House Price Expectations and Inflation Expectations: Evidence from Survey Data*

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Abstract

We find that households tend to overweight house price expectations when forming their inflation expectations. The finding is robust across several specifications and two survey data sets for the United States. We also find that there is a significant effect of the cognitive abilities of households as more sophisticated households don't overweight house price inflation as much. We model this household behaviour in a two-sector New Keynesian model with an overweighted and a non-overweighted sector and analytically derive a welfare loss function consistent with the micro-foundations of the model. In this setup, we show that to gauge the correct interest rate response, the central bank needs to be aware that some sectors are overweighted and that movements in expected inflation in such sectors are important for monetary policy.

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1 Introduction

Expectations about the future course of the economy have come to play a pivotal role in macroeconomics. In this context, it has become increasingly important to understand how households form inflation expectations. For instance, Coibion et al. (2020) have found a significant role of households' priors and perceptions about inflation, their shopping experience, knowledge about monetary policy, cognitive abilities, and exposure to media coverage about the economy, as main factors influencing inflation expectations of individuals.

Amidst cognitive and informational constraints, it has been observed that households rely on their personal experiences and frequently observed prices to form expectations about inflation. For example, Coibion and Gorodnichenko (2015) and D'Acunto et al. (2021) have found that gasoline and grocery prices, respectively, play a major role in determining inflation expectations by virtue of being most frequently observed by consumers. Additionally, based on insights from psychology and memory research, and confirmed by studies observing household behaviour in economics, it has been found that people tend to focus more on extreme experiences and large changes. Bordalo et al. (2022) have found that contrasting, surprising, or prominent stimuli automatically drive the attention of the decision-maker and distract them from their original goals. This implies that individuals would focus disproportionately more on items for which extreme price changes have been observed, even if those items account for low weights in the official inflation measurement.

In this paper, we find a novel channel of salience through house price expectations. Using two sets of household survey data – Survey of Consumer Expectations (SCE) by the Federal Reserve Bank of New York (FRBNY) and the Survey of Consumers by the University of Michigan – we find that individuals overweight from house price expectations to their inflation expectations. To obtain this finding, we use instrumental variables to control for possible endogeneity through common factors and/or omitted variables. We also examine the role of cross-sectional heterogeneity. In this respect, we find that households with higher numeracy don't overweight house price inflation as much.

Subsequently, we model this household behaviour in a two-sector New Keynesian (NK) model with an overweighted and a non-overweighted sector, and analytically derive the welfare loss function using a second-order approximation to the representative household's utility. Relative to a standard two-sector NK framework, we find that this overweighting behaviour modifies the IS equation, while the NK Phillips curve and central bank's loss function remain unchanged. We show that to gauge the correct interest rate response, it is imperative for the central bank to be aware that some sectors are overweighted by consumers and that movements in expected inflation in such sectors are important for monetary policy.

The motivation for examining the salience of house prices comes from the observation that house prices have increased dramatically in the years prior to 2007 and have also received extensive media attention, especially since the global financial crisis. The preoccupation of US households with housing markets has always been strong such that it has been noticed that "house price watching has become a national pastime" (Himmelberg et al., 2005, p.67). Houses are typically the largest asset in the household portfolio and are associated with significant wealth and collateral effects. A large majority of the population in the US are homeowners and there is high geographic mobility suggesting that house prices are closely watched.[1] It is also important to note that Consumer Price Index (CPI) only accounts for the consumption part of houses, that is, housing services through rents and imputed rents, and not houses as assets. This implies that there is no direct impact of house prices on inflation. But households, as non-specialists, may not be able to make the distinction between the asset aspect of house prices and the price of housing services. They may see house prices changing and gauge signals from that to form their inflation expectations. This could potentially lead to overweighting of house price expectations to overall inflation expectations.

Our work is closely related to previous studies examining the role of the salience of frequently observed prices and large price changes in driving inflation expectations. D'Acunto et al. (2021) use novel data on the combination of prices and quantities of non-durable consumption baskets of US households, matched with their inflation expectations at the time they go shopping. They find that inflation expectations are governed by the size and frequency of household-specific grocery price changes, instead of the representative bundle, irrespective of their share in expenditure. Infrequent shoppers who tend to observe larger changes across shopping trips respond more to grocery price changes, and larger price changes have a stronger effect on inflation expectations. Coibion and Gorodnichenko (2015) have confirmed the sensitivity of consumers' expectations to oil prices using the Michigan Survey of Consumers. They find that households' inflation expectations rose sharply between 2009 and 2011 explained by the rise in the price of oil at the same time, thereby preventing a decrease in the price level. Yellen (2016) has also discussed the strong correlation between gasoline prices and the inflation

[1]As per the US Census Bureau, the homeownership rate in the country stands at 66 percent in the year 2020 and an average person moves residences more than eleven times in their lifetime.

expectations of households.

Bruine de Bruin et al. (2011) have conducted two studies to examine how respondents taking part in national surveys form their inflation expectations in order to explain the heterogeneity between responses. The first part instructed participants to recall 'any' price change and in the second part to recall the 'largest' price change; in either of the cases, households reported recalling items for which price changes were perceived to be extreme and went on to report extreme inflation expectations. They found that participants had specific prices in mind while reporting their expectations in surveys and were biased towards items associated with more extreme perceived price changes.

Our work also relates to the impact of cross-sectional heterogeneity on inflation expectations. Ehrmann et al. (2018) find that households with pessimistic attitudes about their future incomes and purchases, or those experiencing financial difficulties are associated with a stronger upward bias in their inflation expectations. In addition to everyday changes that households observe, Malmendier and Nagel (2016) document that individuals overweight the inflation experienced during their lifetimes in the sense that people who have lived through high inflationary episodes have systematically higher inflation expectations.

Additionally, our work connects with the literature on house prices, house price expectations and inflation as well. Building on the role of experiences in shaping expectations, Kuchler and Zafar (2019), using survey data, find that individuals extrapolate from their personal experiences of local house price changes and volatility to country-wide house price inflation, and that this holds irrespective of the extent of usefulness of such personal experiences. Exploiting individual heterogeneity, they find that the extrapolation is stronger for less sophisticated individuals. Adam et al. (2022) show that households revise their house price expectations too sluggishly over time and their capital gain expectations have a positive relationship with the price-to-rent ratio. Using geographically disaggregated local house price and survey data, Stroebel and Vavra (2019) establish a causal response of local retail prices to changes in local house prices driven by changes in retail markup, in areas of high homeownership rates. They find that the retail price sensitivity of homeowners decreases with an increase in house prices and firms use that opportunity to raise their markups, thereby delineating a new source of business cycle variation.

The model in our paper is related to prior work on two-sector NK models. These include, but are not limited to, Aoki (2001) with a flexible price sector and a sticky price sector, Erceg and Levin (2006), Barsky et al. (2007), Petrella et al. (2019) with durable and non-durable sectors, and Gali and Monacelli (2005) with a domestic and foreign sector for a small open economy.

The paper is structured as follows: Section 2 describes the accounting benchmark to determine the impact of house price inflation on (overall price) inflation, which is later used to check the presence of overweighting in the survey data. Section 3 describes the data and Section 4 describes the empirical results. Section 5 presents the two-sector NK model taking into account the overweighting behaviour of households, and Section 6 concludes.

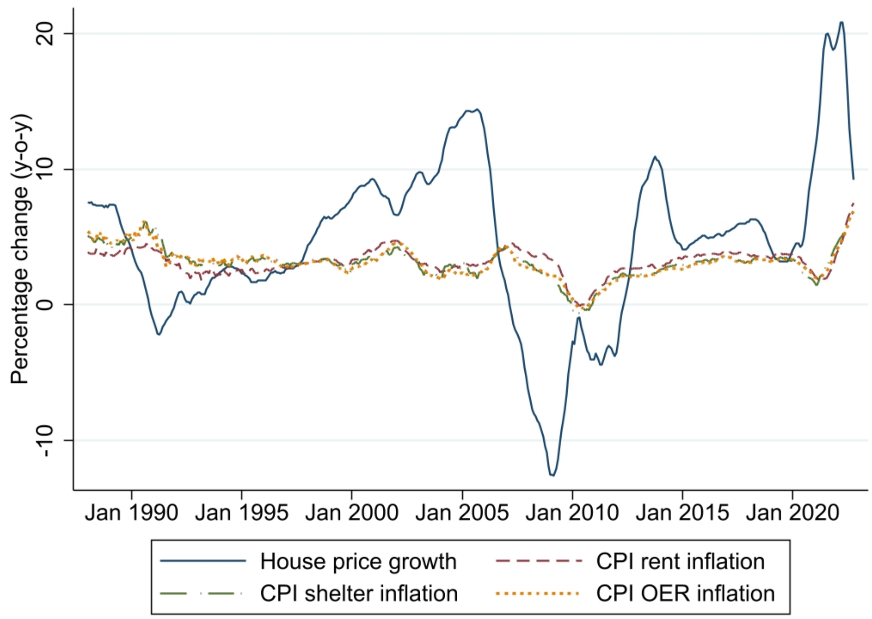
2 Estimating an accounting benchmark

In order to understand whether individuals are over or under-weighting from house price expectations to overall inflation expectations, we need to set a benchmark. This is on account of one key observation that actual house prices are not directly reflected in the CPI. Instead, CPI only reflects the consumption part of housing services relevant to the cost-of-living index. In the current practice in the United States, housing services are captured through the CPI component on 'shelter' which accounts for 32.706 per cent weight in the index; shelter, in turn, has four sub-components, namely, rent of primary residence which accounts for 7.378 per cent share, owner's equivalent rent (OER) which accounts for 24.043 per cent, lodging away from home, and tenants and household insurance account which account for 0.925 and 0.360 per cent, respectively.[2]

The OER component in CPI shelter is the imputed rent of owner-occupied housing. This represents the rent that homeowners implicitly pay to themselves to live in their home or the amount they could obtain by renting out their home. Since the majority of households in the US are homeowners, this component is very significant to keep a track of changes in housing 'services'. Over the last few decades, OER has been subject to various methodological changes: up to 1983, this used actual house prices to account for housing inflation, but that was abandoned as this reflected the asset aspect of housing, and not the consumption aspect needed for CPI. Starting in 1983, owners and renters were interviewed through housing surveys to get OER and rents information, respectively. However, since 1999, no homeowners are considered in the CPI housing survey sample, and a re-weighting of renters as per the share of homeowners in each region has been used to estimate OER. Over the period 1987 - 2022, there have been some large swings in house prices, as captured by the growth rate of the S&P/Case-Shiller U.S. National Home Price Index, while OER and other housing-related components of shelter have not kept up with these, as shown in Figure 1. These

[2]Weights in overall CPI as on October 2022 (Source: Bureau of Labour Statistics).

Figure 1: House price growth and CPI shelter inflation



Notes: This figure shows CPI shelter inflation and the two sub-components of the same: CPI-rent and CPI-OER from the Bureau of Labour Statistics, US. House price growth is the growth rate of the S&P/Case-Shiller US national home price index. The sample period runs from 1987 to 2022.

large price changes could be salient to households and might distort their inflation expectations, while not being reflected in the CPI-related targets used by the central bank.

To calculate the benchmark to get the impact of house price inflation on CPI inflation, we use linear regressions with house price growth as the independent variable and varied dependent variables under four specifications – CPI inflation, CPI shelter inflation, individual sub-components of CPI shelter, and OER sub-component of CPI shelter, respectively. These regressions are run for two different samples, namely 1987 to 2022 as well as 1999 to 2022 in order to be mindful of the changes in CPI components. All specifications include twelve leads and lags of house price growth.[3] These regression coefficients are then weighted by the relative weight of the component in CPI over the respective sample. The estimated coefficients and relative weights are reported in Table A.1 in Appendix A.1. The product of these two gives the benchmark coefficients which are reported in Table 1.

[3]We get similar results if we do not include leads and lags of house price growth.

Table 1: Benchmark coefficients

Sample	Specification 1	Specification 2	Specification 3	Specification 4
1987–2022	0.004	0.03	-	0.02
1997–2022	0.03	0.04	0.03	0.02

Notes: The benchmark coefficients in this table are the product of regression coefficients from specifications 1 – 4 with the relative weight of the respective CPI component. The regression coefficients along with relative weights are shown in Table A.1 in Appendix A.1. Specification 3 for 1987-2022 is blank because the four components of CPI shelter, as in the current practice, came into effect from 1997 onwards. Standard errors are in parentheses.

