impulse responses are similar in both cases, hence discussion is limited to the results based on a diagonal Σ.

[15] The OLS estimation of the AR(1) process in Eq. (1) after augmenting with aggregate shocks v_t from the SVAR specified in Section 4 yields a test statistic of -0.5252 ($p = 0.599$) for the null hypothesis that the coefficient on v_t is equal to zero. Although v_t is a generated regressor, under the zero null hypothesis, the estimated standard error is consistent and the resulting test statistic remains valid (Pagan, 1984).

model yields $\hat{\lambda} = 0.82$. Hence, both approaches highlight significant information rigidities with respect to updating u_t. Both estimates are also higher than the 0.743 obtained using the typical approach in Eq. (14).

For IAAB expectations, the minimization of Eq. (15) yields estimates $\gamma_0 = 0.75$, $\gamma_1 = 6.67$ and $\kappa = 20.58$. The estimates indicate that, in addition to basic sticky expectations, individuals materially raise their inflation expectations in the presence of increasingly negative aggregate demand shocks. To interpret the κ, γ_0 and γ_1 parameters, which characterise the IAAB properties of the model, two measures are considered. The first (in Figure 6) quantifies the time-varying impact of IAAB-type expectations on the cross-sectional mean of inflation expectations. This quantity is computed as κp_t, where p_t is based on Eq. (13), and shows the *additional* impact of IAAB-type heuristics on the cross-sectional mean of inflation expectations over and above that predicted by the presence of sticky information. The second, in Section 5.2, is to compare the actual cross-sectional moments with those predicted by the proposed model with the sticky information, diagnostic expections and rational expectations models.

Figure 6 shows significant time-variation in the impact of IAAB-type expectations on the cross-sectional mean. Their impact is heavily characterised by episodic spikes in the cross-sectional mean that reflect the consumer response to aggregate contractions. The spikes are extremely onerous in particular periods, rising to 1.5 percentage points. Since the values of κp_t for canonical models (e.g. sticky information, diagnostic expectations, rational expectations) are always zero, it is clear that the presence of IAAB-perceptions materially alters expected inflation. Moreover, since sticky expectations are nested in the IAAB model, the presence of IAAB perceptions induces greater inflation expectations than the sticky information model, particularly during periods of negative aggregate contraction.

5.2 Does the proposed model fit the data?

Table 1 presents the square root of the sum-of-squared errors using Eq. 15 for the proposed model, the sticky information model, rational expectations and diagnostic expectations. Since the proposed model nests both the sticky information and rational expectations models, Eq. 15 is evaluated by minimizing the sum of squared errors after imposing restrictions consistent with the sticky and rational forms.[16] To produce diagnostic expectations, I rely on equation (1) and use the same estimates of ρ, μ and σ^2 as in the IAAB and sticky information models. The resulting model yields diagnostic estimates of expected inflation distributed as $N\left(E_t^{\theta}(\pi_{t+1})(i), \sigma^2\right)$, where $E_t^{\theta}(\pi_{t+1})(i) = \pi_t^{re} + \theta\rho\left(\pi_{t-1} - \pi_{t-1}^{re}\right)$ and θ reflects the extent to which agents over-react to recent news (see, further, Bordalo et al. (2018)). I estimate θ by maximizing the capacity of the model to fit the observed moments

[16] The restrictions are discussed in Section 5.

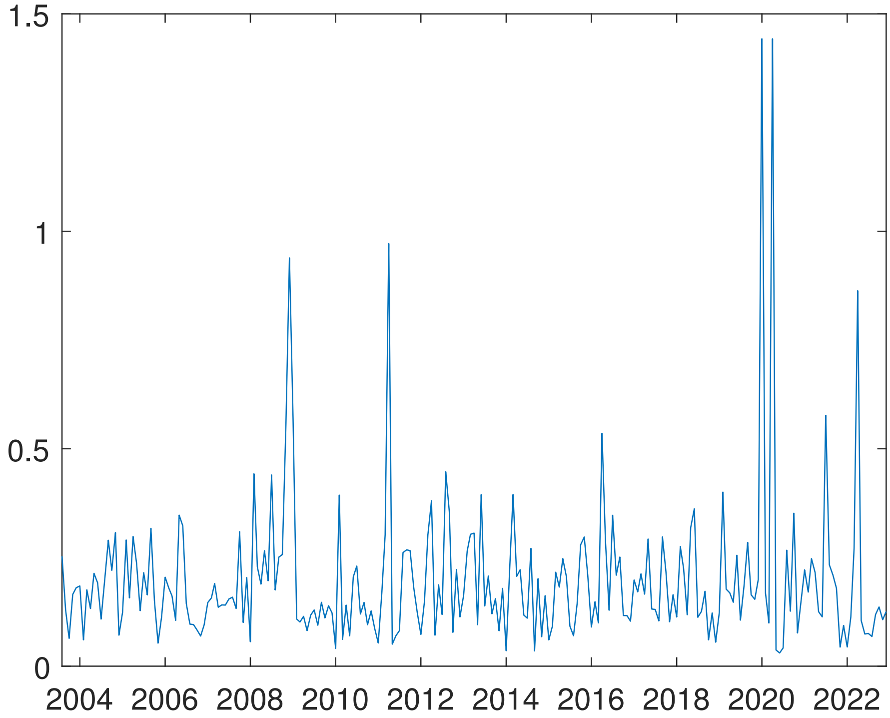

Figure 6: Time-varying percentage point impact of IAAB-expectations on the cross-sectional mean of inflation expectations.

of the data using equation (15). If I restrict θ to the non-negative space, the model yields $\theta \approx 0$ hence producing similar estimates to rational expectations.

