Heterogeneous Attention to Inflation and Monetary Policy*

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Abstract

We study how heterogeneous attention to inflation affects monetary policy transmission. Firstly, we empirically show that households' attention to inflation varies with socio-demographic characteristics. Specifically, using household-level surveys for the US and Australia, we find robust cross-country evidence that both high-income and self-employed households pay higher attention to inflation than low-income and employed households. Given that some prices are salient, we also measure shock-specific attention. Using local projections, we find that attention to oil price shocks is high, with small under-reaction for low-income and employed households in the Australian survey and full attention of all household groups in the US survey. Results for monetary policy shocks differ across countries, with US households overreacting to some monetary policy shock series. Secondly, we study how differential attention to inflation through the formation of inflation expectations affects monetary policy transmission. For this purpose, we introduce a sparsity-based maximization operator into a two-asset HANK model calibrated to match empirical evidence for both countries. Quantitative simulations show that compared to rational inflation expectations, monetary policy faces a worse inflation-output trade-off due to larger indirect effects compared to direct effects. Those effects in a model with inattention manifest through a larger perceived fall in labor income after monetary policy tightening, which leads to a larger fall in consumption despite a weaker intertemporal substitution effect that results from lower perceived real rates.

Keywords: rational inattention, HANK, monetary policy, inflation expectations.

JEL: D84, D91, E21, E71, E52

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1. Introduction

How much attention do households pay to inflation? And does their attention vary with socio-demographic characteristics? Both questions have been of increasing interest in the recent years. Not only economic literature but also policymakers have highlighted the importance of addressing heterogeneity and inattention in economic modeling. In particular, wealth distribution and heterogeneous exposure to shocks play a central role in the transmission mechanism of monetary policy (Auclert, 2019). At the same time, rational inattention substantially changes monetary policy transmission in New Keynesian models (Gabaix, 2020). Hence, it is important to quantify how micro-level dynamics of households' attention to inflation and consumption-saving choices affect macro dynamics.

We address this question by showing that households' attention to inflation varies across cross-sectional characteristics and across oil price and monetary policy shocks. First, we provide new empirical evidence on cross-sectional subjective inflation expectations, using both US and Australian survey data on expectations. We find that high-income households or those who are self-employed pay higher attention to inflation than low-income or employed households. This pattern emerges robustly across a variety of specifications we consider. Second, we estimate attention using externally constructed monetary policy and oil price shocks by running local projections in the vein of Jordà (2005). We find high attention to oil price news shocks in both countries consistent with the evidence that those prices are considered salient. Regarding monetary policy shocks we find different evidence across countries. In the US, depending on the shock series considered, we either can not reject the full information rational expectation hypothesis (FIRE) or we find over-reaction (e.g. for the shock series constructed by Bauer and Swanson (2023)). In the Australian survey, on the other hand, we do not reject FIRE or find under-reaction to monetary policy shocks. For Australia, we also measure attention to foreign monetary policy shocks taken from the US and find that households also under-react to those.

To measure over- and under-reaction or in general deviations from full information rational expectations (FIRE) in microdata, we run regressions of forecast errors on demand side and supply side shocks akin to the regressions in Kučinskas and Peters (2022). However, we also control for a number of socio-demographic characteristics. We apply our method to the consumer survey of expectation from the New York Fed (CSE) for the US and the CASiE survey for Australia. We use a set of monetary policy shocks, namely those of Nakamura and Steinsson (2018), Acosta (2022), Gürkaynak et al. (2005) and Bauer and Swanson (2023) for the US and Beckers et al. (2020) and Hambur and Haque (2023) for Australian monetary policy shocks. To capture supply side effects in our model we use oil price news shocks constructed by Känzig (2021). Subsequently, to estimate the levels of attention households pay to inflation, we extend the framework of Pfäuti (2021) by incorporating a number of household characteristics.

To quantify the effects of our empirical findings on heterogeneous attention, we build a state-of-the-art heterogeneous agent two-asset New Keynesian (HANK) model with rationally inattentive households. We use a two-asset HANK model because two assets are essential to properly assess the monetary policy transmission as shown by Kaplan et al. (2018). To account for the empirically found inattention, we draw on Gabaix (2014) and let households in our model be rationally inattentive, more specifically they have a "sparse" representation of the world and rationally decide towards which prices they want to allocate their limited attention to which in turn affect their inflation expectations. We calibrate our model to match the attention levels of high or low-income and self-employed or employed households found in the data. The model is solved in discrete time using the sequence-space Jacobian method by Auclert et al. (2019). Counterfactual impulse responses show that with inattention in response to monetary tightening demand is weaker due to a larger perceived fall in labor income, and in spite of a subdued intertemporal substitution effect. Households do not fully anticipate the drop in inflation, so they perceive the fall in real wages as larger than it actually is. Thus, they cut consumption by more compared to the FIRE case. Lower perceived interest rates lead to a weaker intertemporal substitution effect. However, it is not large enough to compensate for the indirect effect coming from the decrease in labor income. Flight to liquidity is, however, stronger with inattention amid lower perceived interest rates and especially so in a model calibrated to Australia where the idiosyncratic income risk is larger. The inflation-output trade-off turns out to be worse with inattention.

We add to the literature in three ways. First, we provide new empirical cross-country evidence on household-level inattention to prices and their effects on inflation expectations in both US and Australian data. To measure under- and overreaction in expectations about inflation, we follow the framework by Kučinskas and Peters (2022). Their method, contrary to the standard approach by Coibion and Gorodnichenko (2015), captures empirical evidence found in microdata correctly on a macro level. The idea is to regress forecast errors about the change of inflation over the next 12 months resp. 4 quarters on the target interest rate or oil price changes for which we use an appropriate instrument in the estimation. We use externally constructed monetary policy shocks as an instrument for central bank interest rates and oil supply news shocks as instruments for oil price changes. Additionally we control for household characteristics like income and employment. Cross-sectional variation in inflation expectations have been studied in the literature before. Early contributions include Malmendier and Nagel (2016) and Ehrmann and Tzamourani (2012) who show that cohorts build their inflation expectations depending on their lifetime inflation experiences, a fact complemented by recent contributions from Coibion et al. (2020), Weber et al. (2023) and Pfäuti (2021) who observe that households' inattention varies with economic conditions. Link et al. (2023) find that attention to macroeconomic variables is strongly persistent at the individual level, specifically, more attentive households are more likely to adjust inflation expectations during a shock to inflation as the cost of acquiring new information is lower for an attentive household than for an inattentive household which translates to an adjustment of expectations - a finding consistent with rational inattention. Estimating inflation rates at the household level, Kaplan and Schulhofer-Wohl (2017) document a negative correlation of inflation with income, in particular households with low incomes experience higher inflation on average. However, they don't look into inflation expectations. A well established paper that studies the effect of observed price changes on inflation expectations is Cavallo et al. (2017) who find that agents are highly influenced by goods' prices when forming inflation expectations and show that rational inattention is an important determinant of information frictions. This evidence is supported by D'Acunto et al. (2019) who highlight that consumers' inflation expectations are strongly affected by the frequency with which households observe goods price changes which in turn affects their inflation expectation formation. Using scanner data, Kaplan and Schulhofer-Wohl (2017) observe that most of the households' inflation rates vary across households due to the variation in their observed household-level prices relative to average prices. Bordalo et al. (2020) find that for inflation, individual forecasts tend to overreact to their own revisions.

Second, our paper adds to the growing literature of macroeconomic models with behavioral frictions, more specifically models with rationally inattentive agents (Sims, 2003; Gabaix, 2014). The idea thereby is that households have a limited view of the economy and only take a reduced representation of the world into their optimal decision making process. In a recent contribution Angeletos and Huo (2021) analyse the consequences for agents with different wealth levels who have a noisy understanding of the economy and show that "the habit-like sluggishness generated by informational frictions is amplified when the agents with the highest MPC are also the ones with the most cyclical income". Additionally, Angeletos and La'o (2020) and Eusepi and Preston (2018) study optimal monetary policy and inflation expectations when agents are imperfectly informed.

Third, we contribute to the heterogeneous agent literature studying monetary policy transmission (Luetticke, 2021, e.g.). The closest paper to ours on this front is Auclert et al. (2020). They study monetary policy transmission with sticky information in a heterogeneous agent model. Contrary to them, our model features heterogeneous inflation expectations, whereas in their framework, all households update their expectations and beliefs about their value of illiquid assets infrequently, but with the same probability. Heterogeneous beliefs in a HANK model have been incorporated in Guerreiro (2022). He shows that households form heterogeneous beliefs about their labor income process which eventually leads to an amplification of business cycle fluctuations. A related paper by Bardóczy and Guerreiro (2023) incorporates homogeneous non-FIRE unemployment expectations and analyzes different unemployment insurance policies. Broer et al. (2021) study wealth taxation and document the impact of heterogeneous information choices on the equilibrium properties of the economy relative to FIRE benchmark. Additionally, (Farhi and Werning, 2019) show analytically that the the interaction of agents heterogeneity with market frictions and behavioral frictions leads to a powerful mitigation of the effects of monetary policy. We add to this literature by quantifying the effects of heterogeneity and information frictions for inflation expectations and document the transmission channels in a rich, structural model.