These coefficients represent the historical impact of house price growth on CPI inflation and its components, and we find that they lie in the range of 0.004 to 0.04.

3 Data description

We use two datasets which complement each other in terms of their sampling and survey methodologies, range of questions asked to households, and level of disaggregation of the survey. From these datasets, the focus of this study is on two questions: one-year-ahead inflation expectations and one-year-ahead house price expectations. In this section, we describe these two datasets and the main questions used for our analysis.

3.1 Survey of Consumer Expectations

The first dataset we use is the Survey of Consumer Expectations (SCE) from the Federal Reserve Bank of New York (FRBNY). Launched in 2013, this is a nationally representative, internet-based monthly survey of approximately 1300 household heads. It has a rotating panel structure where respondents remain in the sample for up to twelve consecutive months.

The quantitative part of the survey used for this analysis consists of three categories of questions: questions that elicit expectations of binary outcomes (such as the likelihood of the US house prices being higher in 12 months), questions that elicit pointwise expectations for continuous outcomes (such as the rate of inflation over the next 12 months), and questions that elicit respondents' probability densities for forecasts of continuous outcomes. The use of questions of the third type to get the subjective probability distribution for certain continuous outcomes is one of the innovations of the

SCE.[4]

This dataset consists of about 109,788 observations over the period from June 2013 to March 2022. For questions on inflation and house price expectations, we rely on expectations from density means from questions of the third type described above, instead of point forecasts, although similar results hold with point forecasts as well. While the basic questions regarding inflation and house price expectations are asked each time the individual takes the survey, some questions on individual-specific information are limited to repeat respondents. To be able to control for these individual characteristics, we exclude one-time respondents from the dataset and work with repeat respondents only. The summary statistics of the main variables from this dataset are presented in Table A.2 in Appendix A.2.

3.2 Michigan Survey of Consumers

The second dataset we use is the Survey of Consumers (MSC) conducted by the Survey Research Center at the University of Michigan. This is a nationally representative survey and has been conducted since 1978. The data are available at a monthly frequency wherein each month about 500 interviews of US households are conducted. This survey also has a rotating panel component as each month about 40 per cent of the households are those that were interviewed six months ago, and about 60 per cent are first-time respondents.

While this is a much older survey than the SCE, house price expectations, unlike other expectations, are only available since 2007 and only for those respondents who are homeowners. Given this, our study covers the period from January 2007 to October 2022 and contains about 67,924 observations. The dataset is only accessible at the Census region level and further geographical dis-aggregation is not available. The summary statistics of the variables used from this dataset are presented in Table A.3 in Appendix A.2.

4 Empirical results

We seek to address the question: Do house price expectations influence overall inflation expectations more than what they should? We analyse this in a linear framework

$$\pi^e_{it} = \alpha + \beta\pi^{he}_{it} + \delta X_{it} + \gamma_t + \nu_r + \epsilon_{it}, \tag{1}$$

[4] For more details on this dataset, see Armantier et al. (2017).

where the dependent variable is the one-year-ahead inflation expectations for respondent i at time t, π_{it}^{he} is the one-year-ahead house price expectations for respondent i at time t, X_{it} are the individual characteristics such as demographics and other expectations, γ_t represents time fixed effects, and ν_r are region fixed effects.

Although we control for time-fixed effects, it is plausible that both house price expectations and inflation expectations could be driven by a third common factor that could lead the individual to revise both expectations or there could be an omitted variable bias from other CPI components. For this reason, we also present results using the Instrumental Variable approach.

We instrument house price expectations with the Wharton Residential Land Use Regulatory Index (WRLURI).[5] This index is a measure of housing supply elasticity developed by Gyourko et al. (2008) and again updated by Gyourko et al. (2019) based on a national survey of local residential land use restrictions pertaining to housing or land use. This aggregate measure comprises eleven subindices that summarize information on different aspects of the regulatory environment. Higher values of this index indicate a stricter regulatory environment as the housing supply could be expanded less easily in response to a demand shock. This in turn implies higher house prices in the region, and subsequently higher house price expectations, as found by Kuchler and Zafar (2019). We use WRLURI based on the second round of survey results completed in the year 2018 from Gyourko et al. (2019). These provide measures of regulation at the state level.

Exploiting the cross-sectional variation in housing supply elasticity is a popular approach in this literature following the seminal work of Mian and Sufi (2011). This approach is useful to isolate changes in house price expectations that are plausibly orthogonal to other factors that may be directly driving the change in inflation expectations.

WRLURI is time-invariant by design as regulations pertaining to land use are not changed very frequently. Even though this is not a drawback of this instrument, an approach in the literature has been to induce time-series variation by using its interaction with other relevant variables of interest, e.g. see Aladangady (2017). In our case, since interest rates affect the user cost of housing and impact housing demand, we also use the interaction of WRLURI with the 30-year fixed mortgage rate by Freddie Mac.

Additionally, earlier work by Coibion and Gorodnichenko (2015) has found that gas and food prices influence households' inflation expectations. Therefore, it is imperative

[5] Among others, this index was recently used by Stroebel and Vavra (2019) to instrument for house price inflation in a similar context.

that we control for these expectations and also for possible endogeneity from the same. For gas price expectations, we use real gasoline taxes as the instrument. This has been previously used by Davis and Kilian (2011) and Coglianese et al. (2017) with the rationale that tax changes are typically implemented with a considerable lag making it unlikely that they are correlated with contemporaneous demand shocks. Additionally, Coglianese et al. (2017) has found that consumers may be more responsive to taxes than equal-sized changes in tax-inclusive gasoline prices because of perceived persistence and salience, and also given higher media coverage to the former. For food price expectations, we use the lagged global price of food index as the instrument. This represents the benchmark prices of the global market which is determined by the largest exporter of a given commodity, so it would introduce exogeneity.

Another approach to control for endogeneity in the household survey literature is to use lagged survey data as instruments, for e.g. in Bachmann et al. (2015). In the same spirit, we utilize the rotating panel nature of the datasets and use the six-month lagged interview data as the instrument for the current period observation. In one of the specifications we estimate in the next section, we have used these lagged observations along with other previously discussed instruments from the literature to estimate an over-identified model using Generalized Method of Moments (GMM).

4.1 Baseline results

The OLS and IV results from the SCE data are presented in Table 2. The first column shows the OLS results in the full sample; we find that a one-percentage-point increase in house price expectations increases inflation expectations of the households by 0.24 percentage-point, ceteris paribus. Comparing this with the benchmark coefficients in the range of 0.004 to 0.04, there is evidence of overweighting from house price expectations to inflation expectations. The second column of Table 2 gives the OLS results for a smaller sample where only the last interview of each household has been used. The third column presents IV results for the same sample using lagged expectations from previous interviews as instruments, and Column 4 uses WRLURI index and other instruments to present the GMM results from an over-identified model. In all cases, IV coefficients are only marginally higher than the OLS coefficients and the first-stage F statistic passes the rule-of-thumb of F greater than 10. The baseline regression results with individual fixed effects is presented in Table A.6 in the Appendix.

Across all specifications, demographics include age, income categories, education, gender, marital status, homeownership, race, and years of living in a state. Time-fixed effects include time dummies for each survey month, and we control for state-fixed

Table 2: Baseline results using SCE

Inflation expectations (1Y)	(1) OLS-Full	(2) OLS	(3) IV - 2SLS	(4) IV - GMM
House Price	0.240***	0.293***	0.458***	0.440***
Expectations (1Y)	(0.008)	(0.017)	(0.055)	(0.049)
First stage F-stat:				
House price expectations (1Y)			140.96	56.19
Gas price expectations (1Y)			43.48	27.51
Food price expectations (1Y)			75.36	38.15
Hansen J-stat(Chi-sq p-value)				0.1539
Demographics	Yes	Yes	Yes	Yes
Time Fixed Effects	Yes	Yes	Yes	Yes
State Fixed Effects	Yes	Yes	Yes	Yes
R-squared	0.2114	0.2789	0.2147	0.2162
N	107519	9064	8917	8917

Notes: Column (1) has OLS results for the full sample. Column (2) has OLS results for the smaller sample of only the last observations for each household. Column (3) has IV-2SLS results using lagged expectations as instruments. Column (4) has IV-GMM results using lagged expectations and interaction of WRLURI with real mortgage rate, real global price of food index, and real gasoline taxes as instruments. Standard errors are in parentheses. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

effects as well. We also control for gas and food price expectations.[6]

The OLS and IV results from MSC data are presented in Table 3. Column (1) presents the OLS results and we find that the coefficient on house price expectations is 0.016, which is more in line with the benchmark. But when we correct for plausible endogeneity using the instruments, the coefficients are higher than the benchmark and more in line with the SCE results, as shown in column (2). The same pattern also holds true in the case where we only consider first-time respondents, as shown in column (3) and column (4).Thus, we find that once we control for the endogeneity, there is evidence of overweighting from house price expectations to inflation expectations on the part of the households in the MSC data.

The Michigan data is available for the four Census regions, so region-fixed effects have been added for OLS. A set of demographics to control for individual characteristics

[6]Table A.4 in Appendix A.3 presents the OLS results with and without controlling for gas and food price expectations. We find that the coefficient on house price expectations goes down to 0.251 from 0.240 when these controls are added.

Table 3: Baseline results using MSC

Price expectations (1Y)	(1) OLS-Full	(2) IV-Full	(3) OLS	(4) IV
House price expectations (1Y)	0.016***	0.251**	0.018**	0.363***
	(0.003)	(0.100)	(0.004)	(0.139)
First stage F-stat:				
House price expectations (1Y)		30.15		16.43
Gas price expectations (1Y)		199.14		107.79
Over-identification test:				
Hansen J-statistic (Chi-sq p-value)		0.7100		0.9661
Time fixed effects	Yes	Yes	Yes	Yes
Region fixed effects	Yes	No	Yes	No
Demographics	Yes	Yes	Yes	Yes
N	58210	58210	33663	33663

Notes: Column (1) has OLS results for the full sample. Column (2) has IV-GMM results for the full sample using WRLURI, the interaction of WRLURI with real 30-year mortgage rate, real gasoline taxes and lagged real gasoline prices as instruments for the full sample. Region-fixed effects are not included in this specification as they are collinear with the WRLURI instrument. Columns (3) and (4) repeat the same for first-time respondents. Standard errors are in parentheses.$^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

have been included as well which include age of the respondent, gender, marital status, income, household size, whether the respondent is a college graduate and whether the respondent is a high school graduate. Idiosyncratic expectations such as gas price expectations, interest rate expectations, expectations on the economic outlook, chances of increase in family income, durables and home buying attitudes, among others have also been controlled for.

4.2 Cross-sectional heterogeneity

In this section, we examine how respondent characteristics could explain differences in the extent of overweighting from house price expectations to overall inflation expectations of households. We examine the role of cognitive abilities captured through numeracy and education.

The SCE includes a measure of respondents' numeracy, captured through questions on the basics of probability and compound interest. Participants who answer at least four of the five questions correctly are deemed to have high numeracy (Ben-David et al., 2018). The effect of education is captured through an individual being (minimum of) a graduate versus not. In our sample, around 73 per cent of individuals have a high numeracy score and 57 per cent of individuals are graduates or higher.

Table 4: By numeracy and education

Inflation expectations (1Y)	(1) Numeracy	(2) Education
High Numeracy*House Price Expectations (1Y)	0.198***	
	(0.009)	
Low Numeracy*House Price Expectations (1Y)	0.303***	
	(0.014)	
Graduate*House Price Expectations (1Y)		0.197***
		(0.010)
Not a graduate*House Price Expectations (1Y)		0.274***
		(0.012)
Statistical Difference in Coefficients (Wald Test)	0.0000	0.0000
Demographics	Yes	Yes
Time Fixed Effects	Yes	Yes
State Fixed Effects	Yes	Yes
R-squared	0.214	0.212
N	107519	107519

Notes: This uses the SCE data. Column (1) looks at the impact of numeracy. Participants who answer at least four out of five questions on numeracy in the survey correctly are classified as 'high numeracy' individuals. Column (2) looks at the impact of the respondent having a minimum of a graduate degree. Standard errors are in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

The analysis of the role of cognitive abilities through these characteristics reveals some interesting results, presented in Table 4. We find that high numeracy individuals overweight less from house price expectations to inflation expectations compared to their low numeracy counterparts. We also find that the difference between the two categories is statistically significant. The same results hold for those who are graduates or higher, i.e. they overweight less from house price expectations to their overall inflation expectations. The difference between the two groups is statistically significant as well. These results make a lot of sense as we would expect less sophisticated individuals, i.e. those with relatively lower numeracy or education qualifications to be more influenced by the signals from salient prices.