The results show a large improvement in the prediction errors associated with the proposed model, with $\sqrt{SSE}$ values that are substantially smaller than those for either the sticky information, rational expectations or diagnostic models ($\sqrt{SSE} = 34.633$ for the proposed model, compared to 63.274 for the sticky information model, 67.095 for rational expectations and 65.305 for diagnostic expectations). The differences in the SSE values also highlight pronounced differences between the actual and predicted moments of the proposed model with those stemming from canonical alternatives.

To provide an alternative perspective on the fit of the models, Table 1 also compares the correlations between the predicted cross-sectional moments and the actual cross-sectional moments. These are denoted as $\rho(\pi^e_{1t}, \hat{\pi}^e_{1t})$ and correlations (based on the Pearson correlation coefficient) are compared for the cross-sectional mean, variance, skewness and kurtosis. The four cross-sectional moments are relevant for the proposed and sticky information models, but only the first cross-sectional moment is relevant for the rational expectations model (which predicts zero cross-sectional variation in the higher-order moments).

All four models produce predictions of the cross-sectional mean of inflation expectations that exhibit a similar level of correlation to the actual cross-sectional mean (with a correlation coefficient of around 0.7). It is clear, therefore, that the fit associated with

Table 1: Comparison of fit

	IAAB	Sticky	Diagnostic	Rational
$\sqrt{SSE}$	34.633	63.724	65.305	67.094
$\rho(\pi^e_{1t}, \hat{\pi}^e_{1t})$	0.716	0.678	0.695	0.695
$\rho(\pi^e_{2t}, \hat{\pi}^e_{2t})$	0.477	-0.110	-0.054	NA
$\rho(\pi^e_{3t}, \hat{\pi}^e_{3t})$	0.108	0.0770	-0.099	NA
$\rho(\pi^e_{4t}, \hat{\pi}^e_{4t})$	0.336	0.315	-0.035	NA

[1.] SSE is the sum of squared errors between the actual cross-sectional moments of inflation expectations and the predicted cross-sectional moments based on Eq. (15). $\rho(\pi^e_{jt}, \hat{\pi}^e_{jt})$ is the Pearson-correlation coefficient between the jth actual cross-sectional moment of inflation expectations and the predicted cross-sectional moment.

the higher-order cross-sectional moments is of primary importance in ascertaining the capacity of each model to reliably characterize the distribution of inflation expectations. A key difference between the models lies in the capacity to model consumer disagreement about inflation. The rational expectations model predicts zero disagreement and is therefore inconsistent with the data. In contrast to rational or diagnostic beliefs, the sticky information model allows for endogenous time-varying disagreement among consumers (via time-varying cross-sectional standard deviations of inflation expectations) and predicts increased disagreement following a shock (irrespective of the sign of the shock). However, it yields predictions about the cross-sectional standard deviation that are negatively correlated with the observed cross-sectional standard deviation (or, alternatively, a correlation that can be interpreted as essentially being close to zero) ($\rho(\pi^e_{2t}, \hat{\pi}^e_{2t}) = -0.11$).

Clearly, neither zero nor negative correlation is satisfactory and the endogenous time-varying disagreement predicted by sticky information is inconsistent with the data. The presence of zero or negative correlation is particularly striking given that a fundamental property and motivating factor for sticky information is that it can generate realistic time-varying disagreement about expected inflation (Mankiw et al., 2003). In contrast, the proposed model produces predictions about cross-sectional disagreement that reliably reflect the observed cross-sectional variation of consumer inflation expectations ($\rho(\pi^e_{2t}, \hat{\pi}^e_{2t}) = 0.414$), improving substantively on the sticky information, diagnostic and rational expectation models.

5.3 Predicted responses

Under the sticky information model, consumers under-react to recent macroeconomic news. This is often a reasonable property, and the proposed model shares the notion of sticky consumer information sets. Nevertheless, sticky information belies the propensity of consumers to react swiftly, often in unexpected ways, to certain information. The proposed model indicates that consumers can also be highly sensitivity to recent macroeconomic news. This sensitivity, however, cannot be captured by the notion of sticky information model since the sensitivity is not a function of the information rigidity parameter λ, nor can it be capture by the assumption of noisy information (both sticky and noisy information produce a cross-sectional mean of inflation expectations characterised by the dynamics in equation 4).

Figures 7 and 8 show the predicted impulse responses for the estimated version of the IAAB model. The former figure shows the response of the cross-sectional moments of inflation expectations to typical inflationary shocks in u_t, with the latter showing the response to real aggregate shocks v_t.[17] Because sign-dependence is a key property of the IAAB model, both positive and negative shocks are considered. The impulse responses to negative shocks in v_t are divided by 2 to facilitate presentation.

The impulse responses to u_t and v_t support the notion that the consumer reaction to economic shocks is highly sensitive to the type of shock. In contrast to the response to u_t, consumers adjust their expectations in the opposite direction of the sign of aggregate shocks, consistent with the presence of heuristic expectations that associate inflation with 'bad' aggregate conditions. Consumers therefore materially raise their inflation expectations following a negative aggregate shock. Relatedly, with increasingly negative aggregate shocks, a greater proportion of consumers adjust their expectations to align with the aforementioned interpretation of inflation as a 'bad'.

The impulse responses also highlight prominent sign-dependent asymmetries in the way consumers respond to shocks. Extreme levels of sign-dependent asymmetry are observed for real aggregate demand shocks v_t, but no asymmetry is observed in the response to typical inflationary shocks u_t. For v_t, consumers raise their expectations in response to a negative aggregate shock by approximately *eight-fold* the size of the reduction in expectations following a positive aggregate shock of the same size. The resulting surge during periods of economic contraction indicates that consumers form beliefs that sharply contradict the underlying premise in the Phillips Curve during critical periods (in other words, consumers form beliefs that are inconsistent with the premise of a positive trade-off between inflation and output). For an unexpected 2% real contraction in global aggregate demand, the cross-sectional mean of inflation expectations rises by 1.6%, versus a 0.2% fall in the cross-sectional mean following an unexpected 2% real expansion in global aggregate demand.