The paper is structured as follows. Section 2 provides the empirical estimation strategy to measure over- and underreaction in the data, followed by our approach to estimate heterogeneous attention levels to monetary policy and oil supply news shocks. Section 3 presents the empirical aggregate and cross-sectional results we find for US and Australian survey data. Then, Section 4 introduces our structural HANK model featuring inattentive agents. We use the model to quantify the structural implications of inattention to inflation expectations. Section 5 specifies our calibration parameters and in Section 6 we show our model results and study the monetary policy implications. Section 7 concludes.

2. Measuring Attention

This section presents our empirical strategy to estimate heterogeneous attention. We use the method proposed by Pfäuti (2021) but additionally control for cross-sectional household characteristics like income, employment, sex and home ownership. Additionally, we derive shock-specific attention and use the derived specification in Section 3 to compare changes in inflation expectations to domestic and foreign monetary vs. oil price shocks.

2.1. Attention to Inflation

Assume that households perceive the following law of motion for inflation

$$\pi_t = \rho\pi_{t-1} + \xi_t \tag{1}$$

and receive a noisy inflation signal

$$s_{i,t} = \pi_t + \varepsilon_{i,t} \tag{2}$$

where $\xi_t \sim i.i.d.N(0, \sigma^2_\xi)$, $\rho \in (-1, 1]$, and $\varepsilon_{i,t} \sim i.i.d.N(0, \sigma^2_{\varepsilon^g})$ where g stands for household's type. The idea is that different types of households pay different attention to inflation, which leads to a decrease in the variance of $\varepsilon_{i,t}$ the larger the attention. The standard Kalman filter equations imply

$$\begin{aligned} E[\pi_{t+1}|\mathcal{I}_{i,t}] = \rho E[\pi_t|\mathcal{I}_{i,t}] &= \rho E[\pi_t|\mathcal{I}_{i,t-1}] + \rho\gamma^g \left(s_{i,t} - E[\pi_t|\mathcal{I}_{i,t-1}]\right) \\ &= \rho E[\pi_t|\mathcal{I}_{i,t-1}] + \rho\gamma^g \left(\pi_t - E[\pi_t|\mathcal{I}_{i,t-1}]\right) + \nu_{i,t} \end{aligned} \tag{3}$$

where $\nu_{i,t} = \rho\gamma^g\varepsilon_{i,t}$ and γ^g measures attention of households of type g. Therefore, as proposed by Pfäuti (2021), attention can be measured by estimating the following specification

$$\pi^e_{t+1,t} = \beta_i + \beta_1\pi^e_{t,t-1} + \beta^g_2 I_g \left(\pi_t - \pi^e_{t,t-1}\right) + \nu_{i,t} \tag{4}$$

where β_i stands for potentially different mean expectations, I_g are type dummies, and $\gamma^g = \frac{\hat{\beta}^g_2 I_g}{\hat{\beta}_1}$. Alternatively, one can further derive the forecast errors starting from Equation 3 which we rewrite for notational convenience as

$$E_{i,t}\pi_{t+1} = \gamma^g E_t\pi_{t+1} + (1-\gamma^g)\, E_{i,t-1}\pi_{t+1} \tag{5}$$

This is the process for inflation expectations assumed in Guerreiro (2022). Rewriting inflation as a function of structural shocks

$$\pi_{t+1} = \sum_{j=-\infty}^{\infty} J_{t+1-j}u_{t+1-j} \tag{6}$$

where u_t is a vector of structural shocks that are uncorrelated across time and with each other, and J_t represents IRFs of inflation to them. The forecast errors are then

$$\begin{aligned}
\pi_{t+1} - E_{i,t}\pi_{t+1} &= \sum_{j=-\infty}^{\infty} J_{t+1-j}u_{t+1-j} - \gamma^g E_t\pi_{t+1} - (1-\gamma^g)E_{i,t-1}\pi_{t+1} = \\
&= \sum_{j=-\infty}^{\infty} J_{t+1-j}u_{t+1-j} - \gamma^g \sum_{j=0}^{\infty}(1-\gamma^g)^j\rho^j E_{t-j}\pi_{t+1-j} = \\
&= \sum_{j=-\infty}^{\infty} J_{t+1-j}u_{t+1-j} - \gamma^g \sum_{j=0}^{\infty}(1-\gamma^g)^j\rho^j \sum_{k=1}^{\infty} J_{t-j+1-k}u_{t-j+1-k} = \\
&= \sum_{j=-\infty}^{\infty} J_{t+1-j}u_{t+1-j} - \gamma^g \sum_{j=1}^{\infty} J_{t+1-j}u_{t+1-j} \sum_{k=0}^{j-1}(1-\gamma^g)^k\rho^k = \\
&= \sum_{j=-\infty}^{0} J_{t+1-j}u_{t+1-j} + \sum_{j=1}^{\infty} J_{t+1-j}u_{t+1-j}\left[1 - \gamma^g \sum_{k=0}^{j-1}(1-\gamma^g)^k\rho^k\right] \qquad (7)
\end{aligned}$$

The first term is unpredictable at time t future shocks that affect inflation (i.e. shocks that occur in periods $t+1$ or later). The second term is how forecast errors depend on past shocks. For example the coefficient in front of the shock in period t, u_t, is simply $J_t(1-\gamma^g)$. So, attention could be estimated by regressing forecast errors on past shocks:

$$e_{i,t+1} = \beta_i + \beta_1^g I_g u_t^m + \nu_{i,t} \qquad (8)$$

where $e_{i,t+1}$ stands for the forecast errors, m stands for the chosen shock (for example, monetary policy shock), and $\gamma^g = 1 - \frac{\hat{\beta}_1^g I_g}{J_t^m}$. J_t^m could be also estimated or taken from other studies. Note, that this way one can estimate attention using different shock series.[1]

3. Empirical Results

This section shows the empirical evidence from the estimation procedure from Section 2. We show cross-country evidence for the US and Australian micro-level data of expectations. We use Fed New York CSE survey for the US and CASiE survey for Australia. We show both

1 Regression can be estimated with each shock at once or with all shocks together. This should not make a difference since these shocks are structural shocks with the assumption that they are uncorrelated with each other.

aggregate and cross-sectional evidence for over- and underreaction as well as the estimated levels of attention.

3.1. Suggestive Evidence

Figure 1 shows the percentage of households who who answer "Yes" to the question "During the last few months, have YOU read or heard any news of changes in economic conditions?" in the CASiE Australian survey for different groups of households. It already presents the first evidence of groups who pay high attention to economic changes, namely households who have high income, self-employed, professionals or males pay high attention to economic news compared to the households who don't belong in the respective group. In the following we base our analysis on the suggestive evidence and divide households into different groups inter alia based on income level, employment and occupation.

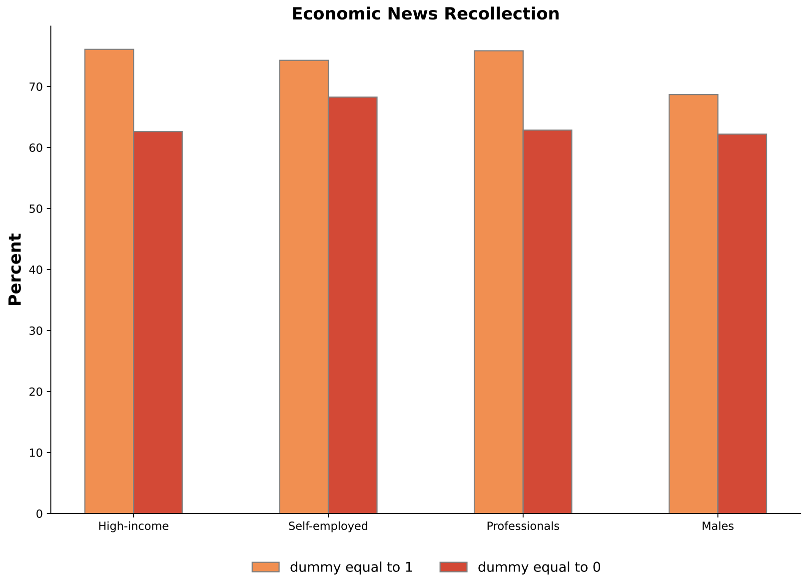


Figure 1: Percentage of Households Recalling Economic News. The figure shows the percentage of households who answer "Yes" to the question "During the last few months, have YOU read or heard any news of changes in economic conditions?" in the CASiE Australian survey. The answers are shown by groups depending on income, occupation, sex and whether a household is self-employed. "1" indicates that the percentage is calculated among households who belong to the category (so the first bar is the percentage of "yes" answers among income rich) and "0" indicates that the percentage is calculated among households who do not belong to the category.

Table 1: Summary Statistics. The table shows summary statistics for Australian survey CASiE.