More results from the examination of cross-sectional heterogeneity in the datasets are presented in Appendix A.4. The different characteristics considered include homeownership, probability of moving to new residences, having moved residences since the last survey, expected financial situation, gender, age cohort experiences, etc.

5 Model

In this section, we present a two-sector closed economy New Keynesian model by extending the one-sector framework of Galí (2015). The model is a stylized framework representative of any two sectors, in which households focus more on one of the sectors relative to its true weight. In this respect, this part of the paper breaks new ground and applies more generally to the modelling and monetary policy implications of overweighting in any good, including the findings relative to gas prices and groceries in Coibion and Gorodnichenko (2015) and D'Acunto et al. (2021), respectively.

As such, the model has two non-durable sectors, and we abstract from the effects of durable goods. In addition to the reason mentioned above, including a durable sector would make the impact of overweighting per se difficult to single out. This is because previous work by Erceg and Levin (2006) has shown that durable sectors are more interest rate sensitive relative to non-durables, which introduces additional trade-offs for monetary policy. Moreover, Barsky et al. (2007) show that the durable goods sector matters disproportionately more for monetary policy. Given this, we abstract from the channel of durability and uncover the impact of overweighting in the simplest and more general framework. This modelling choice also offers the benefit of obtaining analytical results.[7]

The economy consists of three types of agents: a representative household, firms and the central bank. We assume that there is full labour mobility between the two sectors so that there is a uniform wage rate in the economy, and that there are no sectoral linkages in production. In what follows, let O denote the overweighted sector which is more salient to the households and N denote the non-overweighted sector.

5.1 Households

The representative infinitely-lived household chooses a composite consumption good, C_t, and supplies labour, L_t, to maximize the present discounted value of the expected utility function

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \mathbb{U}(C_t, L_t), \tag{2}$$

[7]With this framework, we are able to show that overweighting has consequences for optimal monetary policy. Extending the results of the previous work by Erceg and Levin (2006) and Barsky et al. (2007) would likely mean that an overweighted durable sector would be even more significant.

where $\beta \in (0,1)$ is the discount factor and

$$\mathbb{U}(C_t, L_t) = \frac{C_t^{1-\sigma}}{1-\sigma} - \frac{L_t^{1+\phi}}{1+\phi}, \tag{3}$$

where σ is the inverse of inter-temporal elasticity of substitution and ϕ is the inverse of Frisch elasticity of labour supply. The household's aggregate consumption, C_t, depends on consumption of the overweighted good, $C_{O,t}$, and non-overweighted good, $C_{N,t}$, according to a Cobb-Douglas technology given by

$$C_t \equiv \frac{\left(C_{N,t}\right)^{1-\omega} \left(C_{O,t}\right)^{\omega}}{\omega^{\omega} \left(1-\omega\right)^{1-\omega}}, \tag{4}$$

where $0 < \omega < 1$ is the share of the overweighted sector in total consumption. The sectoral consumption, C_j for $j = N, O$, is in turn a CES aggregate of quantities of the continuum of differentiated goods (of variety i) in the two sectors given by

$$C_{j,t} \equiv \left(\int_0^1 C_{j,t}\left(i\right)^{\frac{\varepsilon_j - 1}{\varepsilon_j}} di\right)^{\frac{\varepsilon_j}{\varepsilon_j - 1}}, \;\; j = N, O,$$

where $\varepsilon_j > 1$ is the elasticity of substitution between the varieties within each sector. The aggregate price index P_t is defined as

$$P_t = \left(P_{N,t}\right)^{1-\omega} \left(P_{O,t}\right)^{\omega}, \tag{5}$$

where $P_{N,t}$ is the price of the non-overweighted consumption good and $P_{O,t}$ is the price of the overweighted good. Define relative price ratio, $S_t = \frac{P_{O,t}}{P_{N,t}}$, such that

$$P_t = P_{N,t} S_t^{\omega} = P_{O,t} S_t^{\omega - 1}. \tag{6}$$

The sectoral price index is

$$P_{j,t} = \left(\int_0^1 P_{j,t}\left(i\right)^{1-\varepsilon_j} di\right)^{\frac{1}{1-\varepsilon_j}}, \;\; j = N, O,$$

where $P_{j,t}(i)$ is the price charged by firm i in sector j for $j = N, O$. The household maximizes utility (3) subject to the intertemporal budget constraint

$$\int_0^1 P_{N,t}\left(i\right) C_{N,t}\left(i\right) di + \int_0^1 P_{O,t}\left(i\right) C_{O,t}\left(i\right) di + Q_t B_t \leq B_{t-1} + W_t L_t + T_t, \tag{7}$$

where W_t denotes the nominal wages, B_t are one-period bonds at price Q_t held by the household, T_t is a lump-sum component of income like dividends from ownership of firms. This also includes the solvency condition, $\lim_{T\to\infty} \mathbb{E}_t\{B_T\} \geq 0$.

To motivate how we bring the empirically observed household behaviour into the model where individuals focus disproportionately more on one good when forming their inflation expectations, define a new parameter δ as the excess weight that households assign to the overweighted good. Also, define $\tilde{\mathbb{E}}_t\pi_{t+1}$ to be the distorted expectations of one-year-ahead inflation that are affected by over-weighting and $\mathbb{E}_t\pi_{t+1}$ as the rational one-year-ahead inflation expectations without any overweighting. Then, we have

$$\begin{aligned}\tilde{\mathbb{E}}_t\pi_{t+1} = \mathbb{E}_t\tilde{\pi}_{t+1} &= (1-\omega-\delta)\mathbb{E}_t\pi_{N,t+1} + (\omega+\delta)\mathbb{E}_t\pi_{O,t+1}, \\ &= \mathbb{E}_t\pi_{t+1} + \delta(\mathbb{E}_t\pi_{O,t+1} - \mathbb{E}_t\pi_{N,t+1}),\end{aligned} \tag{8}$$

where $\mathbb{E}_t\tilde{\pi}_{t+1}$ is the rational expectation of inflation which is computed with the wrong weights and $\mathbb{E}_t\pi_{j,t+1}, j = N, O$ is the sectoral inflation expectations. This implies that the distorted expectations of inflation where households give excess weight to sector O are equivalent to rational inflation expectations computed with distorted weights. Note that with $\delta = 0$, i.e. when there is no overweighting, we have $\tilde{\mathbb{E}}_t\pi_{t+1} = \mathbb{E}_t\tilde{\pi}_{t+1} = \mathbb{E}_t\pi_{t+1}$.

To incorporate this in the model, the aggregate price index would be modified in periods t and $t+1$ to reflect the households' 'perceived' price index, relative to (5) as follows

$$\begin{aligned}\mathbb{E}_t\tilde{P}_{t+1} &= \mathbb{E}_t P_{N,t+1}^{1-\omega-\delta} P_{O,t+1}^{\omega+\delta}, \\ \tilde{P}_t &= P_{N,t}^{1-\omega-\delta} P_{O,t}^{\omega+\delta},\end{aligned} \tag{9}$$

where $\tilde{P}$ is the overweighted perceived price index for the households.

From the household's optimisation problem, the Euler equation is

$$\beta Q_t^{-1}\mathbb{E}_t\left\{\left(\frac{C_{t+1}}{C_t}\right)^{-\sigma}\frac{\tilde{P}_t}{\tilde{P}_{t+1}}\right\} = 1. \tag{10}$$

Note that when $\delta = 0$, that is when households are not focusing disproportionately on one sector, we are back to the original two-sector NK model without any overweighting.

5.2 Firms

On the production side, there are two distinct sectors in the economy which produce goods in sectors O and N. There is a continuum of firms, indexed by $i \in [0, 1]$ within each sector $j = N, O$ which produce differentiated goods for consumption. Each firm faces a common production technology

$$Y_{j,t}(i) = A_{j,t} L_{j,t}(i),$$

where $Y_{j,t}(i)$ is the output of firm i in sector j, and $L_{j,t}(i)$ is the hours of labour employed by firm i in sector j. $A_{j,t}$ is the sector-specific productivity shock that follows an autoregressive process

$$a_{j,t} = \rho_{a_j} a_{j,t-1} + \varepsilon_{a_j,t},$$

where $a_{j,t} \equiv log A_{j,t}$ and $\varepsilon_{a_j,t} \sim i.i.d(0, \sigma_{a_j})$. Since labour is assumed to be fully mobile across the two sectors, there is a uniform wage rate in the economy. The nominal marginal cost for each firm in sectors $j = N, O$ is

$$MC^n_{j,t} = \frac{W_t}{A_{j,t}}.$$

The firms face identical sectoral demands taking aggregate price level P_t and consumption C_t as given. Following Calvo (1983), a firm in sector j resets its price with probability $(1 - \theta_j)$ in any given period and a fraction θ_j keeps their prices unchanged. Thus, the sectoral prices evolve according to

$$P_{j,t} = \left[\int\limits_{s_j(t)}^{1} P_{j,t-1}^{1-\varepsilon_j}(i)\, di + (1 - \theta_j) \left(P^*_{j,t}\right)^{1-\varepsilon_j} \right]^{\frac{1}{1-\varepsilon_j}},$$

which simplifies to

$$P_{j,t} = \left[\theta_j P_{j,t-1}^{1-\varepsilon_j} + (1 - \theta_j) P^*_{j,t} \right]^{\frac{1}{1-\varepsilon_j}},$$

where $P^*_{j,t}$ is the common price chosen by the firms of sector j at time t and $s_j(t) \subset [0, 1]$ represents the set of firms not re-optimizing their posted price in period t. The firms which are able to update their prices choose price $P^*_{j,t}$ which maximises the expected present discounted value of future profits subject to a sequence of demand constraints for $k \geq 0$. That is,

$$\max_{P^*_{j,t}} \mathbb{E}_t \sum_{k=0}^{\infty} \theta_j^k Q_{t,t+k} \Pi_{j,t+k},$$

where $Q_{t,t+k}$ is the stochastic discount factor for nominal pay-offs between t and $t + k$, and $\Pi_{j,t+k} = P^*_{j,t} Y_{j,t+k} - TC^n_{j,t+k|t}(Y_{j,t+k})$ are the nominal profits for firms in sector j at time $t+k$ given that price chosen at t is being charged. $Y_{j,t+k}$ is the output in period k in sector j, and $TC^n(.)$ is the nominal total cost function.

Now, consider the case where the households' overweighting behaviour enters the firm's problem. This is a relevant case as Coibion and Gorodnichenko (2015) have shown that households' inflation expectations are a good proxy to the inflation expectations of firms. Hence it would be important to look at the impact of overweighting on the price-setting behaviour of firms. One way to incorporate household behaviour in the firm's problem is through the stochastic discount factor, $Q_{t,t+k} = \beta^k \left(\frac{C_{t,t+k}}{C_t}\right)^{-\sigma} \frac{\tilde{P}_t}{\tilde{P}_{t+k}}$, where $\tilde{P}$ reflects the distorted price index. The first order condition which maximizes the firm's profits and determines the price is:

$$\mathbb{E}_t \sum_{k=0}^{\infty} \theta_j^k \left[\beta^k \left(\frac{C_{t+k}}{C_t}\right)^{-\sigma} \frac{\tilde{P}_t}{\tilde{P}_{t+k}} \left(\frac{P^*_{j,t}}{P_{j,t+k}}\right)^{-\varepsilon_j} Y_{j,t+k} \left(P^*_{j,t} - \frac{\varepsilon_j}{1-\varepsilon_j} MC^n_{j,t+k|t} \right) \right] = 0, \quad (11)$$

where $MC^n_{j,t+k|t}$ is the nominal marginal cost for a firm in sector j at time $t+k$ which last reset its price in t.