In addition to the sign-dependent asymmetries for the cross-sectional mean of infla-

[17] Since v_t induces time variation in the impact of IAAB consumers, a representative impulse response is obtained by constructing k-period ahead impulses responses produced by the model over ten equally spaced periods over the five years to 2022. The resulting average of the impulse responses is presented. The patterns observed in the impulse responses are insensitive to the dates chosen.

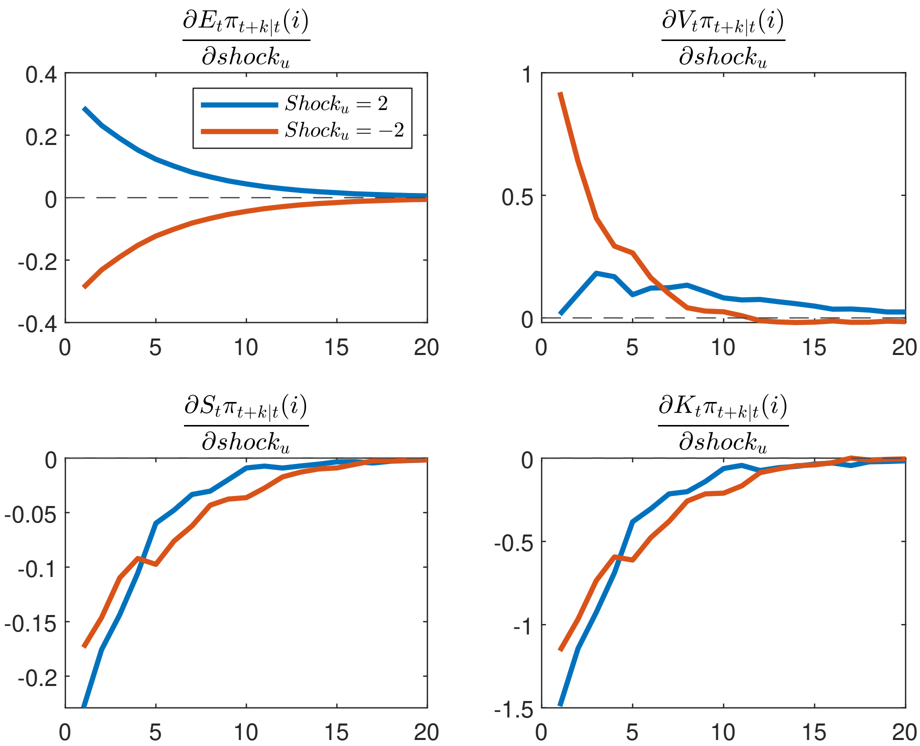

Figure 7: Estimated impulse response of the cross-sectional mean, variance, skewness and kurtosis of inflation expectations (denoted π_1^e to π_4^e respectively) to a -/+2% typical inflationary shock u_t.

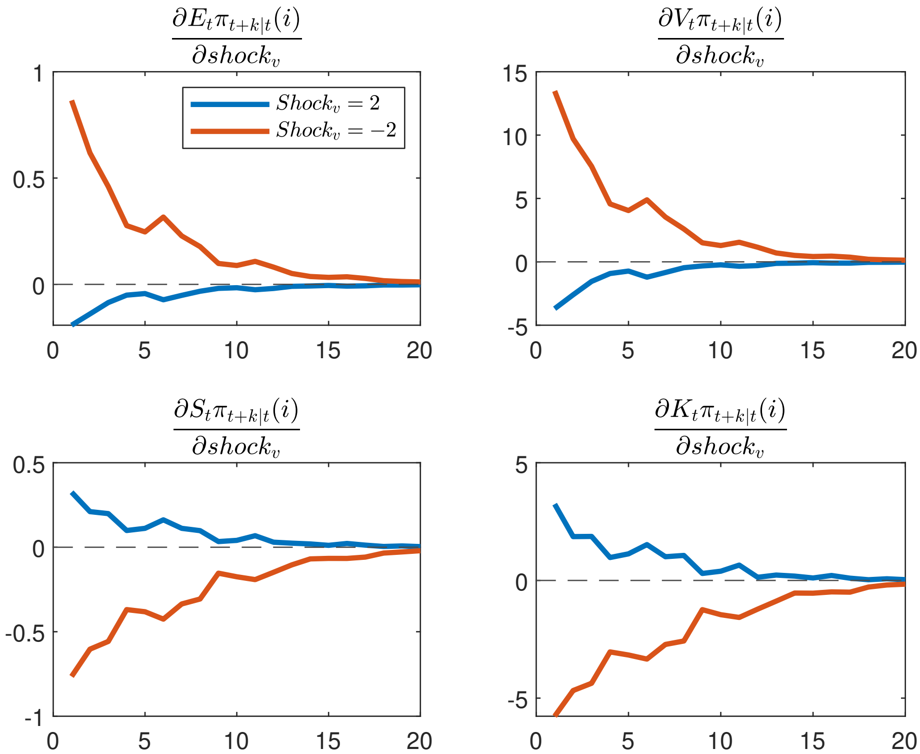

Figure 8: Estimated impulse response of the cross-sectional mean, variance, skewness and kurtosis of inflation expectations (denoted π_1^e to π_4^e respectively) to a -/+2% real aggregate demand shock v_t. Impulse responses when $v_t = -2$ are multiplied by half to facilitate presentation.

tion expectations, the results also support the presence of sign-dependent asymmetries in consumer disagreement about inflation. In contrast to the predictions from sticky or noisy information models, both the sign and magnitude of the response of consumer disagreement to aggregate shocks depend on the sign of the shock. Under sticky information, disagreement rises irrespective of the sign of the shock, with both positive and negative shocks resulting in similar levels of disagreement. Neither of these properties is consistent with the data.