Variable	Median	25%	75%	1%	99%
Inflation expectations	5.0	2.0	6.0	-2.0	15.0
CPI inflation	2.5	1.7	3.1	-0.3	7.3
Romer-Romer shocks	0.008	-0.06	0.08	-0.40	0.35
Romer-Romer aug. shocks	0.008	-0.07	0.09	-0.50	0.38
Level shocks	0.0	-0.10	0.03	-2.16	2.24
Path shocks	0.0	-0.20	0.0	-1.46	2.36
Term-premia shocks	0.0	-0.04	0.13	-1.94	2.07
Oil news shocks	-0.05	-0.35	0.37	-1.58	1.30
Oil news shocks precovid	-0.005	-0.38	0.39	-1.44	1.35
Male	1.0	0.0	1.0	0.0	1.0
Income level	\$40-90k	$\leq$ \$40k	$\geq$ \$90k	$\leq$ \$40k	$\geq$ \$90k
Self-employed	0.0	0.0	0.0	0.0	1.0
Education	above school	school or below	above school	school or below	above school
Home-owners	1.0	1.0	1.0	0.0	1.0
Age	$\geq$ 45	34-45	$\geq$ 45	18-34	$\geq$ 45
Not urban	0.0	0.0	1.0	0.0	1.0
Full-time workers	1.0	0.0	1.0	0.0	1.0
Changed jobs	0.0	0.0	0.0	0.0	1.0

3.2. Results for Australia

Table 1 shows first summary statistics for the quarterly Australian data. We show descriptive statistics for Inflation expectations found in the survey data, actual CPI inflation, the monetary policy and oil news shocks we consider, and different cross-sectional characteristics we assume to be relevant for our analysis for which we also present cross-sectional evidence in the subsequent sections.

3.2.1. Aggregate Results

In the first step, we measure aggregate over- and underreaction running both the reduced form regressions and IV regressions as proposed by Kučinskas and Peters (2022). The idea is to either regress forecast errors about inflation directly on the set of monetary policy respectively oil news shocks or to use these shocks for the interest rate respectively oil price changes as instruments. According to Table 2 we can not reject the null hypothesis of FIRE. If anything we can fine some underreaction to oil price shocks at the 15% level of significance. The results are robust to stricter winsorizing, using shadow rate changes in IV, before 2008 with oil shocks under-reaction, robust to inclusion of macro controls.

Table 2: Aggregate Inflation Expectations. The table shows regression coefficients for aggregated across households inflation forecasting errors regressed on different shocks either directly (reduced form) or using IV (where shocks are used as an instrument for cash rate changes or oil price changes). Romer-Romer shocks are monetary policy shocks constructed for Australia by Beckers et al. (2020) following Romer and Romer (2004) methodology. Level, path and term-premia shocks are high-frequency identified monetary policy shocks constructed by Hambur and Haque (2023) following Gürkaynak et al. (2005) with the Kaminska et al. (2021) extension that decomposes shocks into level, path and term-premia components. Oil news shocks are taken from Känzig (2021).

Shocks	Romer-Romer	Romer-Romer aug.	Level	Path	Term-premia	Oil News	Oil News pre-covid
			IV				
β	0.10 (0.61)	-0.05 (1.17)	0.03 (0.58)	6.08 (25.94)	-0.42 (4.70)	1.75 (1.21)	0.59 (1.00)
			Reduced Form				
β	0.12 (0.78)	-0.03 (0.81)	-0.01 (0.10)	-0.06 (0.10)	-0.01 (0.10)	0.23 (0.16)	0.07 (0.13)
No. of observations	96	96	109	109	109	109	100

3.2.2. Cross-sectional Variation

Next, wen consider cross-sectional variation across households' inflation expectations in 3 again running either standard regressions of forecast errors or using IV regressions. We find heterogeneous inflation expectations among households with high-income/low-income, households who are self-employed and not self-employed and professionals vs other occupational households, and males/females.

The results are robust to stricter winsorizing except education becomes insignificant, robust to inclusion of industry dummies (small and not robust coefficients for industry dummies), robust to inclusion of time fixed effects (except education and age become insignificant), robust to inclusion of macro controls.

3.2.3. Panel Regressions: overall over/under-reaction

As US monetary policy has an effect on the the Australian monetary policy, we now study the effects of foreign, US monetary shocks on the Australian economy in Table 4. We find high attention to oil price shocks: either do not reject FIRE (pre-covid, so attention equal 1) or attention of $1 - \frac{0.14}{0.34} = 0.59$.[2] Now, looking at tentative evidence of high attention to monetary policy shocks. With controls, except for the path shocks, all coefficients are insignificant, so attention is equal to 1. Only without controls using Beckers et al. (2020) shocks we find low

2 The coefficient 0.34 was obtained by running a regression of inflation on oil shocks: $\pi_{t+4} = c + OilShock_t + \gamma X_t + \varepsilon_t$, where X_t are controls and the regression is run using quarterly data.

Table 3: Cross-sectional Distribution of Inflation Expectations. The table shows regression coefficients for inflation expectation errors on different demographics. Errors are clustered at the time-period level.

Variables	Abs. Errors	Abs. Errors Controling for Cohorts	Squared Errors	Squared Errors Controling for Cohorts
Income				
$40k to $90k	-0.37** (0.14)	-0.16 (0.23)	-4.06** (1.59)	-1.61 (3.02)
more than $90k	-0.84*** (0.14)	-0.61*** (0.23)	-8.55*** (1.65)	-6.96** (2.92)
Sex				
male	-0.41*** (0.08)	-0.28*** (0.09)	-2.95*** (1.07)	-2.00 (1.33)
Occupation				
self-employed	-0.81*** (0.19)	-0.82*** (0.27)	-10.77*** (2.34)	-13.28*** (3.22)
professionals and paraprofessionals	0.28 (0.17)	0.26 (0.50)	4.06*** (1.43)	6.42 (4.30)
managers	0.86*** (0.18)	0.86* (0.49)	11.34*** (1.88)	14.16*** (4.39)
trades and salespersons	0.78*** (0.17)	0.58 (0.48)	8.89*** (1.86)	9.03** (4.21)
clerks	1.03*** (0.22)	0.77 (0.53)	13.33*** (2.88)	13.18** (5.87)
plant and machine operators and drivers	0.80*** (0.24)	0.68 (0.57)	10.23*** (2.60)	11.13* (5.75)
labourers	1.12*** (0.20)	1.02** (0.47)	12.48*** (2.10)	13.70*** (4.36)
Education				
above school	-0.38*** (0.10)	-0.35** (0.15)	-4.30*** (1.17)	-3.79* (2.04)
Renting/owning				
home owners	-0.41*** (0.11)	-0.24* (0.14)	-4.20*** (1.34)	-1.87 (1.92)
Age				
35-44 years	0.07 (0.09)	0.41*** (0.13)	0.31 (1.01)	3.76** (1.64)
older than 44	-0.19* (0.11)	0.81*** (0.16)	-3.00** (1.35)	8.30*** (2.24)
Other dummies				
regional dummy (not urban)	0.30*** (0.05)	0.19* (0.10)	2.58*** (0.60)	1.47 (1.09)
full-time worker	-0.03 (0.15)	-0.22 (0.17)	-0.83 (1.93)	-3.23 (2.30)
changed jobs	-0.12 (0.15)	-0.17 (0.17)	-1.58 (1.87)	-2.85 (2.28)
Constant	3.87*** (0.22)	0.24 (0.50)	24.45*** (2.43)	-0.25 (5.36)
No. of observations	6954	3474	6954	3474
R-squared	0.06	0.05	0.04	0.04

Table 4: Panel Regressions of Inflation Expectations, Domestic Shocks. The table shows regression coefficients for households inflation forecasting errors regressed on different shocks either directly (reduced form) or using IV (where shocks are used as an instrument for cash rate changes or oil price changes). Romer-Romer shocks are monetary policy shocks constructed for Australia by Beckers et al. (2020) following Romer and Romer (2004) methodology. Level, path and term-premia shocks are high-frequency identified monetary policy shocks constructed by Hambur and Haque (2023) following Gürkaynak et al. (2005) with the Kaminska et al. (2021) extension that decomposes shocks into level, path and term-premia components. Oil news shocks are taken from Känzig (2021).

Shocks	Romer-Romer	Romer-Romer aug.	Level	Path	Term-premia	Oil News	Oil News pre-covid
			IV				
β	-0.52*** (0.19)	-0.57* (0.31)	-0.23 (0.20)	-5.01** (2.50)	-11.00 (16.50)	1.13** (0.47)	-0.39 (0.38)
			Reduced Form				
β	-0.93*** (0.33)	-0.67* (0.37)	0.04 (0.03)	-0.13*** (0.03)	0.11*** (0.03)	0.14** (0.06)	-0.05 (0.05)
No. of observations	832	832	1035	1035	1035	1035	896

Table 5: Panel Regressions of Inflation Expectations, Foreign Shocks. The table shows regression coefficients for households inflation forecasting errors regressed on different shocks either directly (reduced form) or using IV (where shocks are used as an instrument for FFR rate changes). Acosta shocks contain the 30-minute change in expectations of the FFR immediately after each FOMC meeting (first component of the policy news shock), constructed by Acosta (2022). NS shocks are the monetary policy shocks constructed by Acosta (2022) following Nakamura and Steinsson (2018). Target and path shocks are high-frequency identified monetary policy shocks all constructed by Acosta (2022) following Gürkaynak et al. (2005). MPS shocks are the monetary policy shock instrument constructed by Bauer and Swanson (2023) using high-frequency data.