5.3 Equilibrium

We complete the non-policy part of the model by adding the dynamic IS equation and NK Phillips Curve. As standard in the literature, the Euler equation (10) can be log-linearised around a zero inflation steady state to determine the dynamic IS equation

$$\tilde{y}_t = \mathbb{E}_t \tilde{y}_{t+1} - \frac{1}{\sigma}\left(i_t - \mathbb{E}_t \tilde{\pi}_{t+1} - r^n_t\right), \quad (12)$$

where $\tilde{y}_t \equiv y_t - y^n_t$ is the (welfare relevant) output gap, y^n_t is the natural level of output, i_t is the nominal interest rate, and $r^n_t = \rho + \sigma \psi^n_{ya} \mathbb{E}_t \Delta a_{t+1}$ is the natural real interest rate with $\psi^n_{ya} = \frac{1+\phi}{\phi+\sigma}$ and $\rho = -\log \beta$.

To understand the impact of overweighting on the IS equation and how it differs from the standard framework, substitute equation (8) in (12) to get

$$\tilde{y}_t = \mathbb{E}_t \tilde{y}_{t+1} - \frac{1}{\sigma}\left(i_t - \mathbb{E}_t \pi_{t+1} - \underbrace{\delta(\mathbb{E}_t \pi_{O,t+1} - \mathbb{E}_t \pi_{N,t+1})}_{\text{impact of overweighting}} - r^n_t \right). \quad (13)$$

Accordingly, the real interest rate r_t is

$$r_t = i_t - \mathbb{E}_t \tilde{\pi}_{t+1}, \quad (14)$$

where the impact of overweighting is reflected through $\mathbb{E}_t\tilde{\pi}_{t+1}$ relative to $\mathbb{E}_t\pi_{t+1}$ in the standard NK framework.

To determine the dynamics of inflation in terms of the sectoral output gap and relative prices, we log-linearise the firm's optimal price setting equation (11) to get

$$p^*_{j,t} = (1-\theta_j\beta)\sum_{k=0}^{\infty}\theta_j^k\beta^k\mathbb{E}_t\left[\hat{mc}^r_{j,t+k} + p_{j,t+k}\right]. \tag{15}$$

We show in Appendix A.6.1 that equation (15) is identical to equation (A.8) where the latter is derived without incorporating the overweighting of households (in Appendix A.6), as in the standard NK framework. We show that this is the case as the terms in $\tilde{p}$ drop out in equation (A.10). Hence, the perceived price index incorporated in the firm's problem through the stochastic discount factor does not alter the price-setting equation. This gives the standard sectoral Phillips curves even in the presence of overweighting, as follows:

$$\pi_{N,t} = \beta\mathbb{E}_t\pi_{N,t+1} + \chi_N\left((\sigma+\phi)\tilde{y}_{N,t} + (1-\sigma-\phi)\omega\tilde{s}_t\right) + u_{N,t} \tag{16}$$

and

$$\pi_{O,t} = \beta\mathbb{E}_t\pi_{O,t+1} + \chi_O\left((\sigma+\phi)\tilde{y}_{O,t} + (\sigma+\phi-1)\left(1-\omega\right)\tilde{s}_t\right) + u_{O,t}, \tag{17}$$

where $\tilde{s}_t$ is the relative price ratio gap , $\chi_j = \frac{(1-\theta_j)(1-\beta\theta_j)}{\theta_j}$, and $u_{j,t}$ are the sector-specific cost-push shocks for $j = N, O$. The sectoral cost-push shocks for $j = N, O$ follow an exogenous AR(1) process

$$u_{j,t} = \rho_{u_j}u_{j,t-1} + \varepsilon_{u_j,t}, \qquad \varepsilon_{u_j,t} \sim i.i.d(0, \sigma_{u_j}).$$

The aggregate NK Phillips curve in the economy is the sector-weighted aggregation of the sectoral Phillips curves (16) and (17) as

$$\pi_t = (1-\omega)\pi_{N,t} + \omega\pi_{O,t}. \tag{18}$$

5.4 Welfare function

We derive the welfare function based on the micro-foundations of the model described in the previous section. Based on Woodford (2003) and Galí (2015), assuming that the monetary authority aims to maximise the welfare of the representative household, we obtain a second-order Taylor approximation of the representative consumer's lifetime utility when the economy remains in a neighbourhood of an efficient steady state. This gives the following loss function for the central bank

$$\frac{\mathcal{W}}{U_C'C} \approx -\frac{1}{2}E_0\Sigma_{t=0}^{\infty}\beta^t\Bigg[(1-\omega)\,\tilde{y}_{N,t}^2+\omega\tilde{y}_{O,t}^2+(\sigma+\phi-1)\,\tilde{y}_t^2 + \frac{\varepsilon_N}{\chi_N}(1-\omega)\,\pi_{N,t}^2+\frac{\varepsilon_O}{\chi_O}\omega\pi_{O,t}^2\Bigg]+t.i.p+O\,\|\xi\|^3\,, \tag{19}$$

where $t.i.p$ denotes the terms independent of policy and $O\,\|\xi\|^3$ includes terms of order higher than two. The welfare function balances the fluctuations in sectoral output gaps along with the variability in sectoral inflation rates.[8] Since (19) does not depend on δ, we find that the overweighting per se does not introduce an additional policy trade-off for the central bank.

Therefore, we find that the model with an overweighted sector differs from the standard two-sector framework with respect to the IS equation. The NK Phillips curve and the welfare function remain the same, even if firms in addition to households also display overweighting behaviour. Given this, it is sufficient to set the nominal rate in line with the expected inflation to stabilize the distortions from overweighting. For completeness, we show this in the next subsection.

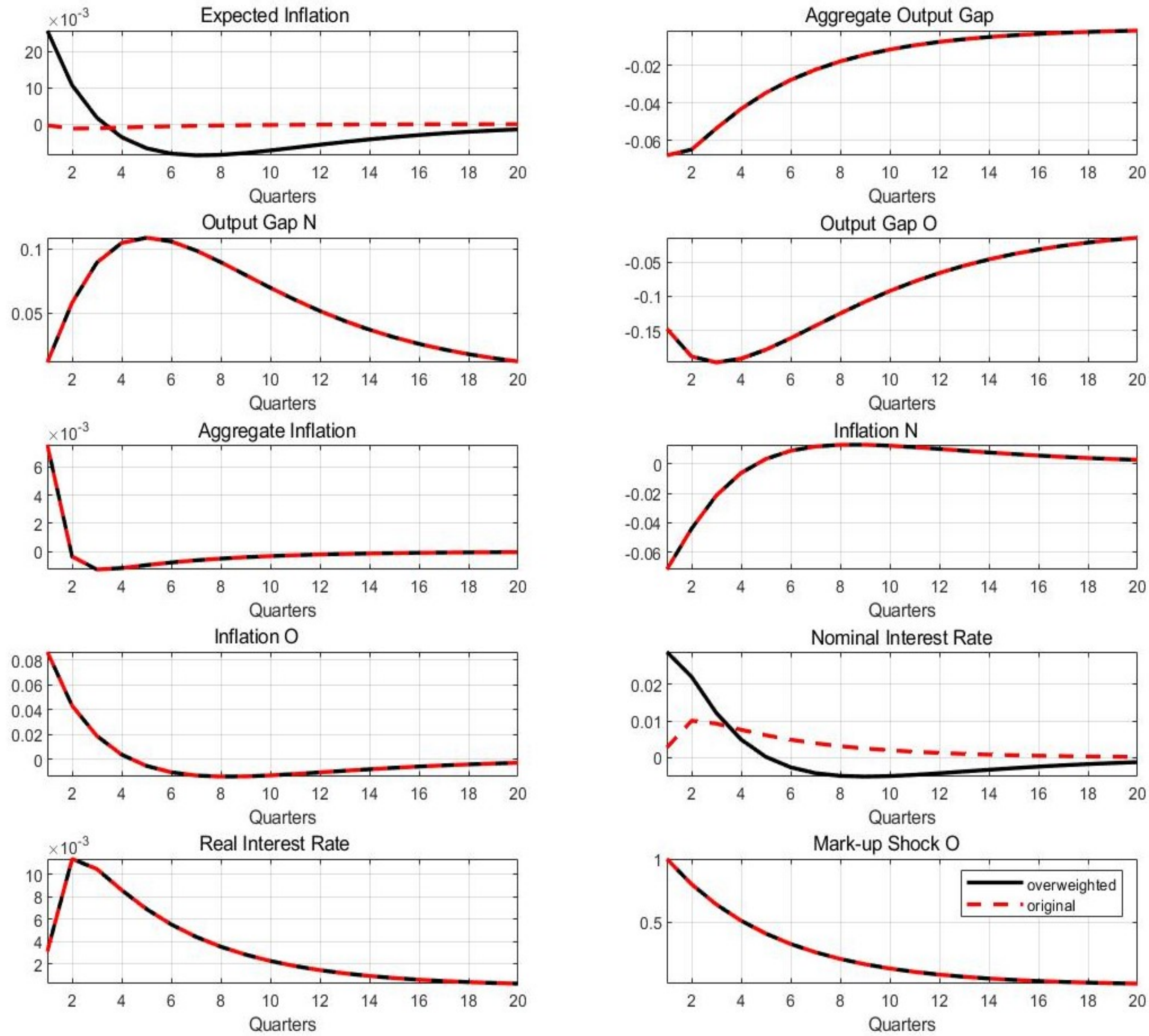
5.5 Ramsey policy

The optimal policy problem of the central bank is of minimising the welfare loss function (19) subject to the IS equation (13) and sectoral Philips curves (16) and (17). We show the Ramsey policy response to a markup shock in the over-weighted sector in Figure 2 and compare it to the standard two-sector NK framework with no overweighting, i.e. $\delta = 0$. For this exercise, we assume the two sectors have equal weight and $\delta = 0.3$ in the overweighted model.

We see that in both the overweighted and the standard two-sector models, inflation in sector O increases and the output gap goes down in response to a markup shock in the sector. As sector O now produces less, wages fall and this makes inflation in sector N also go down. Overall the economy experiences higher inflation and a negative aggregate output gap. The optimal policy response of the central bank is to increase the nominal interest rate in line with expected inflation in both models. As expected inflation in the overweighted model is higher on account of a shock in sector O being overweighted by households, the nominal interest rate needs to be raised more strongly relative to the standard two-sector model. We see that the final allocations in the model with

[8] Note that with $\omega = 1$, that is by putting all weight on a single sector, this loss function becomes identical to the standard one-sector loss function as in Galí (2015).

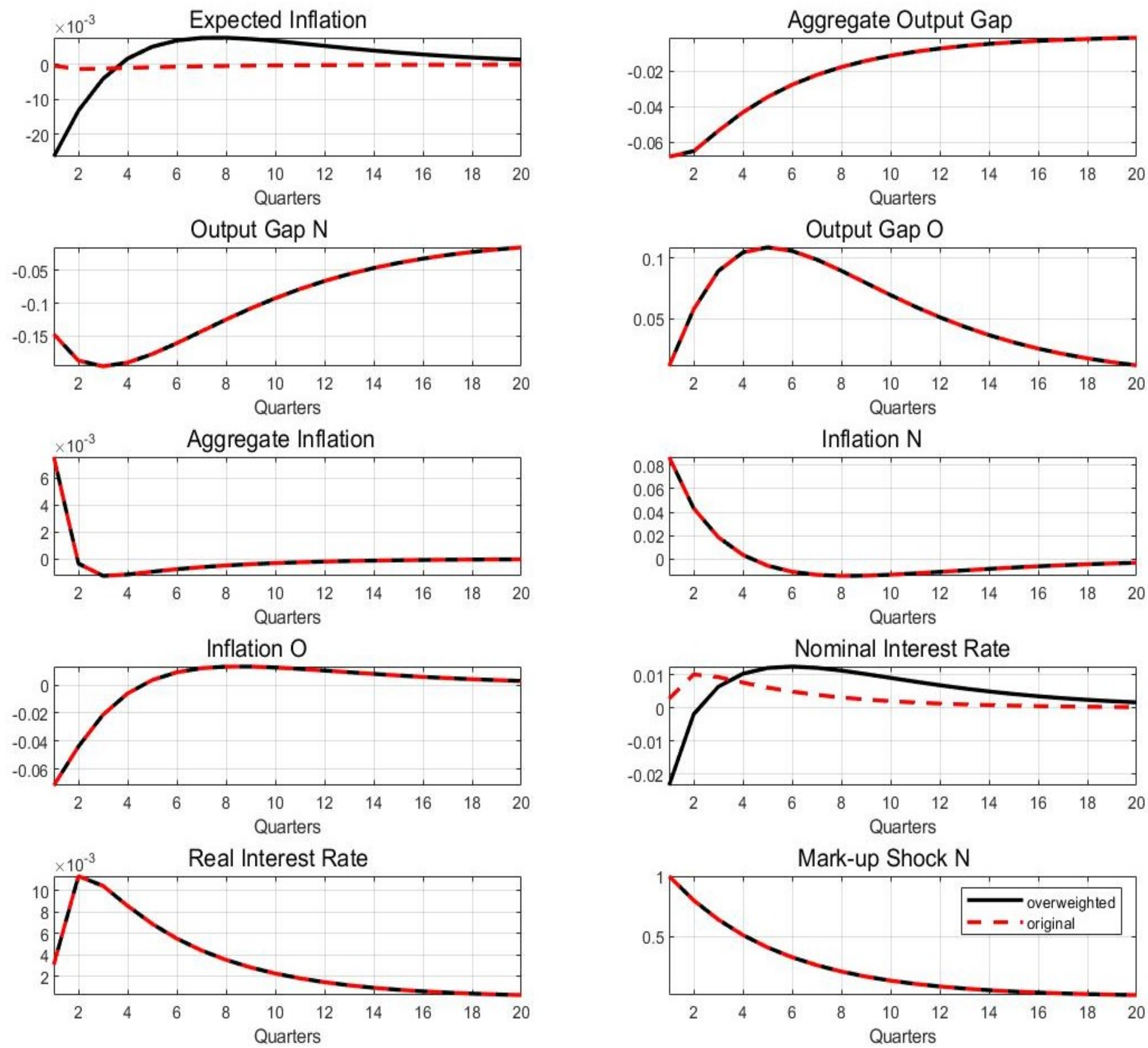
Figure 2: Optimal response to a persistent markup shock in sector O