The estimated impulse responses show that consumer disagreement about inflation expectations declines materially following a positive aggregate shock, but rises sharply following a negative aggregate shock. Consumers therefore exhibit greater disagreement about the inflationary effects of negative aggregate shocks. Consistent with the prediction that the sign of aggregate shocks influences both the sign and size of the consumer inflationary response, the size of the increase in disagreement following a negative aggregate shock is greater than the size of the decrease in disagreement following a positive aggregate shock of the same magnitude. Quantitatively, the size of the increase in the cross-sectional variance of inflation expectations following a 2% unexpected contraction in global demand is approximately *five-fold* that of the size of the decline in the cross-sectional variance following a 2% unexpected expansion.

The evidence also strongly rejects the notion that endogenous sources of disagreement (as in the sticky information model) reliably reflect actual disagreement in inflation expectations. The dramatic improvement observed in the capacity to explain disagreement after incorporating information about aggregate demand shocks in the model with IAAB expectations, highlights the importance of the IAAB-type treatment of aggregate demand shocks for understanding the distribution of inflation expectations. The predicted cross-sectional standard deviation of inflation expectations under the sticky information model fails to satisfy the basic condition of a positive correlation with observed cross-sectional standard deviation (with $\rho(\pi^e_{2t}, \hat{\pi}^e_{2t}) = -0.11$). However, the notion of sticky information remains useful and coupling the endogenous disagreement stemming from sticky information sets with information about aggregate demand shocks, yields predictions about consumer disagreement that reliably reflect actual disagreement.

5.4 A comparison to sticky information impulse responses

In addition to allowing for IAAB perceptions, a key property of the proposed model is that it rejects the general notion that positive and negative shocks increase disagreement in a similar manner. Instead, the impact of a shock on disagreement depends on both the type of shock and the sign of the shock. The sticky information model does not allow for such heterogeneity, hence a quantitative comparison of the response to shocks u_t and v_t between the two models is not possible. However, it is possible to focus only on the impact of shocks u_t (that are present in both the proposed and sticky information model), thereby comparing how the accommodation of IAAB perceptions influences the impact of typical inflationary shocks on inflation expectations. As noted for the simulated impulse responses in Section 5 and Figure 4, setting $v_t = 0$ yields the sticky information model, hence yielding identical impulse responses to those predicted using sticky information. However, to demonstrate the impact of the contemporaneous presence of IAAB-perceptions on shocks to u_t (essentially their indirect impact, as opposed to the direct impact of IAAB perceptions via v_t), I follow the same approach used to construct Figure 4 and construct impulse responses to typical shocks u_t, whilst allowing for non-zero values of v_t. Since v_t induces time variation in the impact of IAAB consumers, I present a representative impulse response constructed by producing k-period ahead impulses responses over ten equally spaced periods over the five years to 2022, and adopting the resulting average.

Figure 9 compares the predicted impact of positive and negative shocks u_t on the cross-sectional moments of inflation expectations across the proposed and sticky information models. The two models yield almost identical effects of shocks to u_t on the cross-sectional mean of expectations, with consumers under-responding to inflationary shocks. Introducing IAAB perceptions, however, impacts materially on the relative impact of u_t on the higher-order cross-sectional moments. Given the aforementioned perceptions, significant size-effects are observed in the extent to which disagreement rises following a shock to u_t. In contrast to the predictions from the sticky information model (where the impact of the sign of u_t on consumer disagreement is largely immaterial), a negative shock to u_t (of the same magnitude as a positive shock) raises the level of disagreement by an entire order of magnitude more than a positive shock to u_t. The reason for this is that IAAB perceptions continue to operate in the background, indirectly influencing the cross-sectional distribution of inflation expectations (conversely, switching off IAAB perceptions leads to the same disagreement across both models following a shock to u_t).

The presence of IAAB heuristics also produces significant differences in the impact of typical inflationary shocks on the cross-sectional skewness and kurtosis of inflation expectations. With IAAB perceptions, the cross-sectional skewness and kurtosis tend to decline following a shock to u_t, hence reducing the propensity for extreme inflation expectations. In contrast, the two cross-sectional moments exhibit extreme responses to u_t under the sticky information model. The introduction of IAAB heuristics renders shocks to u_t far less important for the cross-sectional skewness and kurtosis. In the presence of IAAB heuristics, shocks to v_t (viz. real aggregate demand shocks) are primarily responsible for sharp shifts in the cross-sectional skewness or kurtosis of consumer inflation expectations, with shocks to u_t having a considerably smaller impact on the distribution of inflation expectations.