Shocks	NS	GSS target	GSS path	Acosta	MPS
			IV		
β	4.11*** (1.23)	-3.63 (2.34)	9.36*** (1.98)	-1.26 (1.79)	3.22*** (0.74)
			Reduced Form		
β	0.10*** (0.03)	-0.09* (0.05)	0.20*** (0.03)	-0.89 (1.18)	0.38*** (0.08)
No. of observations	1003	1003	1003	1003	864

attention. Beckers et al. (2020) and Hartigan and Morley (2020) estimate the response of inflation to monetary policy shocks equal -0.49 and -0.44 respectively. This means attention is almost 0 (as -0.57 divided by -0.49 is almost equal to 1). We also document potentially lower attention to foreign monetary shocks in Table 5. The responses of realized inflation are of similar sign and magnitude, but they are significant only at a 20% significance level for Nakamura and Steinsson (2018) shocks (0.12 coefficient), with even lower significance for other shocks. Results are robust to inclusion of macro controls. Robustness: before 2008 we measure much larger under-reaction in the data. When including macro controls, coefficients for monetary policy shocks become insignificant except for the path variable in the reduced form. Coefficients for oil price shocks are robust to inclusion of macro controls.

3.2.4. Panel Regressions: heterogeneous attention

In this section we now present our estimates for heterogeneous attention. The estimated regressions follow specification the specification in equation 8 and equation 4 and we include households characteristics on income level, self-employment, occupation and sex. Results are shown in 6. Cross-sectional evidence shows that high-income and self-employed households have higher attention to inflation than other groups. For a robustness checks, we find

Table 6: Panel Regressions of Inflation Expectations Across Households Characteristics. The table shows regression coefficients for households inflation forecasting errors regressed on different shocks (reduced form) interacted with different dummies (one at a time). Romer-Romer shocks are monetary policy shocks constructed for Australia by Beckers et al. (2020) following Romer and Romer (2004) methodology. Level, path and term-premia shocks are high-frequency identified monetary policy shocks constructed by Hambur and Haque (2023) following Gürkaynak et al. (2005) with the Kaminska et al. (2021) extension that decomposes shocks into level, path and term-premia components. Oil news shocks are taken from Känzig (2021).

Shocks	Romer-Romer	Romer-Romer aug.	Level	Path	Term-premia	Oil News	Oil News pre-covid
Income level							
High-income	-0.88* (0.46)	-0.50 (0.49)	-0.01 (0.04)	-0.13*** (0.04)	0.12** (0.05)	0.10 (0.08)	-0.04 (0.06)
Mid and low-income	-0.98** (0.48)	-0.85 (0.55)	0.09* (0.05)	-0.13*** (0.04)	0.10** (0.05)	0.18** (0.09)	-0.05 (0.07)
Entrepreneurs							
Self-employed	-1.36*** (0.52)	-1.09* (0.58)	0.04 (0.04)	-0.16*** (0.04)	0.13*** (0.05)	0.08 (0.09)	-0.10 (0.07)
Not self-employed	-0.50 (0.41)	-0.26 (0.45)	0.03 (0.04)	-0.10*** (0.04)	0.09** (0.04)	0.20*** (0.07)	0.01 (0.05)
Occupation							
Professionals	-1.14** (0.46)	-0.91* (0.51)	0.05 (0.04)	-0.11*** (0.04)	0.12*** (0.05)	0.06 (0.08)	-0.07 (0.07)
Not professionals	-0.72 (0.47)	-0.43 (0.53)	0.03 (0.04)	-0.14*** (0.04)	0.10** (0.05)	0.22*** (0.08)	-0.03 (0.06)
Sex dummy							
Female	-0.85* (0.47)	-0.76 (0.53)	0.02 (0.05)	-0.17*** (0.04)	0.14*** (0.05)	0.10 (0.08)	-0.06 (0.07)
Male	-1.01** (0.46)	-0.58 (0.52)	0.05 (0.04)	-0.08** (0.04)	0.08* (0.05)	0.19** (0.08)	-0.04 (0.06)
No. of observations	832	832	1034	1034	1034	1034	896

insignificant results for monetary policy shocks when including macro controls except for the path variable. Results for oil shocks are robust to inclusion of macro controls. The attention levels for the cross-sectional groups are shown in Table 7. Robustness: results are robust to stricter winsorizing and using AR(2) as a perceived inflation process in Pfäuti (2021) methodology, robust to inclusion of macro controls.

Summary of results for attention from Australian survey: Based on Table 3 on average high-income, males, professionals and self-employed have lower forecasting errors. This means they potentially have higher attention. Table 7 confirms that high-income, self-employed and professionals have higher attention (higher γ). Males have higher attention according to pooled regressions, but not according to Arellano-Bond estimator. Lastly, Table

Table 7: Heterogeneous Attention. The table shows estimated level of attention across households groups. Attention of households belonging to the group is shown in row with γ_1, and attention of households not belonging to the group is shown in row γ_2. The estimation of attention is according to Pfäuti (2021) methodology. Estimated average attention is 0.26. Stars in the γ_2 row indicate significance for the other group, stars in the γ_1 indicate significant difference to the other group.

Shocks	High-income	Self-employed	Professionals	Male
Arellano–Bond estimator				
γ_1	0.34*	0.36***	0.30	0.24
γ_2	0.22***	0.16***	0.22***	0.28***
No. of observations	998	1016	1016	1016
Pooled regressions (without fixed effects)				
γ_1	0.30**	0.25*	0.26*	0.27**
γ_2	0.19***	0.17***	0.17***	0.16***
No. of observations	1016	1035	1035	1035

6 shows that across shocks FIRE could not be rejected more often for high-income (FIRE can not be rejected when coefficients are insignificant). For oil shocks FIRE also could not be rejected more often for self-employed and professionals, but for monetary policy shocks those two categories of households under-react by more compared to households not belonging to each category. Old households have higher average errors, see Table 3. They also under-react to monetary policy shocks and have lower attention coefficients when estimated following Pfäuti (2021), but the results are not robust to collapsing based only on age dummy. In sum, high-income have higher attention which shows consistently across Tables 3, 7, 6. If we drop part of the evidence a case for self-employed, professionals or young could be made.

3.3. Results for the US NY Fed CSE

In this section we present our next set of evidence for the US using the Fed New York CSE household survey.

3.3.1. Summary Statistics

Table 8 shows the summary statistics for the data for the period June 2013-January 2023. For the US we consider a larger set of monetary policy shocks, in particular we use shocks constructed by Nakamura and Steinsson (2018), Acosta (2022), Gürkaynak et al. (2005) and Bauer and Swanson (2023) and for the oil supply shocks we again consider the shocks constructed by Känzig (2021). We define the same set of variables and cross-sectional characteristics for the US data as we did for the Australian survey. We however, find some differences in the data, especially in the levels of expected inflation, as they are a lot higher in the US compared to the data for Australia.

Table 8: Summary Statistics, monthly. The table shows summary statistics for New York Fed CSE. Acosta shocks contain the 30-minute change in expectations of the FFR immediately after each FOMC meeting (first component of the policy news shock), constructed by Acosta (2022). NS shocks are the monetary policy shocks constructed by Acosta (2022) following Nakamura and Steinsson (2018). Target and path shocks are high-frequency identified monetary policy shocks all constructed by Acosta (2022) following Gürkaynak et al. (2005). MPS shocks are the monetary policy shock instrument constructed by Bauer and Swanson (2023) using high-frequency data and MPS shocks orth are the orthogonalized MPS shocks with respect to the news variables as in Bauer and Swanson (2023). Oil news shocks are taken from Känzig (2021).

Variable	Median	25%	75%	1%	99%
Inflation expectations	3.0	2.0	7.0	-29.0	60.0
Inflation expectation trimmed	3.0	2.0	6.0	-25.0	49.0
CPI Inflation monthly	2.5	0.93	4.59	-7.40	12.69
NS shock	0.00	0.00	0.18	-1.37	1.99
GSS target shock	0.0	0.00	0.08	-0.95	1.03
GSS path shocks	0.0	-0.01	0.16	-1.62	3.24
Acosta shocks	0.0	-0.004	0.0	-0.04	0.03
MPS shocks	0.0	0.0	0.01	-0.08	0.05
MPS shocks orth	0.0	0.0	0.002	-0.05	0.07
Oil news shocks	-0.05	-0.36	0.38	-1.66	1.49
Oil news shocks precovid	-0.09	-0.46	0.39	-1.69	1.36
Male	2.0	2.0	2.0	2.0	2.0
Male dummy	1.0	0.0	1.0	0.0	1.0
Income level	\$40-99k	$<$ \$40k	$\geq$ \$100k	$<$ \$40k	$\geq$ \$100k
Income level encode	$>$ 100k	\$50k-100k	$<$\$50k	\$50-100k	$<$ \$50k
Self-employed	0.0	0.0	0.0	0.0	1.0
Education	College	Some College	College	High School	College
Home-owners	1.0	0.0	1.0	0.0	1.0
Age dummy	40-60	$<$ 40	$>$ 60	$<$ 40	$>$ 60
Full-time workers	1.0	0.0	1.0	0.0	1.0

3.3.2. Aggregate Results

Again, we measure aggregate over- and underreaction using both the reduced form regressions as well as running IV regressions proposed by Kučinskas and Peters (2022). Here we are able to use a larger set of monetary policy shocks as instrument for the fed funds rate, as they are freely available. According to Table 9 we find some underreaction to monetary policy shocks as well as to oil price shocks but also overreaction to monetary policy shocky by Acosta (2022) and Nakamura and Steinsson (2018) for IV regressions. The results are robust to the inclusion of macro controls.