Notes: The figure shows the impulse responses of selected variables to a persistent one per cent markup shock in the overweighted sector. All series are in per cent deviations from their steady state except for the interest rate which is in absolute deviation from the steady state. The black line corresponds to the model which accounts for the overweighting while the red dashed line corresponds to the model with no overweighting.

and without overweighting are the same, including the real interest rate. However, the policy instrument which is the nominal interest rate is different in the two models and needs to move in line with the respective expected inflation. The symmetric response to a markup shock in the non-overweighted sector N is in Figure 3.

Figure 3: Optimal response to a persistent markup shock in sector N



Notes: The figure shows the impulse responses of selected variables to a persistent one per cent markup shock in the non-overweighted sector. All series are in per cent deviations from their steady state except for the interest rate which is in absolute deviation from the steady state. The black line corresponds to the model which accounts for the overweighting while the red dashed line corresponds to the model with no overweighting.

6 Conclusion

Recent literature on salience has found that individuals focus disproportionately more on frequently observed prices and large price changes when forming their inflation expectations, even if those items account for low weight in official inflation measurement. The impact of gas and grocery prices in this regard has been well-established in the literature. In this paper, we find a novel channel through house prices. The motivation to look at house prices is that these are one of the larger price changes observed by households which are given substantial media attention, especially since the global financial crisis. High homeownership rates and geographic mobility in the United States also suggest that house prices are watched closely. Also, since houses are one of the biggest assets in a household's portfolio and are associated with significant wealth and collateral effects, there is a preoccupation with house prices among individuals.

Using two household survey data sets for the US, we examine the relationship between house price expectations and inflation expectations. We use the instrumental variable approach to control for possible endogeneity through common causes and/or omitted variable bias. We find that households tend to overweight their house price expectations when forming their inflation expectations. Furthermore, we find that there is a significant impact of the cognitive abilities of individuals in this behaviour as more sophisticated individuals overweight by a lesser degree.

Subsequently, we model this overweighting behaviour in a two-sector NK Model, with an overweighted sector and a non-overweighted sector. We find that the model with an overweighted sector differs from the standard two-sector framework with respect to the IS equation. The NK Phillips curve and the welfare function remain the same, even if firms in addition to households also display overweighting behaviour. In this model, overweighting per se does not introduce an additional policy trade-off for the central bank. Crucially, the nominal interest rate needs to be set differently; the central bank needs to realize that there is overweighting on the part of the households and measure inflation expectations correctly such that it sets the policy instrument appropriately.

This is a stylized model and can be representative of any two non-durable sectors that are captured in the CPI basket, such as grocery, gasoline or housing 'services', among others. Thus, these results extend to any sector(s) that is salient to households and we show that knowledge of such household behaviour has implications for monetary policy. It is important that the central bank is aware that some sectors are overweighted in consumers' inflation expectations. Once the central bank takes that into account, it is able to deliver the appropriate nominal interest rate.

In future research, we plan to make use of additional data sets to examine if there is overweighting of housing in inflation expectations in more countries. In this paper, we have kept the model as simple as possible in order to understand the direct implications of overweighting. As a next step, we will also analyze if additional trade-offs and interactions arise in more complex frameworks.

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Appendix

A.1 Benchmark coefficients

To get an 'accounting' benchmark, we regress CPI and components of CPI relevant to housing on house price inflation. We use four different specifications, where the independent variable is house price growth and the dependent variable in the respective specification is (1) CPI inflation, (2) CPI shelter inflation, (3) sub-components of CPI shelter inflation, and (4) OER sub-component of CPI shelter inflation. All specifications include twelve leads and lags of house price growth. The regression coefficients from each specification are then weighted by the relative weight of that specific component in the CPI over two sample periods, 1987 to 2022 and 1997 to 2022. The relative weights and estimated coefficients are as in Table A.1. The product of the coefficient with the relative weight gives the benchmark coefficients which are reported in Table 1 in the main text.

Table A.1: Relative weights of CPI components and estimated coefficients

CPI component	CPI inflation		Shelter		Rent of primary residence	
Sample	Average weight	Coefficient	Average weight	Coefficient	Average weight	Coefficient
1987 – 2022	1	0.004	0.310	0.087	0.071	0.086
1997 – 2022	1	0.033	0.322	0.123	0.068	0.090

CPI component	Lodging away from home		Owners equivalent rent of residences		Tenants and HH's insurance	
Sample	Average weight	Coefficient	Average weight	Coefficient	Average weight	Coefficient
1987 – 2022			0.222	0.072		
1997 – 2022	0.016	0.141	0.233	0.107	0.003	-0.032

Notes: The independent variable is house price growth across all specifications. Specification (1) has CPI inflation as the dependent variable. In specification (2), the dependent variable is CPI shelter where the 'average weight' refers to the average share of shelter in the aggregate CPI index over the specified sample periods. For specification (3), each of the components of CPI shelter – rent of primary residence, lodging away from home, owners equivalent rent, and tenants and households insurance – are regressed on house price inflation, one at a time. The relative weight of each component in the CPI is reported next to the coefficients. A weighted sum of these coefficients gives the benchmark coefficient in the main text from this specification. We only estimate the 1997-2022 sample period under this specification since the current practice of reporting these four components came into practice in 1997. In specification (4), the dependent variable is OER inflation. The average weight is the share of OER in the aggregate CPI index over the sample. All specifications include twelve leads and lags of the independent variable. Standard errors are in parentheses, *$p < 0.10$, **$p < 0.05$, ***$p < 0.01$.

A.2 Summary statistics

For the SCE data, the summary statistics for the main variables are in Table A.2. The full sample includes about 109788 observations. The average one-year-ahead inflation expectations are about 3.82 per cent, the average one-year-ahead house price expectations are 4.36 per cent, and the average one-year-ahead gas, food and rent price expectations are 7.02, 6.45, and 7.99 per cent, respectively. The average age in the sample is around 51 years and about 47 per cent of the respondents are females. 57 per cent of the respondents are a minimum of college graduates and 73 percent of the respondents have high numeracy skills. Additionally, 55 per cent of respondents are employed full-time, 73 per cent of the respondents are homeowners and around 64 per cent of respondents are married or living with someone. Around 36 percent of the respondents have household income in the range of $50000-100000 and around 29 percent have household incomes above $100000.

Table A.2: Summary statistics - SCE

Variable	Obs	Mean	Std. Dev.	Min	Max	P25	P50	P75
Inflation Exp.(1Y)	109788	3.82	4.8	-36	36	1	3	5
House Price Exp.(1Y)	109187	4.36	5.64	-36	36	1	3	6
Food Price Expectations (1Y)	110341	6.45	5.79	-5	30	3	5	10
Gas Price Exp. (1Y)	110341	7.02	9.31	-15	50	2	5	10
Rent Exp. (1Y)	110341	7.99	7.55	-6	50	3	5	10
Graduate or Higher	110122	.57	.49	0	1	0	1	1
Gender	110319	.47	.49	0	1	0	0	1
Age	110311	50.94	15.21	17	99	38	52	63
Homeowner	110332	.73	.44	0	1	0	1	1
Married or living with someone	110331	.64	.47	0	1	0	1	1
Employed full-time	110341	.55	.49	0	1	0	1	1
Household Income (over 100K)	109179	.29	.45	0	1	0	0	1
Household Income (50-100K)	109179	.36	.48	0	1	0	0	1
Numeracy (high)	110302	.73	.44	0	1	0	1	1

For the Michigan Survey of Consumers, the summary statistics for the variables of interest are in Table A.3. The full sample includes about 67,924 observations. The average one-year-ahead inflation expectations are about 3.6 per cent, the average one-year-ahead house price expectations are 1.4 per cent and the average gas price expectations are 6.03 per cent. The twelve-month-ahead gas price expectations in the interview look at the expected increase/decrease in gas prices in cents per gallon. The US All-Grade Conventional Gas Price series has been used to convert this into one-year-ahead gas price expectations.

The average age in the sample is around 55 years and about 42 per cent of the respondents are females. Close to 60 per cent of the respondents are a minimum of college graduates while almost the entire sample has graduated high school. Around 71 per cent of respondents are married or living with someone. The average family size is more than two individuals and the average total household income is $109382.

Table A.3: Summary statistics - MSC

Variable	Obs	Mean	Std. Dev.	Min	Max	P25	P50	P75
Price expectations (1Y)	67924	3.60	4.02	-20	20	1	3	5
House price expectations (1Y)	67924	1.40	4.97	-20	20	0	0	4
Gas price expectations (1Y)	67924	6.03	9.66	-15.04	50.32	0	2.30	9.45
College graduate	67661	.60	.48	0	1	0	1	1
High school graduate	67730	.97	.15	0	1	1	1	1
Age	67517	54.96	15.74	18	97	44	56	66
Gender	67924	.42	.49	0	1	0	0	1
Marital status	67850	.71	.45	0	1	0	1	1
Family Size	67924	2.64	1.36	1	13	2	2	3
Total household income (current USD)	64648	109382.7	89611.66	2400	500000	50000	85000	140000
Market value of home	67924	845433.1	2181054	1000	9999998	150000	250000	450000

A.3 Additional regression results

Table A.4 presents the OLS results after controlling for gas and food price expectations using the SCE data. We find that the coefficient on house price expectations goes down to 0.24 as reported in the main text in Table 2. For this reason, all specifications in the main text include gas and food expectations.

Table A.4: Controlling for other expectations

	(1)	(2)	(3)
Inflation expectations (1Y)	(1)	(2)	(3)
House Price	0.251^{***}	0.248^{***}	0.240^{***}
Expectations (1Y)	(0.009)	(0.008)	(0.008)
Gas Price		0.053^{***}	0.020^{***}
Expectations (1Y)		(0.003)	(0.003)
Food Price			0.154^{***}
Expectations (1Y)			(0.006)
Demographics	Yes	Yes	Yes
Time Fixed Effects	Yes	Yes	Yes
State Fixed Effects	Yes	Yes	Yes
Other Expectations	Yes	Yes	Yes
R-squared	0.182	0.191	0.2114
N	107519	107519	107519

Notes: This uses SCE data. Column (1) has OLS coefficients for the impact of house price expectations on inflation expectations. Columns (2) and (3) control for gas price expectations, and gas as well as food price expectations, respectively. Standard errors are in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

The baseline results for first-time respondents only using MSC data are shown in Table A.5. The baseline regression results for SCE with individual fixed effects are shown in Table A.6.