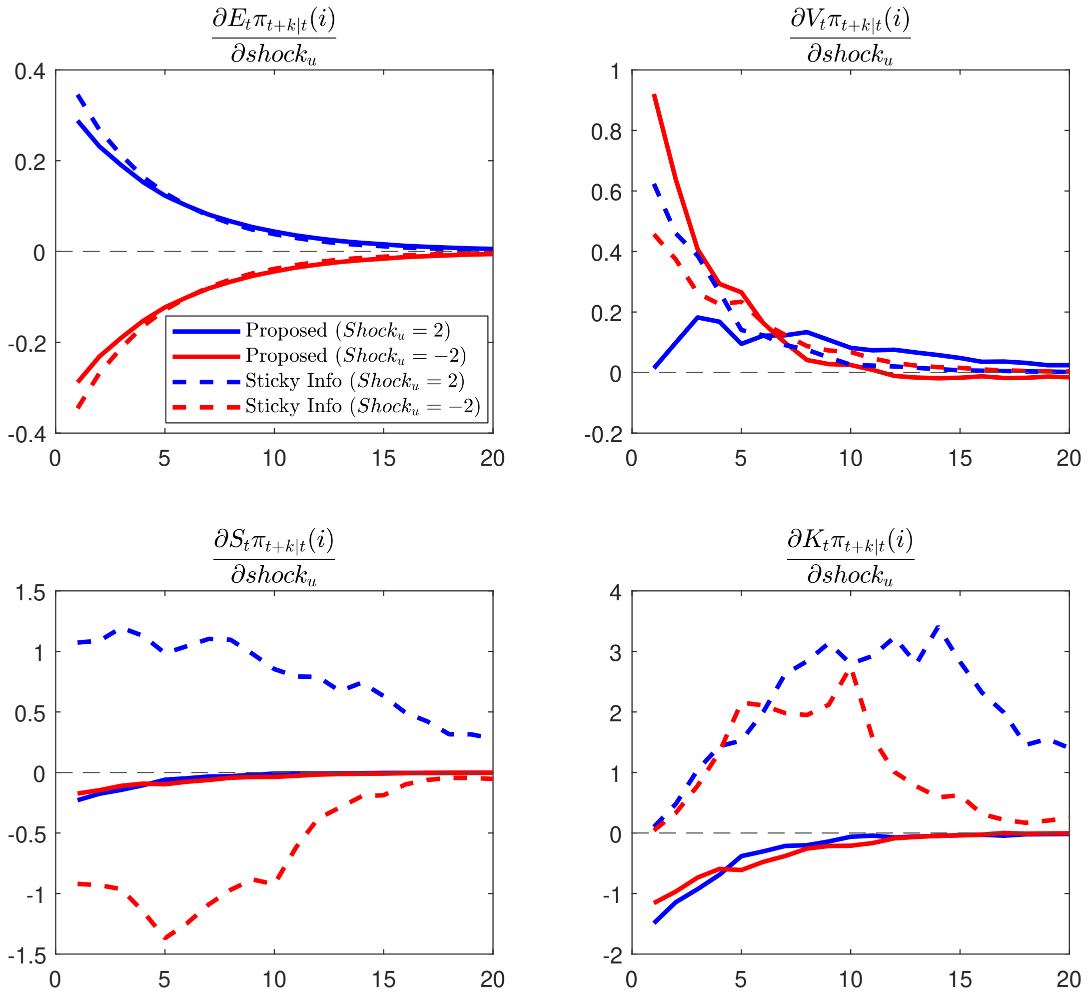

Figure 9: Comparison of estimated impulse responses of the cross-sectional mean, variance, skewness and kurtosis of inflation expectations (denoted π_1^e to π_4^e respectively) to a -/+2% shock to u_t.

5.5 Explaining IAAB perceptions

The significant impact of IAAB perceptions on the cross-sectional distribution of inflation expectations renders them important for understanding the dynamics of inflation expectations (hence for facets of the economy related to inflation expectations such as consumption and monetary policy). To better understand the drivers of IAAB perceptions, I utilize survey information (from the same survey used to generate the inflation expectations data) about unemployment expectations, family finances (relative to a year ago and year-ahead), economic conditions (year-ahead and five-year ahead), buying conditions for major items and economic news. The relevant wording is listed in Appendix D. The first four sets of questions (about unemployment, family finances, economic conditions and buying conditions) are associated with ordinal responses (e.g. better, same, worse). The ordinal responses are used to create consumer indices of unemployment expectations, family finances, economic conditions and buying conditions by calculating the difference between the proportion of positive and negative responses in each period. For example, an unemployment expectations index is constructed using the difference between the proportion of respondents expecting higher unemployment versus that expecting lower unemployment in each survey. Similarly, the household finance (relative to a year ago) index is the difference between the proportion of respondents reporting better household finances and the proportion reporting worse household finances (with the economic and buying condition indices constructed in an analogous manner).[18]

The news variables elicit quarterly information about relevant news that respondents have heard about, categorising the responses by references to the type of news. I focus on economic news about wages, inflation, unemployment, interest rates, the Australian dollar, business profits and general economic conditions, and calculate the proportion of news recall for each of the aforementioned seven categories in the relevant quarter. Because economic news is elicited every three months (in March, June, September and December), the indices above are also constructed in the same months to ensure compatibility.

To relate the above information to IAAB perceptions, I consider the following regression specification

$$\begin{aligned} IAAB_t =& \beta_0 + \beta_1 \Delta unemployment\_expectations + \beta_2' \Delta family\_finances \\ &+ \beta_3' \Delta economic\_conditions + \beta_4 \Delta buying\_conditions \\ &+ \beta_5' \Delta economic\_news + e_t \end{aligned} \tag{16}$$

where $IAAB_t = \kappa p_t$, discussed in Section 5.1 and shown in Figure 6, is the time-varying impact of IAAB-expectations on the the cross-sectional mean of inflation expectations. Δ is the first-difference operator.

The results in Table 2 highlight the importance of longer term economic beliefs, current buying conditions and news about business profits in explaining IAAB perceptions. An improvement in beliefs about *longer-term* economic conditions, hence relatively weaker current conditions, is associated with greater IAAB perceptions, as is the belief that buying conditions will worsen (hence better *current* buying conditions). Increased news recall about business profits materially raises IAAB perceptions, suggesting that consumers anticipate that the likely response of businesses to profit-related concerns is to raise prices. In particular, the estimates indicate that consumers treat news about profits as potential precursors to future price hikes. Consumers therefore adopt supply-side interpretations of inflation, which feed positively into IAAB perceptions. Interestingly, the results suggest that IAAB perceptions are only marginally influenced by specific news about wages, inflation, unemployment, interest rates or the exchange rate, with

[18] For beliefs about year-ahead and five-year-ahead economic conditions, the ordinal responses about 'good times' (bad times) and 'good with qualifications' (bad with qualifications) are bundled together for the purposes of comparing positive and negative responses.

consumers inordinately focusing on news about business profits as an inflationary signal.