Table 9: Aggregate Inflation Expectations, quarterly. The table shows regression coefficients for aggregated across households inflation forecasting errors regressed on different shocks either directly (reduced form) or using IV (where shocks are used as an instrument for FFR or oil price changes). Acosta shocks contain the 30-minute change in expectations of the FFR immediately after each FOMC meeting (first component of the policy news shock), constructed by Acosta (2022). NS shocks are the monetary policy shocks constructed by Acosta (2022) following Nakamura and Steinsson (2018). Target and path shocks are high-frequency identified monetary policy shocks all constructed by Acosta (2022) following Gürkaynak et al. (2005). MPS shocks are the monetary policy shock instrument constructed by Bauer and Swanson (2023) using high-frequency data. Oil news shocks are taken from Känzig (2021).

Shocks	NS	GSS target	GSS path	Acosta	MPS	Oil News	Oil News pre-covid
				IV			
β	-2.35 (8.40)	0.02 (0.31)	-0.56 (0.86)	-0.09 (0.36)	4.14 (19.77)	1.80 (3.62)	1.98 (2.54)
				Reduced Form			
β	0.33 (0.51)	0.05 (0.64)	0.29 (0.51)	-4.90 (19.08)	10.94 (9.23)	0.25 (0.50)	0.25 (0.32)
No. of observations	36	36	36	36	27	36	27

3.3.3. Cross-sectional Variation

Table 10 presents the results for cross-sectional variation in inflation expectations. We analyze households based on their income level, occupation, sex, owning or renting a house, education and age levels as well as on their regional area. We find significant, heterogeneous inflation expectations among high-income/low-income, self-employed and not self-employed, professionals vs other occupations, and males/females, consistent with the survey for Australian data. Based on Table 10, households who are mid-/high-income, males, home-owners and self-employed on average have lower forecasting errors, i.e. they overreact to shocks. This means they potentially have higher attention which is confirmed by Table 13 (i.e. for higher

Table 10: Cross-sectional Distribution of Inflation Expectations, quarterly. The table shows regression coefficients for inflation expectation errors on different demographics. Errors are clustered at the time-period level.

Variables	Abs. Errors	Squared Errors
Income		
$40k to $100k	-1.45*** (0.14)	-41.07*** (5.51)
more than $100k	-1.81*** (0.12)	-41.73*** (3.97)
Sex		
male	-2.15*** (0.13)	-50.21*** (4.38)
Occupation		
full-time	-3.54** (1.13)	-118.32* (43.96)
part-time	-2.02 (1.07)	-65.67 (40.54)
unemployed	-0.38 (1.07)	-16.59 (39.80)
unable to work and retiree	-2.84* (1.08)	-106.40* (40.99)
student/school/in training	-2.63* (1.20)	-68.68 (43.92)
homemaker	-1.97 (1.17)	-64.05 (42.97)
Education		
High school	-3.26 (2.48)	-137.108 (127.812)
Some College	-5.54* (2.49)	-215.27* (127.10)
College	-7.45** (2.50)	-260.61 (127.65)
Regional		
Northeast	-0.19 (0.12)	-4.48 (5.51)
South	0.76*** (0.16)	18.14** (6.63)
West	0.35* (0.15)	5.86 (5.77)
Renting/owning		
home owners	-1.49*** (0.17)	-45.65*** (6.03)
Age		
40 to 60 years	0.49** (0.14)	11.35* (5.23)
Over 60 years	0.17 (0.16)	1.90 (6.44)
Other dummies		
full-time worker	0.68 (0.40)	14.72 (14.13)
self-employed	-0.64* (0.23)	-26.43** (8.48)
Constant	16.65*** (2.85)	467.20** (143.74)
No. of observations	14962	14962
R-squared	0.12	0.07

Table 11: Panel Regressions of Inflation Expectations, quarterly. The table shows regression coefficients for households inflation forecasting errors regressed on different shocks either directly (reduced form) or using IV (where shocks are used as an instrument for FFR or oil price changes). Acosta shocks contain the 30-minute change in expectations of the FFR immediately after each FOMC meeting (first component of the policy news shock), constructed by Acosta (2022). NS shocks are the monetary policy shocks constructed by Acosta (2022) following Nakamura and Steinsson (2018). Target and path shocks are high-frequency identified monetary policy shocks all constructed by Acosta (2022) following Gürkaynak et al. (2005). MPS shocks are the monetary policy shock instrument constructed by Bauer and Swanson (2023) using high-frequency data. Oil news shocks are taken from Känzig (2021).

Shocks	NS	GSS target	GSS path	Acosta	MPS	Oil News	Oil News pre-covid
				IV			
β	-2.46 (3.57)	-0.01 (0.12)	-0.56* (0.34)	-0.14 (0.14)	3.25 (4.50)	2.19 (1.46)	2.36* (1.12)
				Reduced Form			
β	0.29 (0.19)	-0.02 (0.25)	0.27 (0.19)	-7.26 (7.29)	10.27** (3.45)	0.30 (0.19)	0.30* (0.14)
No. of observations	284	284	284	284	212	284	212

γ_1). Males, high-income and self-employed households have higher attention according to both pooled regressions and Arellano-Bond estimator.

3.3.4. Panel Regressions: overall over/under-reaction

Table 11 shows the measured overall over- and under-reaction in the US survey. In the data we find under-reaction to all shocks. Results in 11 are mostly robust to collapsing based only on male dummy. However for the IV regressions, path shock becomes insignificant, target has a small positive coefficient (0.13) and the oil news pre-covid shock becomes insignificant. For the reduced form regression, oil new shocks pre-covid becomes insignificant, reaction to target shock becomes positive (0.29). Results in 11 are mostly robust to collapsing based only on income level. However for the IV regressions, path shock becomes insignificant, target has a small positive coefficient (0.064) and the oil news pre-covid shock becomes insignificant. For the reduced form regression, oil new shocks pre-covid becomes insignificant, reaction to target shock becomes positive (0.29). For the reduced form regressions, oil news shock pre-covid shock and oil news become insignificant and target becomes slightly positive (0.13).

3.3.5. Panel Regressions: heterogeneous attention

Table 12 shows that across shocks FIRE could not be rejected more often for high-income. However, for quarterly data, FIRE could be rejected for high-income households to Bauer and Swanson (2023) monetary policy shocks and for male households to pre-covid oil news shocks. Those two categories of households under-react to these shocks by more compared to households not belonging to each category. Table 13 shows the levels of attention across socio-demographic characteristics for high-/low-income, employed/self-employed households and males/females. The results are consistent with 10 implying that households who belong into either of the groups have higher attention (shown by higher γ_1) than those households who don't fall into this category (shown by lower γ_2).

Table 12: Panel Regressions of Inflation Expectations Across Households Characteristics, quarterly. The table shows regression coefficients for households inflation forecasting errors regressed on different shocks (reduced form) interacted with different dummies (one at a time). Acosta shocks contain the 30-minute change in expectations of the FFR immediately after each FOMC meeting (first component of the policy news shock), constructed by Acosta (2022). NS shocks are the monetary policy shocks constructed by Acosta (2022) following Nakamura and Steinsson (2018). Target and path shocks are high-frequency identified monetary policy shocks all constructed by Acosta (2022) following Gürkaynak et al. (2005). MPS shocks are the monetary policy shock instrument constructed by Bauer and Swanson (2023) using high-frequency data. Oil news shocks are taken from Känzig (2021). Oil news shocks are taken from Känzig (2021).