Table A.5: Baseline results for first-time respondents

Price expectations (1Y)	(1) OLS	(2) IV-GMM
House price expectations (1Y)	0.019***	0.396***
	(0.006)	(0.139)
First stage F-stat:		
House price expectations (1Y)		15.47
Gas price expectations (1Y)		74.31
Hansen J-stat(Chi-sq p-value)		0.5383
Time fixed effects	Yes	Yes
Region fixed effects	Yes	No
Demographics	Yes	Yes
N	34695	33663

Notes: This uses MSC data. Column (1) has OLS for first-time respondents. Column (2) has IV-GMM results for first-time respondents using WRLURI, the interaction of WRLURI with real 30-year mortgage rate, and real gasoline taxes, and lagged real gasoline prices as instruments. Standard errors are in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A.6: Baseline with individual fixed effects

Inflation Expectations (1Y)	(1)
House Price Expectations (1Y)	0.137***
	(0.007)
Time Fixed Effects	Yes
State Fixed Effects	Yes
Other Expectations	Yes
R-squared	0.046
N	107519

Notes: This uses SCE data. Standard errors are in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

A.4 Cross-sectional heterogeneity

We explore cross-sectional heterogeneity in both datasets. We first examine the impact of having moved residences recently, by looking at respondents in SCE who answer affirmatively to the question, "Since [last survey Month Year], have you moved to a different primary residence (the place where you usually live)?". This is shown in Table A.7 along with how this differs for homeowners and renters. We find that those who have moved homes since the last survey overweight house price expectations more than those who haven't, irrespective of home-ownership status.

Table A.7: By home-ownership and having moved since the last survey

	(1)	(2)	(3)
Inflation Expectations(1Y)	All	Homeowners	Renters
Moved home recently*House	0.335***	0.332***	0.345***
Price Expectations (1Y)	(0.028)	(0.039)	(0.043)
Not Moved home recently*House	0.238***	0.220***	0.273***
Price Expectations (1Y)	(0.008)	(0.009)	(0.017)
Stat. diff. in coefficients (Wald Test)	0.0005	0.0032	0.0905
Demographics	Yes	Yes	Yes
Time Fixed Effects	Yes	Yes	Yes
State Fixed Effects	Yes	Yes	Yes
Other Expectations	Yes	Yes	Yes
R-squared	0.210	0.215	0.209
N	107502	78915	26730

Notes: This uses SCE data. Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Subsequently, we split the sample between homeowners and renters to look at the impact of likelihood of default i.e. not being able to make one of the debt payments (that is, the minimum required payments on credit and retail cards, auto loans, student loans, mortgages, or any other debt) in Table A.8. This is useful to understand the impact of (pessimistic) attitudes on overweighting behaviour. We find that irrespective of homeownership, those who have a likelihood of default overweight from house price expectations more than those who do not expect to default on their payments.

Next, we look at the impact of gender and age-cohorts in Table A.9. We find that females overweight more from house price expectations relative to males, and the difference is statistically significant. Also, those in the age group of over 60 overweight the least from house price expectations, but the difference across age groups is not statistically significant.

Table A.8: By likelihood of default

Inflation expectations (1Y)	(1) Homeowner	(2) Renter
Default*House Price	0.251***	0.296***
Expectations (1Y)	(0.015)	(0.021)
No default*House	0.211***	0.259***
Price Expectations (1Y)	(0.010)	(0.018)
Statistical Difference in Coefficients (Wald Test)	0.0052	0.0645
Demographics	Yes	Yes
Time Fixed Effects	Yes	Yes
State Fixed Effects	Yes	Yes
Other Expectations	Yes	Yes
R-squared	0.216	0.210
N	78888	26706

Notes: This uses SCE data. Standard errors are in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A.9: By gender and age

Inflation expectations (1Y)	(1) Gender	(2) Age
Male*House Price Expectations (1Y)	0.196***	
	(0.012)	
Female*House Price Expectations (1Y)	0.273***	
	(0.010)	
Age (> 60)*House Price Expectations (1Y)		0.228***
		(0.012)
Age (40 - 60)*House Price Expectations (1Y)		0.246***
		(0.012)
Age (< 40)*House Price Expectations (1Y)		0.249***
		(0.015)
Statistical Difference in Coefficients (Wald Test)	0.0000	0.3856
Demographics	Yes	Yes
Time Fixed Effects	Yes	Yes
State Fixed Effects	Yes	Yes
Other Expectations	Yes	Yes
R-squared	0.212	0.210
N	107519	107519

Notes: This uses SCE data. Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

A.5 Derivation of the IS equation

Log-linearizing the Euler equation (10) after imposing market clearing condition $y_t = c_t$ gives

$$y_t = \mathbb{E}_t y_{t+1} - \frac{1}{\sigma}\left(i_t - \mathbb{E}_t \tilde{\pi}_{t+1} - \rho\right). \tag{A.1}$$

Substituting the real interest rate $r_t = i_t - \mathbb{E}_t \tilde{\pi}_{t+1}$ in the above gives

$$y_t = \mathbb{E}_t y_{t+1} - \frac{1}{\sigma}\left(r_t - \rho\right). \tag{A.2}$$

Equation (A.2) in the case of natural output is

$$y_t^n = \mathbb{E}_t y_{t+1}^n - \frac{1}{\sigma}\left(r_t^n - \rho\right). \tag{A.3}$$

Subtracting $(A.3)$ from $(A.2)$

$$\tilde{y}_t \equiv y_t - y_t^n = \left[\mathbb{E}_t y_{t+1} - \frac{1}{\sigma}\left(i_t - \mathbb{E}_t \tilde{\pi}_{t+1} - \rho\right)\right] - \left[\mathbb{E}_t y_{t+1}^n - \frac{1}{\sigma}\left(r_t^n - \rho\right)\right],$$

gives the IS in the main text, equation (13).

To get the natural real interest rate, from $(A.1)$ we get

$$\mathbb{E}_t \Delta y_{t+1} = \frac{1}{\sigma}\left(i_t - \mathbb{E}_t \tilde{\pi}_{t+1} - \rho\right).$$

Natural output is defined as

$$y_t^n = \psi_{ya}^n a_t + \vartheta_y^n,$$

where $\psi_{ya}^n = \frac{1+\phi}{\phi+\sigma}$ and ϑ_y^n is a set of constants.
Taking the first difference of the above gives

$$\mathbb{E}_t \Delta y_{t+1}^n = \psi_{ya}^n \mathbb{E}_t \Delta a_{t+1}. \tag{A.4}$$

Using equation (A.4), we then evaluate equation (13) for r_t^n to yield an expression for r_t^n as

$$r_t^n = i_t - \mathbb{E}_t \pi_{t+1} - \sigma\left(\mathbb{E}_t \hat{y}_{t+1} - \hat{y}_t\right).$$

Simplifying further,

$$r_t^n = i_t - \mathbb{E}_t \pi_{t+1} - \sigma\left(\mathbb{E}_t\left(y_{t+1} - y_{t+1}^n\right) - \left(y_t - y_t^n\right)\right) = i_t - \mathbb{E}_t \pi_{t+1} - \sigma\left(\mathbb{E}_t \Delta y_{t+1} - \mathbb{E}_t \Delta y_{t+1}^n\right).$$

This gives the final expression for the natural level of interest rate

$$r_t^n = \rho + \sigma \psi_{ya}^n \mathbb{E}_t \Delta a_{t+1}. \tag{A.5}$$

This shows that the natural level of interest rate is a function of expected technological progress as well as households' discount rate, as in the standard NK framework, and is not affected by the households' overweighting behaviour.

A.6 Derivation of the NKPC

In this section, we show the derivation of the sectoral NKPCs in the case without accounting for the overweighting behaviour of the households.
The firm's profit maximization problem is given by

$$\max_{P_{j,t^*}} \Sigma_{k=0}^{\infty}\theta_j^k \mathbb{E}_t\left[Q_{t,t+k}\left(P_{j,t}^* Y_{j,t+k}(i) - TC_{j,t+k|t}^n \left(Y_{j,t+k}(i)\right)\right)\right],$$

where $TC_{j,t+k|t}^n$ denotes the nominal total cost of the firm in sector j. Substituting the demand functions and using the market clearing conditions we get

$$\max_{P_{j,t^*}} \Sigma_{k=0}^{\infty}\theta_j^k \mathbb{E}_t\left[Q_{t,t+k}\left(P_{j,t}^*\left(\frac{P_{j,t}^*}{P_{j,t+k}}\right)^{-\epsilon_j} C_{j,t+k} - TC_{j,t+k|t}^n\left(\left(\frac{P_{j,t}^*}{P_{j,t+k}}\right)^{-\epsilon_j} C_{j,t+k}\right)\right)\right].$$

Substituting the discount factor $Q_{t,t+k} = \beta^k \left(\frac{C_{t+k}}{C_t}\right)^{-\sigma} \frac{P_t}{P_{t+k}}$ and maximizing with respect to $P_{j,t}^*$, the first-order condition is

$$\Sigma_{k=0}^{\infty}\theta_j^k \mathbb{E}_t\left[\beta^k\left(\frac{C_{t+k}}{C_t}\right)^{-\sigma}\frac{P_t}{P_{t+k}}\left((1-\epsilon_j)\left(\frac{P_{j,t}^*}{P_{j,t+k}}\right)^{-\epsilon_j} C_{j,t+k} + MC_{j,t+k|t}^n \epsilon_j \left(\frac{P_{j,t}^*}{P_{j,t+k}}\right)^{-1-\epsilon_j}\frac{C_{j,t+k}}{P_{j,t+k}}\right)\right] = 0.$$

This simplifies to

$$\Sigma_{k=0}^{\infty}\theta_j^k \mathbb{E}_t\left[\beta^k\left(\frac{C_{t+k}}{C_t}\right)^{-\sigma}\frac{P_t}{P_{t+k}}\left(\frac{P_{j,t}^*}{P_{j,t+k}}\right)^{-\epsilon_j} C_{j,t+k}\left(P_{j,t}^* - \frac{\epsilon_j}{\epsilon_j - 1} MC_{j,t+k|t}^n\right)\right] = 0.$$

Using the sectoral prices to get the real marginal cost we get

$$\Sigma_{k=0}^{\infty}\theta_j^k \mathbb{E}_t\left[\beta^k\left(\frac{C_{t+k}}{C_t}\right)^{-\sigma}\frac{P_t}{P_{t+k}}\left(\frac{P_{j,t}^*}{P_{j,t+k}}\right)^{-\epsilon_j} C_{j,t+k}\left(P_{j,t}^* - \frac{\epsilon_j}{\epsilon_j - 1} MC_{j,t+k|t}^r P_{j,t+k}\right)\right] = 0.$$

Solving further and dividing by $P_{j,t-1}$ throughout

$$\begin{aligned} &\frac{P_{j,t}*}{P_{j,t-1}}\Sigma_{k=0}^{\infty}\theta_j^k \mathbb{E}_t\left[\beta^k\left(\frac{C_{t+k}}{C_t}\right)^{-\sigma}\frac{P_t}{P_{t+k}} P_{j,t+k}^{\epsilon_j} C_{j,t+k}\right] \\ &= \frac{\epsilon_j}{\epsilon_j - 1}\Sigma_{k=0}^{\infty}\theta_j^k \mathbb{E}_t\left[\beta^k\left(\frac{C_{t+k}}{C_t}\right)^{-\sigma}\frac{P_t}{P_{t+k}}\left(P_{j,t+k}^*\right)^{1+\epsilon_j} C_{j,t+k} MC_{j,t+k|t}^r \frac{1}{P_{j,t-1}}\right]. \end{aligned} \tag{A.6}$$

Now, the first-order Taylor expansion of the LHS is

$$\Sigma_{k=0}^{\infty}\theta_j^k\beta^k P_j^{\varepsilon_j}C_j\Bigg[1+\left(\frac{P_{j,t}^*-P_j}{P_j}\right)-\left(\frac{P_{j,t-1}-P_j}{P_j}\right)+(-\sigma)\left(\frac{C_{t+k}-C}{C}\right)-(-\sigma)\left(\frac{C_t-C}{C}\right)+ \left(\frac{P_t-P}{P}\right)-\left(\frac{P_{t+k}-P}{P}\right)+\varepsilon_j\left(\frac{P_{j,t+k}-P_j}{P_j}\right)+\left(\frac{C_{j,t+k}-C_j}{C_j}\right)\Bigg].$$

This simplifies to

$$\Sigma_{k=0}^{\infty}\theta_j^k\beta^k P_j^{\varepsilon_j}C_j[1+\left(p_{j,t}^*-p_j\right)-\left(p_{j,t-1}-p_j\right)+(-\sigma)\left(c_{t+k}-c\right)-(-\sigma)\left(c_t-c\right) +\left(p_t-p\right)-\left(p_{t+k}-p\right)+\varepsilon_j\left(p_{j,t+k}-p_j\right)+\left(c_{j,t+k}-c_j\right)].$$