Table 2: Parameter estimates for $IAAB_t$

Variable	
Unemployment expectations	0.328
	(0.179)
Family finances (relative to last year)	-0.100
	(0.269)
Family finances (year-ahead)	0.067
	(0.221)
Economic conditions (year-ahead)	-0.430
	(0.251)
Economic conditions (five-years-ahead)	0.646***
	(0.207)
Current buying conditions for major items	0.520***
	(0.180)
News recall (wages)	0.421
	(0.604)
News recall (inflation)	-0.009
	(0.195)
News recall (unemployment)	-0.278
	(0.242)
News recall (interest rates)	0.094
	(0.120)
News recall (Australian dollar)	-0.259
	(0.359)
News recall (Business profits)	0.653***
	(0.229)
News recall (Economic conditions generally)	-0.078
	(0.201)
N	78
Adj. r^2	0.327

1. Standard errors in parentheses. ***/**/* denote significance at the .01, .05 and .10 levels respectively.

The results complement the findings in Shiller (1997) and Stantcheva (2024), who study why people dislike inflation. Using survey evidence between December 2023 and January 2024, Stantcheva finds that consumer aversion to inflation is heavily influenced by the wide-spread belief that it diminishes their purchasing power, with consumers believing that prices rise at a faster pace than wages. The survey results also indicate that many respondents believe that firms often opt to curtail wage growth (relative to the growth of prices) in order to boost profits.

The significance of news recall about business profits on IAAB perceptions supports the US-based survey evidence in Stantcheva (2024), highlighting similar beliefs and fears about corporate activity between the Australian consumers underpinning the results in this analysis and the US consumers in Stantcheva's survey. The results also strongly suggest that IAAB-perceptions are likely to be a general phenomenon, rather than Australian or US specific. Moreover, although the findings in Stantcheva (2024) span a relatively short time period (December 2023 and January 2024), the results in this study span the period 2003 to 2022, suggesting that IAAB perceptions and inflationary fears are general in nature, and are unlikely to hinge on a specific time period.

6 Conclusion

This paper examines the formation of inflation expectations, the role of Inflation-as-a-Bad (IAAB) perceptions and the association of the latter perceptions with economic shocks and the expectation formation process. The proposed model is evaluated using model-free representative cross-sectional moments of inflation expectations based on approximately 365 thousand consumers and their population weights.

New evidence is provided that IAAB perceptions mediate the consumer response to aggregate shocks and materially alter the distribution of inflation expectations. In so doing, they generate spikes in expected inflation, positive bias, large inflation surprises that contradict the Phillips Curve, and sharp shifts in disagreement about future inflation.

A key ramification of IAAB perceptions is that they generate extreme asymmetries and sign-dependencies in expected inflation that depend on shock type and sign. Whereas the effects of negative oil price shocks are consistent with macroeconomic theory, the response to unexpected contractions cannot be explained by canonical models such as sticky information, diagnostic expectations or rationality. In line with induced asymmetries, consumers raise their inflation expectations in response to a negative aggregate shock by approximately eight-fold the size of the reduction in expected inflation in response to a positive aggregate shock.

The impact of IAAB-perceptions is not limited to the first cross-sectional moment of inflation expectations. In sharp contradiction to the predictions from popular expectation formation mechanisms, strong evidence is provided rejecting the notion that consumer disagreement about future inflation increases following a shock. Whereas typical inflationary shocks always yield greater disagreement, I document the dual presence of large falls in disagreement following real aggregate contractions and small rises in disagreement following real aggregate expansions of the same magnitude. The resulting disagreement, which is inconsistent with popular expectation formation mechanisms, closely tracks the actual disagreement of consumers.

The presence of sign dependencies in the impact of shocks contrasts sharply with predictions from existing models and is important for policy-makers and bodies that are concerned with the management of inflation expectations. The results demonstrate, in particular, the importance of accounting for sign-dependencies in understanding the consumer response to aggregate shocks. With negative shocks, inflation expectations are susceptible to sharp surges and increased disagreement, with potentially significant ramifications for consumer spending and savings decisions (Coibion et al., 2023b, 2024).

Finally, I demonstrate a significant association between IAAB perceptions and news about business profits. Consistent with supply-side interpretations of inflation, IAAB perceptions rise in response to news about business profits, highlighting inflationary-related fears about corporate activity, particularly the belief that corporations will raise prices in response to profit-related concerns.

Overall, by incorporating IAAB perceptions, which are strongly associated with consumer fears about inflation, the proposed model reliably explains time-variation in the mean of expected inflation and in disagreement about future inflation. The impact of IAAB perceptions is distinct from that of canonical properties such as information rigidities, over-reaction and rationality, which are shown to inadequately characterise the distribution of consumer inflation expectations. Future research includes placing the IAAB inflation expectation process into a general equilibrium framework in order to understand the wider implications of IAAB beliefs.

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Appendix A Sticky information moments

The predictions stemming from the sticky information framework imply an association between inflationary shocks and the asymmetry and tail properties of the distribution of inflation expectations such that

$$S_t\pi_{t+1|t}(i)_{sticky} = (1-\lambda)\sum_{j=0}^{\infty}\lambda^j \frac{(E_{t-j}\pi_{t+1} - E_t\pi_{t+1|t}(i))^3}{V_t\pi_{t+1|t}(i)^{1.5}_{sticky}} \tag{A1}$$

$$K_t\pi_{t+1|t}(i)_{sticky} = (1-\lambda)\sum_{j=0}^{\infty}\lambda^j \frac{(E_{t-j}\pi_{t+1} - E_t\pi_{t+1|t}(i))^4}{V_t\pi_{t+1|t}(i)^{2}_{sticky}} \tag{A2}$$

where $S_t\pi_{t+1|t}(i)_{sticky}$ and $K_t\pi_{t+1|t}(i)_{sticky}$ reflect the cross-sectional skewness and kurtosis, respectively, of inflation expectations.