Shocks	NS	GSS target	GSS path	Acosta	MPS	Oil News	Oil News pre-covid
Income level							
High-income	0.33 (0.27)	-0.04 (0.38)	0.30 (0.27)	-8.01 (10.87)	11.35* (4.64)	0.36 (0.28)	0.39* (0.19)
Mid and low-income	0.25 (0.27)	-0.00 (0.32)	0.24 (0.26)	-6.38 (9.40)	9.09* (5.14)	0.24 (0.28)	0.19 (0.21)
Entrepreneurs							
Self-employed	0.24 (0.28)	-0.10 (0.36)	0.24 (0.28)	-9.69 (10.40)	8.77 (5.18)	0.34 (0.30)	0.32 (0.23)
Not self-employed	0.35 (0.25)	0.07 (0.34)	0.31 (0.25)	-4.47 (10.11)	11.91 (4.45)	0.27 (0.25)	0.28 (0.23)
Sex dummy							
Female	0.12 (0.30)	-0.11 (0.39)	0.15 (0.30)	-11.57 (10.88)	8.79 (5.26)	0.20 (0.31)	0.25 (0.22)
Male	0.46 (0.23)	0.07 (0.32)	0.40 (0.23)	-2.69 (9.56)	11.79* (4.56)	0.40 (0.23)	0.34 (0.17)
No. of observations	284	284	284	284	212	284	212

Summary of results for attention from NY Fed Based on Table 10 on average high-income, males and self-employed have lower forecasting errors. This means they potentially have higher attention. Table 13 confirms that high-income, self-employed have higher attention (higher γ_1). Males however have low attention according to pooled regressions and according to the Arellano-Bond estimator. In sum, we find consistent cross-country evidence

Table 13: Heterogeneous Attention, quarterly. The table shows estimated level of attention across households groups. Attention of households belonging to the group is shown in row with γ_1, and attention of households not belonging to the group is shown in row γ_2. The estimation of attention is according to Pfäuti (2021) methodology. Estimated average attention is 0.13. Stars in the γ_2 row indicate significance for the other group, stars in the γ_1 indicate significant difference to the other group.

Shocks	High-income	Self-employed	Male
Arellano–Bond estimator			
γ_1	0.18	0.19	0.08
γ_2	0.13**	0.08***	0.18***
No. of observations	268	276	276
Pooled regressions (without fixed effects)			
γ_1	0.16	0.17	0.10
γ_2	0.11**	0.06*	0.13**
No. of observations	276	284	284

for the US and Australian survey that households who are high-income or self-employed pay higher attention to inflation than low-income and employed households.

4. Quantitative Model

This section describes our HANK model which apart from inattention follows Auclert et al. (2019) two-asset model. We allow households to be inattentive to inflation and rationally decide on the amount of attention they want to allocate to it. For this, we follow Gabaix (2014) and let the households have a "sparse" representation of the world. Based on how much they allocate their attention, they optimize their consumption-savings decisions.

We assume that the steady state is common knowledge. This means that the steady state is solved under fully rational expectations. For the dynamics, we then need to incorporate 1) the households' beliefs and 2) the choice of attention.

4.1. Household Problem and Beliefs

Household's beliefs are specified similarly to Guerreiro (2022) and Gabaix (2020). Specifically, each household i solves the following Bellman equation

$$
\begin{aligned}
V_j(e_t, a_{t-1}, b_{t-1}) &= \max_{c_t, a_t, b_t} u(c_t, n_t) + \beta E_t V_j(e_{t+1}, a_t, b_t) \\
\text{s.t.} \quad & c_t + a_t + b_t = (1 - \tau_t) e_t w_t n_t + (1 + r_t^a) a_{t-1} + (1 + r_t^b) b_{t-1} - \Phi(a_t, a_{t-1}) \\
& a_t \geq 0, \quad b_t \geq \underline{b} \\
& w_t = \frac{W_t}{(1 + \pi_t) P_{t-1}}, \quad r_t^a = \frac{1 + i_t^a}{1 + \pi_t} - 1, \quad r_t^b = \frac{1 + i_t^b}{1 + \pi_t} - 1
\end{aligned} \tag{9}
$$

where W_t is nominal wage, i^a and i^b are nominal interest rates, r^a and r^b are real interest rates on illiquid and liquid assets accordingly, e_t are Bewley-type idiosyncratic income shocks, τ is the labor income tax, c, a, b and n are consumption, savings in illiquid and liquid assets and hours worked by each household.

Households observe all current and past prices. In the model with borrowing constraints this assumption also guarantees that the constraints are not violated due to misperceptions of current prices. Expectations, on the other hand, are formed based on attention households pay to inflation when forming inflation expectations. We follow the same formulation of expectations as we use in our empirical estimations, specifically

$$E_{i,t}\pi_{t+1} = \gamma^g E_t\pi_{t+1} + (1-\gamma^g)\, E_{i,t-1}\pi_{t+1} \tag{10}$$

Following Auclert et al. (2020) we solve the behavioral model using FIRE Jacobians. The following proposition shows the relationship between behavioral Jacobians and FIRE Jacobians in our setting.

Proposition 1. In the outlined above setting behavioral Jacobians could be related to FIRE Jacobians in the following form

$$J^{o,\pi}_{t,s} = \begin{cases} \gamma^g J^{FI,o,\pi}_{t,s}, & t=0,\ s>0 \\ J^{FI,o,\pi}_{t,s}, & t \geq s \\ \gamma^g J^{FI,o,\pi}_{t,s} + (1-\gamma^g) J^{o,\pi}_{t-1,s-1}, & t<s,\ t\neq 0 \end{cases} \tag{11}$$

where J^{FI} stands for FIRE Jacobians, we assume that $\forall t$ price at period t is fully observed. The groups g that we model are high-income and low-income and self-employed and workers.

Proof. See app:A.

4.2. The attention choice

The household's attention choice is incorporated via Gabaix (2014)'s sparsity operator. The household decides in every period but independent from idiosyncratic income and assets states. Each household of type j chooses attention $m^j_t \in [0,1]$ to solve the following problem

$$\min_{m^j_t} -\frac{1}{2}(1-m^j_t)^2\sigma_p^2 \sum_z \int \left(\frac{\partial c^j_t}{\partial p_t}\right)^2 \frac{\partial^2 V^j(z_t,a_t)}{\partial {c^j_t}^2} dD^j(z,da) + \kappa m^j_t \tag{12}$$

which yields a solution of

$$m^j_t = \max\left\{0, 1 - \frac{\kappa}{-\sigma_p^2 \sum_z \int \left(\frac{\partial c^j_t}{\partial p_t}\right)^2 \frac{\partial^2 V^j(z_t,a_t)}{\partial {c^j_t}^2} dD^j(z,da)}\right\} \tag{13}$$

Lemma 1. The derivative of the value function reads as $\frac{\partial^2 V(z_t,a_t)}{\partial c_t^2} = u''(c_t) + \beta p_t^2 E_t u''(c_{t+1}) \frac{1+i_t}{p_{t+1}} \frac{\partial c_{t+1}}{\partial a_{t+1}}$. For unconstrained households $\frac{\partial c_t}{\partial p_t} = -\frac{1}{\sigma}$, for borrowing-constrained households $\frac{\partial c_t}{\partial p_t} = -\frac{(1+i_{t-1})a_t + z_t W_t}{p_t^2}$.

Proof. See app:A.

The value of the price volatility is found through the fixed point. In particular, the value is guessed with an initial guess equal to a rational expectations price volatility. Then the model is solved given the guessed value of the price volatility. The price volatility is calculated based on the obtained solution and the guess is updated. The procedure is repeated until convergence.

4.3. The Rest of the Model

4.3.1. Production

Monopolistic competitive firms produce output by combining total labor input and capital using the production function:$y_t = z_t k_{t-1}^{\nu} L_t^{1-\nu}$, where y_t is the variety, z_t is the total factor productivity, ν is the capital share, k is capital and L is labour input. The optimal demand for each variety is given by $p_t = \left(\frac{Y_t}{y_t}\right)^{\frac{1}{\eta}} P_t$, where P_t is the aggregate price index and is normalized to 1 in the steady state. Firms choose labor demand, capital demand, k_t, and investment, I_t, to maximize the sum of future discounted real profits, which recursively reads as follows:

$$J_t(k_{t-1}) = \max_{p_t,k_t,I_t,L_t} \left\{ \frac{p_t}{P_t} y_t - w_t L_t - I_t - \frac{1}{2\varepsilon_I}\left(\frac{k_t - k_{t-1}}{k_{t-1}}\right)^2 k_{t-1} - \frac{\eta}{2\kappa}\ln(1+\pi_t)^2 Y_t + \frac{J_{t+1}(k_t)}{1+r_{t+1}} \right\}$$

$$\text{s.t.} \qquad k_t = (1-\delta)k_{t-1} + I_t - k_t^{adj}; \;\; p_t = \left(\frac{Y_t}{y_t}\right)^{\frac{1}{\eta}} p_t; \;\; y_t = z_t k_{t-1}^{\nu} L_t^{1-\nu} \tag{14}$$

where the first constraint is the capital accumulation equation, δ is the depreciation rate of capital, and $\frac{\eta}{2\kappa}\ln(1+\pi_t)^2 Y_t$ is the quadratic price adjustment cost. Firms also face quadratic adjustment costs on physical capital: $k_t^{adj} = \frac{1}{2\varepsilon_I}\left(\frac{k_t - k_{t-1}}{k_{t-1}}\right)^2 k_{t-1}$. Adjustment costs amplify the response of investment bringing it closer to the data. Since they are commonly employed in macro models, their inclusion facilitates the comparison of our results to past literature.