Next, consider the first-order Taylor expansion of the RHS

$$\frac{\varepsilon_j}{\varepsilon_j-1}\Sigma_{k=0}^{\infty}\theta_j^k\mathbb{E}_t\beta^k P_j^{\varepsilon_j}C_j MC_j^r\Bigg[1+(-\sigma)\left(\frac{C_{t+k}-C}{C}\right)-(-\sigma)\left(\frac{C_t-C}{C}\right)+(1+\varepsilon_j)\left(\frac{P_{j,t+k}-P_j}{P_j}\right) -\left(\frac{P_{t+k}-P}{P}\right)+\left(\frac{P_t-P}{P}\right)+\left(\frac{C_{j,t+k}-C_j}{C_j}\right)-\left(\frac{P_{j,t-1}-P_j}{P_j}\right)+\left(\frac{MC_{j,t+k|t}^r-MC_j^r}{MC_j^r}\right)\Bigg],$$

which further simplifies to

$$\frac{\varepsilon_j}{\varepsilon_j-1}\Sigma_{k=0}^{\infty}\theta_j^k\mathbb{E}_t\beta^k P_j^{\varepsilon_j}C_j MC_j^r[1+(-\sigma)\left(c_{t+k}-c\right)-(-\sigma)\left(c_t-c\right)+(1+\varepsilon_j)\left(p_{j,t+k}-p_j\right) -\left(p_{t+k}-p\right)+\left(p_t-p\right)+\left(c_{j,t+k}-c_j\right)-\left(p_{j,t-1}-p_j\right)+\left(mc_{j,t+k|t}^r-mc_j^r\right)]. \tag{A.7}$$

Combining the LHS and RHS, we get

$$\sum_{k=0}^{\infty}\theta_j^k\beta^k\mathbb{E}_t\left(p_{j,t}^*-p_{j,t+k}\right)=\frac{\varepsilon_j}{\varepsilon_j-1}MC_j^r\sum_{k=0}^{\infty}\theta_j^k\beta^k\mathbb{E}_t\left[mc_{j,t+k|t}^r-mc_j^r\right],$$

which simplifies to

$$p_{j,t}^*=(1-\theta_j\beta)\sum_{k=0}^{\infty}\theta_j^k\beta^k\mathbb{E}_t\left[mc_{j,t+k|t}^r-mc_j^r+p_{j,t+k}\right].$$

Substituting $mc^r_{j,t+k|t} = mc^r_{j,t+k}$ and $mc^r_{j,t+k} - mc^r_j = \hat{mc}^r_{j,t+k}$ we get

$$p^*_{j,t} = (1-\theta_j\beta)\sum_{k=0}^{\infty}\theta_j^k\beta^k\mathbb{E}_t\left[\hat{mc}^r_{j,t+k} + p_{j,t+k}\right]. \tag{A.8}$$

Subtracting $p_{j,t-1}$ from both sides and simplifying,

$$\begin{aligned}
p^*_{j,t} - p_{j,t-1} &= (1-\theta_j\beta)\sum_{k=0}^{\infty}\theta_j^k\beta^k\mathbb{E}_t\left[\hat{mc}^r_{j,t+k} + p_{j,t+k} - p_{j,t-1}\right], \\
&= (1-\theta_j\beta)\sum_{k=0}^{\infty}\theta_j^k\beta^k\mathbb{E}_t\hat{mc}^r_{j,t+k} + (1-\theta\beta)\sum_{k=0}^{\infty}\theta_j^k\beta^k\mathbb{E}_t\left(p_{j,t+k} - p_{j,t-1}\right), \\
&= (1-\theta_j\beta)\sum_{k=0}^{\infty}\theta_j^k\beta^k\mathbb{E}_t\hat{mc}^r_{j,t+k} + (1-\theta_j\beta)\,\mathbb{E}_t[\theta_j^0\beta^0\left(p_{j,t} - p_{j,t-1}\right) + \theta_j^1\beta^1(p_{j,t+1} - p_{j,t} \\
&\quad + p_{j,t} - p_{j,t-1}) + \theta_j^2\beta^2\left(p_{j,t+2} - p_{j,t+1} + p_{j,t+1} - p_{j,t} + p_{j,t} - p_{j,t-1}\right) + ...], \\
&= (1-\theta_j\beta)\sum_{k=0}^{\infty}\theta_j^k\beta^k\mathbb{E}_t\hat{mc}^r_{j,t+k} + \mathbb{E}_t\left[\theta_j^0\beta^0\pi_{j,t} + \theta_j^1\beta^1\pi_{j,t+1} + \theta_j^2\beta^2\pi_{j,t+2} + ...\right], \\
&= (1-\theta_j\beta)\sum_{k=0}^{\infty}\theta_j^k\beta^k\mathbb{E}_t\hat{mc}^r_{j,t+k} + (1-\theta_j\beta)\sum_{k=0}^{\infty}\theta_j^k\beta^k\mathbb{E}_t\left(\pi_{j,t+k}\right).
\end{aligned}$$

We can take out $k=0$ terms from each of the summation operators to write the above equation compactly as a difference equation. Using $\pi_{j,t} = (1-\theta_j)\left(p^*_{j,t} - p_{j,t-1}\right)$, we get

$$\begin{aligned}
p^*_{j,t} - p_{j,t-1} &= \theta_j\beta\left[(1-\theta_j\beta)\sum_{k=0}^{\infty}\theta_j^k\beta^k\mathbb{E}_t\hat{mc}^r_{j,t+k+1} + \sum_{k=0}^{\infty}\theta_j^k\beta^k\mathbb{E}_t\left(\pi_{j,t+k+1}\right)\right] + (1-\theta_j\beta)\,\hat{mc}^r_{j,t} + \pi_{j,t}, \\
&= \theta_j\beta\mathbb{E}_t\left(p^*_{j,t+1} - p_{j,t}\right) + (1-\theta_j\beta)\,\hat{mc}^r_{j,t} + (1-\theta_j)\left(p^*_{j,t} - p_{j,t-1}\right), \\
&= \beta\left(1-\theta_j\right)\mathbb{E}_t\left(p^*_{j,t+1} - p_{j,t}\right) + \left(\frac{(1-\theta_j)(1-\theta_j\beta)}{\theta_j}\right)\hat{mc}^r_{j,t}.
\end{aligned}$$

This gives the NKPC in terms of marginal cost

$$\pi_{j,t} = \beta\mathbb{E}_t\pi_{j,t+1} + \chi_j\hat{mc}^r_{j,t},$$

where $\chi_j = \frac{(1-\theta_j)(1-\theta_j\beta)}{\theta_j}$.

To derive NKPCs in terms of output gaps as in equations (16) and (17) in the main text, we begin by linearizing the price ratio defined in equation (6). This gives $p_t = p_{N,t} + \omega_t = p_{O,t} + (\omega - 1)\,s_t$. To derive equation (16), the real marginal cost of a firm in sector N can be defined as

$$
\begin{aligned}
mc^r_{N,t} &= w_t - p_{N,t} - a_{N,t}, \\
&= w_t - p_t + \omega s_t - a_{N,t}, \\
&= \sigma y_t + \phi l_t - a_{N,t} + \omega s_t, \\
&= \sigma y_t + \phi y_t - \phi a_t - a_{N,t} + \omega s_t, \\
&= (\sigma + \phi) y_{N,t} - (\sigma + \phi)\omega s_t - \phi a_t - a_{N,t} + \omega s_t, \\
&= (\sigma + \phi) y_{N,t} + (1 - \sigma - \phi)\omega s_t - \phi a_t - a_{N,t},
\end{aligned}
$$

where we have used the household's labour supply condition, $w_t - p_t = \sigma c_t + \phi l_t$, demand relation, $c_{N,t} = \omega s_t + c_t$, and market clearing condition $c_{N,t} = y_{N,t}$.
We have $\hat{mc}^r_{N,t} = mc^r_{N,t} - mc^r_N = (\sigma + \phi)\hat{y}_{N,t} + (1 - \sigma - \phi)\omega \hat{s}_t$.
Hence, the sectoral NKPC for sector N is

$$
\pi_{N,t} = \beta \mathbb{E}_t \pi_{N,t+1} + \chi_N \left((\sigma + \phi)\hat{y}_{N,t} + (1 - \sigma - \phi)\omega \hat{s}_t \right).
$$

Proceeding in the same way, we get the sectoral NKPC for sector O

$$
\pi_{O,t} = \beta \mathbb{E}_t \pi_{O,t+1} + \chi_O \left((\sigma + \phi)\hat{y}_{O,t} + (\sigma + \phi - 1)(1 - \omega)\hat{s}_t \right).
$$

A.6.1 NKPC in case of over-weighting

In the presence of overweighting, equation (11) in the main text for $j = N$ is

$$
\frac{P_{N,t}*}{P_{N,t-1}} \Sigma_{k=0}^{\infty} \theta_N^k E_t \left[\beta^k \left(\frac{C_{t,t+k}}{C_t} \right)^{-\sigma} \frac{P_{N,t}^{1-\omega-\delta} P_{O,t}^{\omega+\delta}}{P_{N,t+k}^{1-\omega-\delta} P_{O,t+k}^{\omega+\delta}} P_{N,t+k}^{\epsilon_N} C_{N,t+k} \right]
$$
$$
= \frac{\varepsilon_N}{\varepsilon_N - 1} \Sigma_{k=0}^{\infty} \theta_N^k E_t \left[\beta^k \left(\frac{C_{t,t+k}}{C_t} \right)^{-\sigma} \frac{P_{N,t}^{1-\omega-\delta} P_{O,t}^{\omega+\delta}}{P_{N,t+k}^{1-\omega-\delta} P_{O,t+k}^{\omega+\delta}} \left(P_{N,t+k}\right)^{1+\epsilon_N} C_{N,t+k} MC^r_{N,t+k|t} \frac{1}{P_{N,t-1}} \right]. \tag{A.9}
$$

This is the equivalent of equation (A.6) in the presence of overweighting behaviour of households through the 'perceived' price index in the stochastic discount factor.

Taking the first-order Taylor expansion of the LHS of the above

$$\Sigma_{k=0}^{\infty}\theta_N^k\beta^k P\frac{P_N^{\epsilon_N+\omega+\delta-1}}{P_O^{\omega+\delta}}C_N\Big[1+\left(\frac{P_{N,t}^{*}-P_N}{P_N}\right)-\left(\frac{P_{N,t-1}-P_N}{P_N}\right)+(-\sigma)\left(\frac{C_{t+k}-C}{C}\right)$$
$$-(-\sigma)\left(\frac{C_t-C}{C}\right)+(1-\omega-\delta)\left(\frac{P_{N,t}-P_N}{P_N}\right)+(\omega+\delta)\left(\frac{P_{O,t}-P_O}{P_O}\right)$$
$$+(\epsilon_N+\omega+\delta-1)\left(\frac{P_{N,t+k}-P_N}{P_N}\right)-(\omega+\delta)\left(\frac{P_{O,t+k}-P_O}{P_O}\right)+\left(\frac{C_{N,t+k}-C_N}{C_N}\right)\Big].$$

This simplifies to

$$\Sigma_{k=0}^{\infty}\theta_N^k\beta^k P\frac{P_N^{\epsilon_N+\omega+\delta-1}}{P_O^{\omega+\delta}}C_N[1+\left(p_{N,t}^{*}-p_N\right)-(p_{N,t-1}-p_N)+(-\sigma)\left(c_{t+k}-c\right)-(-\sigma)\left(c_t-c\right)$$
$$+(1-\omega-\delta)\left(p_{N,t}-p_N\right)+(\omega+\delta)\left(p_{O,t}-p_O\right)+(\epsilon_N+\omega+\delta-1)\left(p_{N,t+k}-p_N\right)$$
$$-(\omega+\delta)\left(p_{O,t+k}-p_O\right)+\left(c_{N,t+k}-c_N\right)].$$