Under the sticky information framework, there is a relationship between the impact of a shock on π_{t+1} and its impact on the kth moment of the cross-sectional distribution of inflation expectations such that $\partial E_t\pi_{t+1}(i)/\partial shock_u \propto shock_u$ and $\partial V_t\pi_{t+1|t}(i)_{sticky}/\partial shock_u \propto shock_u^2$, where the shock is defined as a shift from steady-state inflation at time t. Hence, the response of the cross-sectional mean of inflation expectations follows the sign of the shock. Moreover, disagreement about future inflation rises in response to the shock in a manner that is proportional to the magnitude of the shock; hence the dispersion of the cross-section rises in the presence of either positive or negative inflationary shocks.

The partial effect of the shock on the next period's cross-sectional skewness depends on the excess information rigidity present in consumer expectations

$$\frac{\partial S_t\pi_{t+1|t}(i)_{sticky}}{\partial shock_u} \propto (\lambda - \kappa) shock_u \tag{A3}$$

where $\kappa \approx 0.5$.

Finally, the step-ahead response of the cross-sectional kurtosis $K_t\pi_{t+1|t}(i)_{sticky}$ also depends on information rigidity λ and the size of the shock. Small shocks, for example, can produce a larger shift in the step-ahead cross-sectional kurtosis than large shocks. For typical estimates in the neighbourhood of $\rho \approx 0.8$, the response of the step-ahead cross-sectional kurtosis to shocks is negative, broadly following (subject to a constant) $(\lambda - \kappa) shock_u^2$ for smaller absolute shocks and converging to a constant negative value for increasingly larger absolute shocks.

Appendix B Other impulse responses

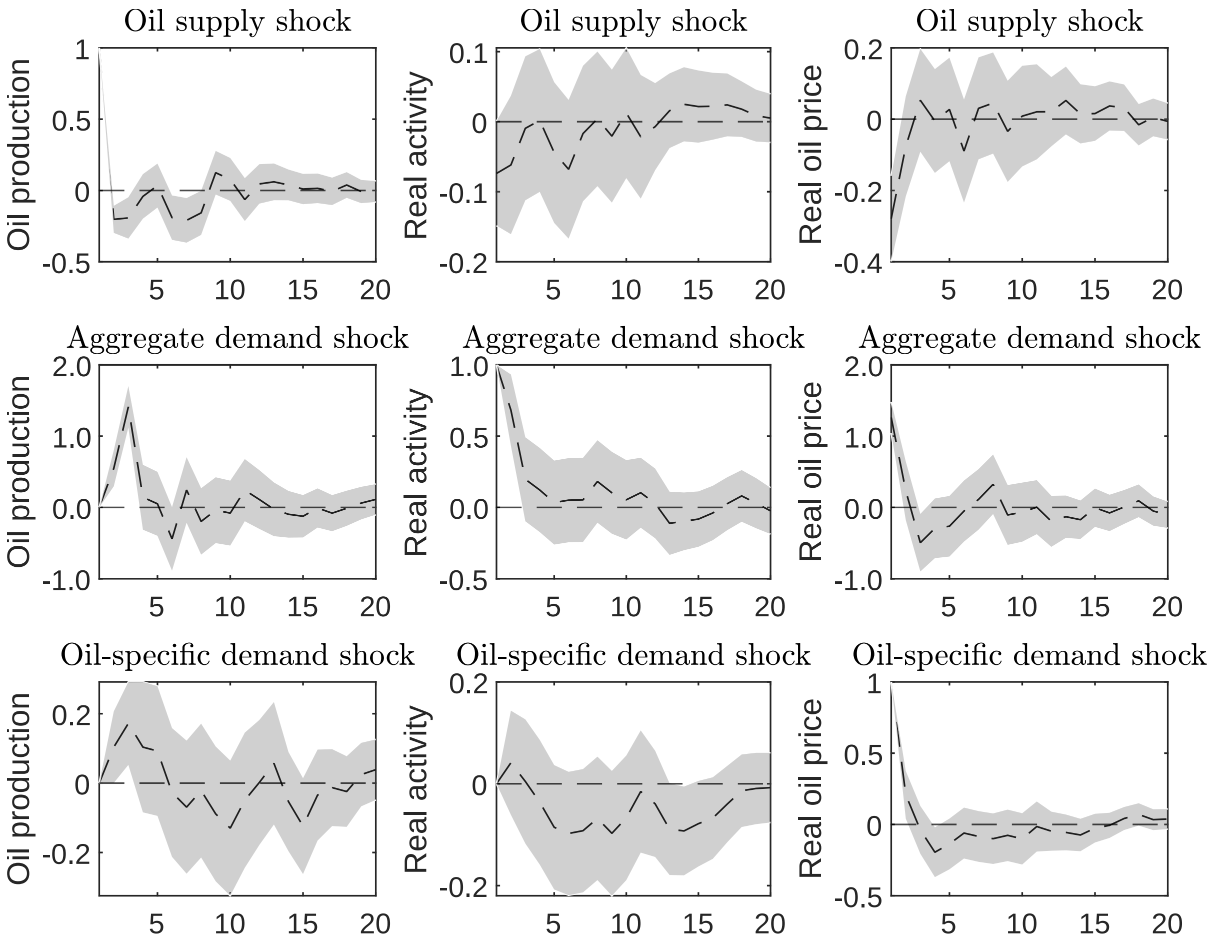

Figure B1: Predicted impulse responses for oil production, real activity and oil prices under the SVAR specification in Section 4.