Defining q_t as the Lagrange multiplier on the capital accumulation and, hence, as the shadow price of capital, the firm's first order condition for the capital stock:

$$(1+r_{t+1})q_t = \nu z_{t+1}\left(\frac{L_{t+1}}{k_t}\right)^{1-\nu} mc_{t+1} - \\ -\left[\frac{k_{t+1}}{k_t}-(1-\delta)+\frac{1}{2\varepsilon_I}\left(\frac{k_{t+1}-k_t}{k_t}\right)^2\right]+\frac{k_{t+1}}{k_t}q_{t+1} \tag{15}$$

where mc_{t+1} is the Lagrange multiplier on the production constraint and represents real marginal cost. The first order condition with respect to investment delivers the price of capital: $q_t = 1+\frac{1}{\varepsilon_I}\left(\frac{k_t-k_{t-1}}{k_{t-1}}\right)$. The first order condition with respect to prices leads to the Phillips curve:

$$\log(1+\pi_t) = \kappa(mc_t - \frac{1}{\mu_p}) + \frac{Y_{t+1}}{Y_t}\log(1+\pi_{t+1})\Psi_{t,t+1} \tag{16}$$

where $\mu_p = \frac{\eta}{\eta-1}$ and $\Psi_{t,t+1}$ is the stochastic discount factor and is equal to $\frac{1}{1+r_{t+1}}$.

4.3.2. Equilibrium Conditions, Labor Supply and Policy

Let r_t denote the ex-post return on government bonds, v_t the price of equity and d_{t+1} the firm dividend. The real return on equity is $\frac{d_{t+1}+v_{t+1}}{v_t}$. The no-arbitrage condition is: $v_t = \frac{d_{t+1}+v_{t+1}}{1+r_{t+1}}$. The combined return on illiquid assets is: $(1+r_t^a) = \left(\frac{v_t}{\mathcal{A}_t}\right)\frac{d_t+v_t}{v_{t-1}} + \frac{B^g-\mathcal{B}_t}{\mathcal{A}_t}(1+r_t)$. The government does not issue new debt, but pays interest on the constant level B^g. The return on liquid assets is set by a representative competitive financial intermediary which transforms illiquid assets into liquid assets through a technology that operates at a proportional cost ψ. Arbitrage between the two assets, coupled with a zero profit condition on the intermediary, leads to the following expression for the return on liquid assets: $r_t^b = r_t - \psi$. Wages are determined in equilibrium by equating labor supply and demand, where labor supply is determined by the household head:

$$\varphi n_t^\rho = \int u_c(e_t, a_{t-1}, b_{t-1})(1-\tau_t)e_t w_t dD_j(e_t, a_{t-1}, b_{t-1}) \tag{17}$$

Aggregate supply of goods is equal to aggregate demand of goods, hence: $Y_t = \mathcal{C}_t + G_t + I_t + \psi\mathcal{B}_t + \Phi_t$, where $\psi\mathcal{B}_t$ is the resource cost from liquidating assets, and where all variables are aggregated through the joint distribution, D_t. Finally, asset markets clearing implies: $\mathcal{A}_t + \mathcal{B}_t = v_t + B^g$, where again aggregation is obtained through the joint distribution D_t.

Fiscal policy G_t follows a balanced-budget policy: $\tau_t \sum_{o=1}^{O} w_t^o l_{o,t} = r_t B^g + G_t$. Monetary policy follows a classical Taylor-type rule, which endogenously responds to macroeconomic conditions as follows: $i_t = r_t^* + \phi_\pi \pi_t + \phi_y (Y_t - Y_{ss})$, where i_t is the monetary policy interest rate, ϕ_π is the weight on inflation π_t, ϕ_y is the weight on output gap, $(Y_t - Y_{ss})$, r_t is the real interest rate, r_t^* is the natural interest rate, which is equal to the real interest rate in the steady state, and $1 + r_t = \frac{1+i_{t-1}}{1+\pi_t}$.

Definition 1. Competitive Equilibrium. *A Competitive Equilibrium of the economy satisfies the following definition: the sequence $[c_t, a_t, b_t]_{t=0}^{\infty}$ solves households' consumption-saving decision in Equation (9), given the distribution of idiosyncratic shocks, $P(e_{t+1}|e_t)$ and the sequence of prices $r_t^a, r_t^b, r_t, w_t, \pi_t$ nad the attetion choices. The policy functions resulting from the consumption-saving and attention problem solve a fixed point equilibrium. Aggregate asset holdings and consumption of the households are equal to the product of the individual optimal functions and the distribution of households across occupations and assets. Firms choose labor demand, and capital inputs to solve discounted profit optimization, given in Equation (14). Market clearing and the aggregate resource constraints are satisfied. Monetary policy determines the short term interest rate according to the Taylor rule and fiscal policy sets a balanced budget.*

5. Calibration

In calibrating the model to the US economy we follow Auclert et al. (2019). Calibration to Australian economy is based on Gibbs et al. (2018). Moments for the idiosyncratic income process were obtained using PLIDA administrative dataset from ABS. Wealth statistics are also taken from ABS. Output, labor hours and price level are normalized to 1.

Table 14: Parameter Values and Description

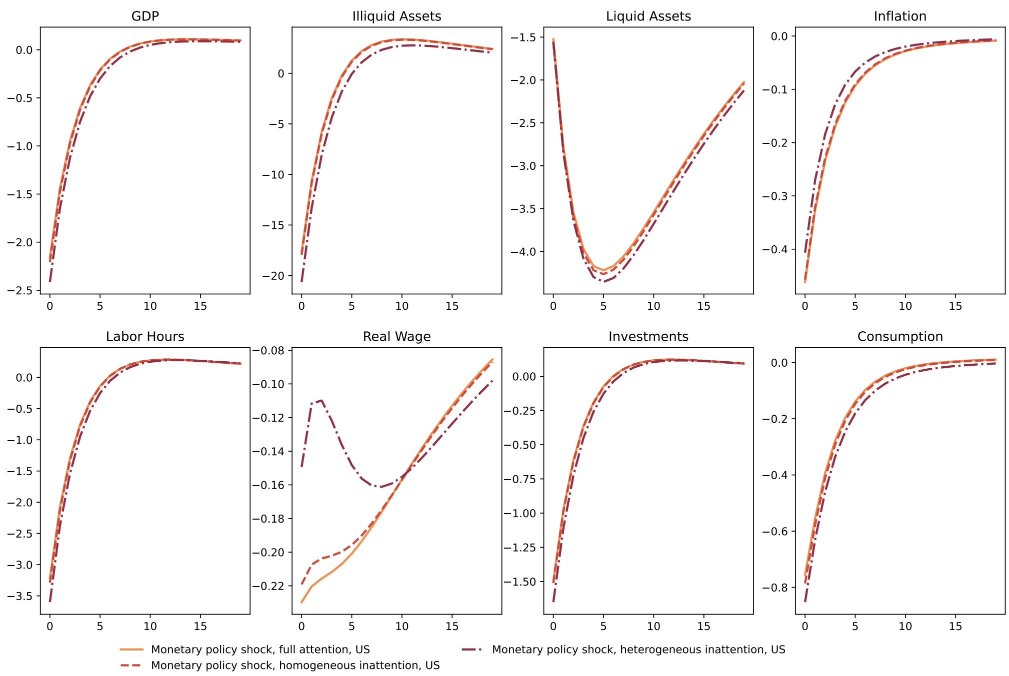
Parameter	Description	Value US	Value AUS
Production Function			
δ	Capital depreciation	0.02	0.0175
ε_I	Capital adj. parameter	4	4
K	Capital to output ratio	10.0	12.23
μ_w	Wage markup	1.1	1.2
κ	Slope of the price Phillips curve	0.1	0.06
κ_w	Slope of the wage Phillips curve	0.1	0.1
Households			
χ_0	Portfolio adj. cost pivot	0.25	0.25
χ_2	Portfolio adj. cost curvature	2	1.9915
σ	EIS	0.5	0.5
ρ	Inverse Frisch elasticity	1	1
ρ_z	Autocorrelation of earnings	0.966	0.973
σ_z	Cross-sectional std of log earnings	0.92	1.08
A	Total wealth	12.96	17.64
B	Liquid assets	1.04	3.55
Asset Markets			
r	Real interest rate	0.0125	0.00875
ψ	Liquidity premium	0.005	0.005
Monetary and Fiscal Policy			
ϕ	Coefficient on inflation in Taylor rule	1.5	1.5
ϕ_y	Coefficient on output gap in Taylor rule	0	0.0
$\mathcal{B}_g$	Bond supply	2.8	1.02
G	Government expenditures to output ratio	0.2	0.227

6. Model Results

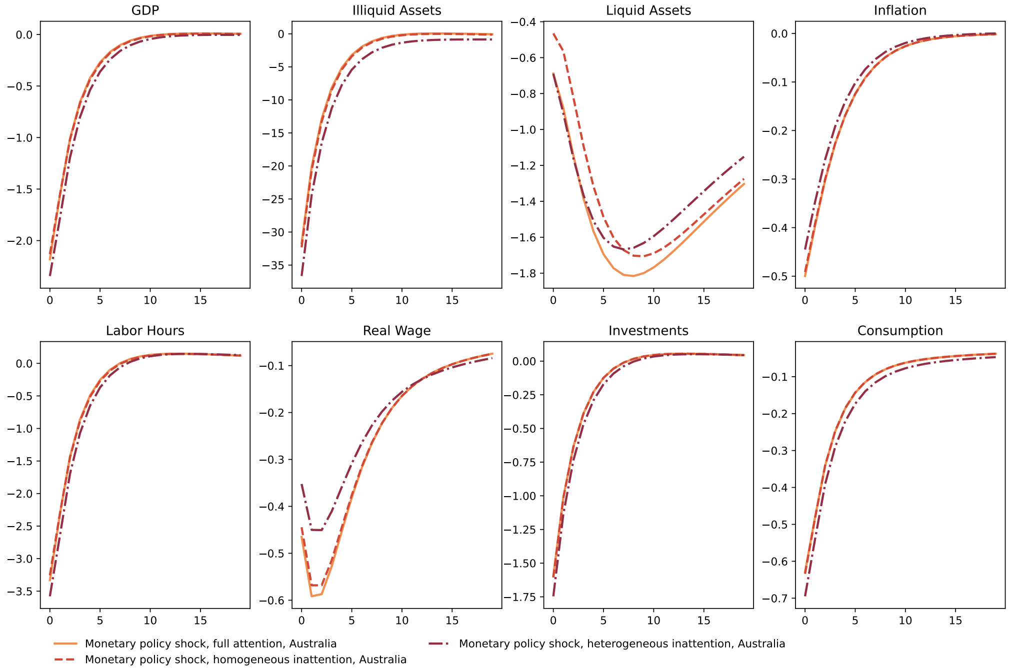
6.1. Heterogeneous Inattention along Exogeneous Income Dimension

Below we show results for Australia and the US. In both countries we model a 1% contractionary monetary policy shock. We compare impulse-responses in our baseline model with heterogeneous inattention to the two counterfactual economies: with homogeneous inattention and with fully rational expectations. In both countries a contractionary monetary policy shock induces a recession and a decrease in inflation. In all cases, wages go down because of the decrease in labor demand followed by a decrease in investments. As a result of a decrease in wages, labor supply and consumption also fall. However, with rationally inattentive households the perceived wages fall by more and the perceived interest rate increases by less. Larger perceived drop in labor income leads to a larger decrease in consumption which dominates more muted intertemporal substitution effect that stimulates consumption. This is another manifestation of a larger indirect effects compared to direct effects. At the same time, recession is deeper with inattention because of the larger drop in consumption and the inflation-output trade-off is worse with inattention.

The effects are more pronounced with heterogeneous inattention. As the consumption drop is mostly concentrated among more constrained households, the lower is their attention the larger is the perceived drop in wages which leads to a larger fall in consumption. With heterogenous attention it is indeed the case that low-income households have lower attention which is in line with our empirical estimates.



As in other two-asset models there is a flight to liquidity in all cases. In a rationally inattentive economy the effect is larger amid lower perceived real rates and especially so in Australia where the idiosyncratic risk is higher.



7. Conclusion

This paper studied the question how attention varies across distribution of households and what implications it has for monetary policy transmission. We have shown empirical cross-country evidence for varying attention across demographic groups, specifically income and self-employed. We find significant results for higher attention of high-income and self-employed households. Among different shocks, we find higher reaction to oil price shocks compared to monetary policy ones (domestic of foreign). To quantify the results we introduce rational inattention into a two-asset HANK model in which households are inattentive to inflation. We calibrate our model to match empirical eveidence on inattention that we find in the data. Counterfactual exercises show that compared to the fully rational expectations monetary policy has less of an effect on inflation, and the inflation-output trade-off is worse with inattention.

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A. Appendix A

A.1. Introducing goods and services

The same problem can be extended to incorporate goods and services inflation separately. Households solve the following Bellman equation with differential attention to the prices of goods and services

$$V^i(z_t, a^n_t) = \max_{c_t} u(c_t) + \beta E_{i,t} V^i(z_{t+1}, a^n_{t+1}) \tag{A.1}$$

$$\text{s.t. } p_t c_t + a^n_{t+1} = (1 + i_{t-1}) a^n_t + z_t W_t \tag{A.2}$$

$$c_t = \left(\frac{c^g_t}{\omega}\right)^{\omega} \left(\frac{c^s_t}{1-\omega}\right)^{\omega} \tag{A.3}$$

$$p_t = (p^g_t)^{\omega} (p^s_t)^{1-\omega} \tag{A.4}$$

$$p_t c_t = p^g_t c^g_t + p^s_t c^s_t \tag{A.5}$$

$$E_{i,t} dp^g_{t+h} = m^{i,g}_t E_t dp^g_{t+h} + (1 - m^{i,g}_t) E_{i,t-1} dp^g_{t+h} \tag{A.6}$$

$$E_{i,t} dp^s_{t+h} = m^{i,s}_t E_t dp^s_{t+h} + (1 - m^{i,s}_t) E_{i,t-1} dp^s_{t+h} \tag{A.7}$$

$$a_t \geq 0 \tag{A.8}$$

The optimal attention is chosen similarly to the case with aggregate inflation, except the attention is chosen separately for goods and services prices.

$$\min_{m^g_t, m^s_t} -\frac{1}{2} \sum_{i,j=g,s} (1 - m^i_t)(1 - m^j_t) \sigma_{i,j} \sum_z \int \left(\frac{\partial c_t}{\partial p^i_t} \frac{\partial c_t}{\partial p^j_t} \right) \frac{\partial^2 V(z_t, a_t)}{\partial c^2_t} dD(z, da) + \kappa (m^s_t + m^g_t) \tag{A.9}$$

B. Appendix B

Questions in the CASiE Survey

1. LOCATION 1. NSW - METRO 2. NSW - RURAL 3. VIC - METRO 4. VIC - RURAL 5. QLD - METRO 6. QLD - RURAL 7. SA - METRO 8. SA - RURAL 9. WA – METRO 10. WA - RURAL 11. TAS - METRO 12. TAS - RURAL 13. ACT - METRO
2. Q13D POSTCODE "And could you please tell me your Postcode" NUM
3. Q1 RESPONDENT GENDER Now just a couple of questions about yourself for analysis purposes 1. Male 2. Female
4. Q2 RESPONDENT AGE GROUP "Could you please tell me into which age group do YOU fall? " 1. 18-24 years 2. 25-34 years 3. 35-44 years 4. 45-49 years 5. 50-54 years 6. 55-64 years 7. 65+ years 8. Refused
5. Q3 RESPONDENT OCCUPATION "Are you working? " ELSE "What is YOUR current occupation? " 1 Managers and Administrators 2 Professionals 3 Para-Professionals 4 Tradespersons 5 Clerks 6 Salespersons and Personal Service Workers 7 Plant and Machine Operators and drivers 8 Labourers and Related workers 9 Retired 10 Unemployed/home duties 11 Refused 15. Cultural, Recreational, Personal and Other Services 16. Don't know/Refused
6. Q4 RESPONDENT EDUCATION LEVEL "And what level of education did/have YOU achieved? " 1. Primary 2. Secondary up to year 10 3. Full secondary 4. Non trade certificate 5. Trade certificate 7. University or tertiary degree, diploma or certificate 8. Post Graduate degree 9. Refused/Not Applicable
7. Q5 VOTING INTENTION "If a FEDERAL election was held today could you please tell me which party YOU PERSONALLY would vote for?" 1. Liberal Party 2. Australian Labor Party 3. Australian Democrats 4. The National Party 5. Greens 6. Independents/other 8. One Nation 7. None/DK
8. Q7 HOME OWNERSHIP " And about your home, is your home...? " 1. Rented 2. Owned, but with a mortgage or loan 3. Owned outright 4. Or some other type (Specify) 5. Refused/Don't know
9. Q11 HOUSEHOLD INCOME "Could you please tell me what the COMBINED HOUSEHOLD PRE-TAX INCOME is?" 1. Up to $20,000 2. $21,000 - $30,000 3. $31,000 -

$40,000 4. $41,000 - $50,000 5. $51,000 - $60,000 6. $61,000 - $70,000 7. $71,000 - $80,000 8. $81,000 - $90,000 9. $91,000 - $100,000 10. More than $100,000 11. Refused

10. Q9A NEXT YEAR EMPLOYMENT CONDITIONS "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
11. Q10A NEXT YEAR PRICE CHANGES " I'd like to find out what YOU THINK will happen to PRICES. Thinking about the prices of things you buy. (PAUSE) By this time next year, do you think they'll have gone up, down, or stayed the same?" 1. Up → Q11A1 2. Down → Q11A2 3. The same 4. Don't know/Uncertain
12. Q11A1 PRICE RISE PERCENTAGE "By what percentage do you think prices will have gone UP by this time next year?" NUM 0-100
13. Q11A2 PRICE FALL PERCENTAGE "By what percentage do you think prices will have gone DOWN by this time next year?" NUM 0-100