Appendix C Impulse responses for untrimmed cross-sectional moments

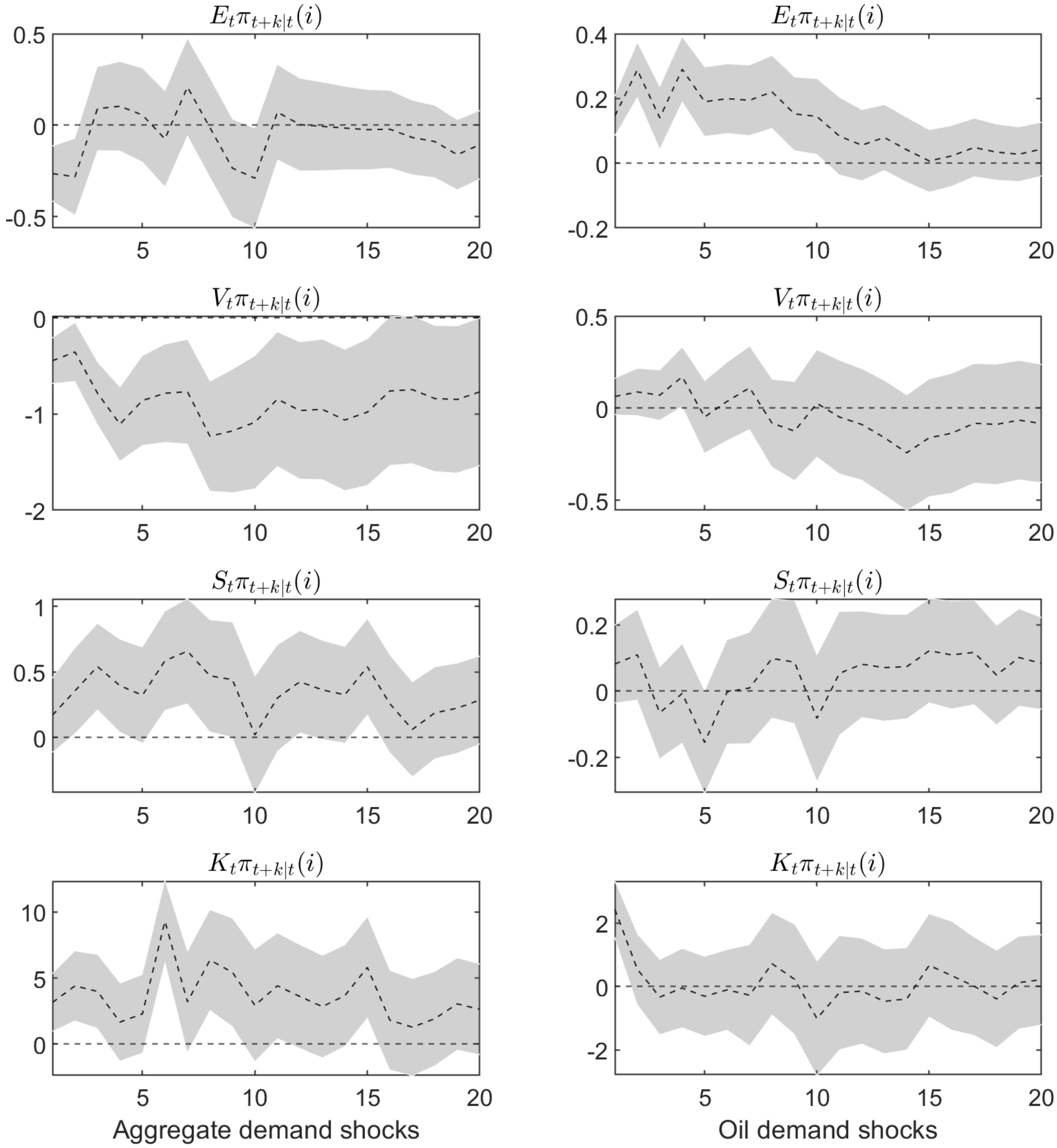

Figure C1: Mean response (with 90% CI) to 1-std. dev. aggregate-demand (left column) and oil-demand (right column) shocks.

Appendix D Survey questions

Would you say you and your family are better-off financially or worse-off than you were at this time last year?"

1. Better-off 2. Same 3. Worse-off 4. Uncertain/Don't Know/It depends

Looking ahead to this time next year. Do you expect you and your family to be better-off financially - or worse-off - or about the same as now?

1. Better-off 2. Same 3. Worse-off 4. Uncertain/Don't Know/It depends

Thinking of economic conditions in Australia as a whole. During the next 12 months, do you expect we'll have good times financially, or bad times, or what?"

1. Good times 2. Good with qualifiations 3. Some good, some bad 4. Bad with qualifications 5. Bad times 6. Uncertain/Don't Know/It depends

Looking ahead, what would you say is more likely? That in Australia as a whole, we'll have continuous good times during the next 5 years or so, or we'll have some bad times - or what?"

1. Continuous good times 2. Good with qualifications 3. some good, some bad 4. Some bad with qualifications 5. Some bad times 6. Uncertain/Don't Know/It depends

Do you think now is a good time or a bad time for people to buy major household items?"

1. Good 2. Some good, some bad 3. Bad 4. Don't know/Uncertain

During the last few months, have you read or heard any news of changes in economic conditions?"

1. Yes 2. No 3. Don't know. (If yes, what in particular, were they about?)

Now about people being out of work during the coming 12 months, do you think there'll be more unemployment than now, about the same, or less?

1. More unemployment 2. About the same/Some more some less 3. Less unemployment 4. Don't know

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