Taking the first-order Taylor expansion of the RHS

$$\frac{\varepsilon_N}{\varepsilon_N-1}\Sigma_{k=0}^{\infty}\theta_N^k E_t\beta^k P\frac{P_N^{\epsilon_N+\omega+\delta-1}}{P_O^{\omega+\delta}}C_N MC_N^r\Bigg[1+(-\sigma)\left(\frac{C_{t+k}-C}{C}\right)-(-\sigma)\left(\frac{C_t-C}{C}\right)$$
$$+(1-\omega-\delta)\left(\frac{P_{N,t}-P_N}{P_N}\right)+(\omega+\delta)\left(\frac{P_{O,t}-P_O}{P_O}\right)+(\omega+\delta+\epsilon_N)\left(\frac{P_{N,t+k}-P_N}{P_N}\right)$$
$$-(\omega+\delta)\left(\frac{P_{O,t+k}-P_O}{P_O}\right)+\left(\frac{C_{N,t+k}-C_N}{C_N}\right)-\left(\frac{P_{N,t-1}-P_N}{P_N}\right)+\left(\frac{MC_{N,t+k|t}^r-MC_N}{MC_N}\right)\Bigg],$$

which simplifies to

$$\frac{\varepsilon_N}{\varepsilon_N-1}\Sigma_{k=0}^{\infty}\theta_N^k E_t\beta^k P\frac{P_N^{\epsilon_N+\omega+\delta-1}}{P_O^{\omega+\delta}}C_N MC_N^r[1+(-\sigma)\left(c_{t+k}-c\right)-(-\sigma)\left(c_t-c\right)$$
$$+(1-\omega-\delta)\left(p_{N,t}-p_N\right)+(\omega+\delta)\left(p_{O,t}-p_O\right)+(\omega+\delta+\epsilon_N)\left(p_{N,t+k}-p_N\right)$$
$$-(\omega+\delta)\left(p_{O,t+k}-p_O\right)+\left(c_{N,t+k}-c_N\right)-\left(p_{N,t-1}-p_N\right)+\left(mc_{N,t+k|t}^r-mc_N\right)].$$

Combining the LHS and RHS, the terms with the overweighting parameter cancel out, we get

$$\sum_{k=0}^{\infty}\theta_N^k\beta^k E_t\left(p_{N,t}^{*}-p_{N,t+k}\right)=\frac{\epsilon_N}{\epsilon_N-1}MC_N^r\sum_{k=0}^{\infty}\theta_N^k\beta^k E_t\left[mc_{t+k|t}^r-mc_N^r\right],$$

further simplifying to

$$p^*_{N,t} = (1-\theta_N\beta)\sum_{k=0}^{\infty}\theta_N^k\beta^k E_t\left[\hat{mc}^r_{N,t+k} + p_{N,t+k}\right]. \tag{A.10}$$

This is the same as in equation (A.8) for $j = N$ in the case with no overweighting. Similarly. it can be shown that we get the same for $j = O$ as well. Thus, overweighting of house price expectations by the firms does not change the Phillips Curve.

A.7 Derivation of central bank's loss function

Consider the utility function of the representative household

$$U = U\left(C_{N,t}, C_{O,t}\right) - V\left(L_{N,t}, L_{O,t}\right). \tag{A.11}$$

To derive the welfare function from the utility function, consider the second-order approximation of the utility from the consumption of the two goods. We know $\mathbf{U}\left(C_t\right) = \frac{C_t^{1-\sigma}}{1-\sigma}$and $C_t = \left(\mathrm{C_{N,t}}\right)^{1-\omega}\left(C_{O,t}\right)^{\omega}$. Then

$$U\left(\mathrm{C_{N,t}}, \mathrm{C_{O,t}}\right) = U\left(C_N, C_O\right) + U'_{C_N}\left(C_{N,t} - C_N\right) + U'_{C_O}\left(C_{O,t} - C_O\right) + \frac{1}{2}U''_{C_N}\left(C_{N,t} - C_N\right)^2 + \frac{1}{2}U''_{C_O}\left(C_{O,t} - C_O\right)^2 + U''_{C_N C_O}\left(C_{N,t} - C_N\right)\left(C_{O,t} - C_O\right) + O\left\|\xi\right\|^3, \tag{A.12}$$

where $O\left\|\xi\right\|^3$summarizes all the terms of the third and higher order.

We know, $\frac{C_{j,t} - C_j}{C_j} = \hat{c}_{j,t} + \frac{1}{2}\hat{c}_{j,t}^2$ where $\hat{c}_{j,t} = log\left(\frac{C_{j,t}}{C_j}\right)$ is the log deviation from the steady state under sticky prices. Substituting the derivative and writing in log deviations from steady state

$$\begin{aligned} U\left(C_{N,t}, C_{O,t}\right) \approx\ & U\left(C_N, C_O\right) + U'_{C_N}C_N\Bigg[\hat{c}_{N,t} + \frac{1}{2}\hat{c}_{N,t}^2 + \frac{\sigma\left(\omega - 1\right) - \omega}{2}\left(\hat{c}_{N,t} + \frac{1}{2}\hat{c}_{N,t}^2\right)^2 \\ & + \omega\left(1 - \sigma\right)\left(\hat{c}_{N,t} + \frac{1}{2}\hat{c}_{N,t}^2\right)\left(\hat{c}_{O,t} + \frac{1}{2}\hat{c}_{O,t}^2\right)\Bigg] \\ & + U'_{C_O}C_O\left[\hat{c}_{O,t} + \frac{1}{2}\hat{c}_{O,t}^2 + \frac{\omega\left(1 - \sigma\right) - 1}{2}\left(\hat{c}_{O,t} + \frac{1}{2}\hat{c}_{O,t}^2\right)^2\right] + O\left\|\xi\right\|^3. \end{aligned} \tag{A.13}$$

Substituting $U'_c C = \left(1 - \omega\right)U'_{C_N}C_N = \omega U'_{C_O}C_O$ in the above and simplifying

$$\begin{aligned} U\left(C_t\right) - U\left(C\right) \approx U'_C C\Bigg[& \left(1 - \omega\right)\hat{c}_{N,t} + \omega\hat{c}_{O,t} + \left(\frac{1 - \sigma}{2}\right)\left(1 - \omega\right)^2\hat{c}_{N,t}^2 + \left(\frac{1 - \sigma}{2}\right)\omega^2\hat{c}_{O,t}^2 \\ & + \omega\left(1 - \omega\right)\left(1 - \sigma\right)\hat{c}_{N,t}\hat{c}_{O,t}\Bigg] + O\left\|\xi\right\|^3. \end{aligned} \tag{A.14}$$

Next, we consider the disutility of labour for the households

$$V\left(L\right) = \frac{L_t^{1+\phi}}{1+\phi}, \tag{A.15}$$

where $L_t = L_{N,t} + L_{O,t}$. The second-order approximation of this function is

$$V\left(L_{N,t}, L_{H,t}\right) \approx V\left(L_N, L_O\right) + V'_{L_N}\left(L_{N,t} - L_N\right) + V'_{L_O}\left(L_{O,t} - L_O\right) + \frac{1}{2}V''_{L_N}\left(L_{N,t} - L_N\right)^2 + \frac{1}{2}V''_{L_O}\left(L_{O,t} - L_O\right)^2 + V''_{L_N L_O}\left(L_{N,t} - L_N\right)\left(L_{O,t} - L_O\right) + O\left\|\xi\right\|^3. \tag{A.16}$$

We know $\frac{L_N}{L} = (1-\omega)$and $\frac{L_O}{L} = \omega$. Substituting the derivatives and further simplifying

$$V\left(L_t\right) - V\left(L\right) \approx V'_L L\Bigg[\left(1-\omega\right)\hat{l}_{N,t} + \left(\frac{1-\omega}{2}\right)\hat{l}^2_{N,t} + \omega\hat{l}_{O,t} + \frac{\omega}{2}\hat{l}^2_{O,t} + \frac{\phi}{2}\left(1-\omega\right)^2\hat{l}^2_{N,t} + \frac{\phi}{2}\omega^2\hat{l}^2_{O,t} + \phi\omega\left(1-\omega\right)\hat{l}_{N,t}\hat{l}_{O,t}\Bigg] + O\left\|\xi\right\|^3. \tag{A.17}$$

Combine equations $(A.14)$, $(A.17)$ and substitute $V'_L L = -U'_C C$ to get the welfare function

$$\mathcal{W} \approx U'_C C\Bigg[\left(1-\omega\right)\hat{c}_{N,t} + \omega\hat{c}_{O,t} + \left(\frac{1-\sigma}{2}\right)\left(1-\omega\right)^2\hat{c}^2_{N,t} + \left(\frac{1-\sigma}{2}\right)\omega^2\hat{c}^2_{O,t} + \omega\left(1-\omega\right)\left(1-\sigma\right)\hat{c}_{N,t}\hat{c}_{O,t} - \left(1-\omega\right)\hat{l}_{N,t} - \left(\frac{1-\omega}{2}\right)\hat{l}^2_{N,t} - \omega\hat{l}_{O,t} - \frac{\omega}{2}\hat{l}^2_{O,t} - \frac{\phi}{2}\left(1-\omega\right)^2\hat{l}^2_{N,t} - \frac{\phi}{2}\omega^2\hat{l}^2_{O,t} - \phi\omega\left(1-\omega\right)\hat{l}_{N,t}\hat{l}_{O,t}\Bigg] + O\left\|\xi\right\|^3. \tag{A.18}$$

We know $\hat{l}_{j,t} = \hat{y}_{j,t} - a_{j,t} + d_{j,t} \forall j = N, O$ where

$$d_{jt} = log\int_0^1 \left(\frac{P_{jt}(i)}{P_{jt}}\right)^{-\varepsilon_{jt}} di. \tag{A.19}$$

Also, from market clearing we have $\hat{c}_{j,t} = \hat{y}_{j,t}$. Substituting in $(A.18)$

$$\frac{\mathcal{W}}{U'_C C} \approx \left(1-\omega\right)\hat{y}_{N,t} + \omega\hat{y}_{O,t} + \left(\frac{1-\sigma}{2}\right)\left(1-\omega\right)^2\hat{y}^2_{N,t} + \left(\frac{1-\sigma}{2}\right)\omega^2\hat{y}^2_{O,t} + \omega\left(1-\omega\right)\left(1-\sigma\right)\hat{y}_{N,t}\hat{y}_{O,t} - \left(1-\omega\right)\hat{y}_{N,t} - \left(1-\omega\right)d_{N,t} - \left(\frac{1-\omega}{2}\right)\hat{y}^2_{N,t} + \left(1-\omega\right)\hat{y}_{N,t}a_{N,t} - \omega\hat{y}_{O,t} - \left(\frac{\omega}{2}\right)^2\hat{y}^2_{O,t} - \omega d_{O,t} + \omega\hat{y}_{O,t}a_{O,t} - \frac{\phi}{2}\left(1-\omega\right)^2\hat{y}^2_{N,t} + \phi\left(1-\omega\right)^2\hat{y}_{N,t}a_{N,t} - \frac{\phi}{2}\left(1-\omega\right)^2\hat{y}^2_{O,t} + \phi\omega^2\hat{y}_{O,t}a_{O,t} - \phi\omega\left(1-\omega\right)\hat{y}_{N,t}\hat{y}_{O,t} + \phi\omega\left(1-\omega\right)\hat{y}_{N,t}a_{O,t} + \phi\omega\left(1-\omega\right)\hat{y}_{O,t}a_{N,t} + t.i.p + O\left\|\xi\right\|^3, \tag{A.20}$$

where $t.i.p$ includes all the terms independent of policy.

The linear terms in (A.20) cancel out. Consider first the following quadratic terms

$$-\left(\frac{1-\omega}{2}\right)\hat{y}_{N,t}^2+(1-\omega)\,\hat{y}_{N,t}a_{N,t}=-\left(\frac{1-\omega}{2}\right)\left[\hat{y}_{N,t}^2-2\hat{y}_{N,t}a_{N,t}\right]. \tag{A.21}$$

Substituting $a_{N,t}=\hat{y}_{N,t}^n-\hat{y}_t^n+a_t$ (where $\hat{y}_t^n$and $\hat{y}_{N,t}^n$are flexible price aggregate and sectoral outputs, respectively) in $(A.21)$

$$-\left(\frac{1-\omega}{2}\right)\hat{y}_{N,t}^2+(1-\omega)\,\hat{y}_{N,t}a_{N,t}=-\left(\frac{1-\omega}{2}\right)\left[\tilde{y}_{N,t}^2-\left(\hat{y}_{N,t}^n\right)^2+2\hat{y}_{N,t}\hat{y}_t^n-2\hat{y}_{N,t}a_t\right], \tag{A.22}$$

where $\tilde{y}_{N,t}=\hat{y}_{N,t}-\hat{y}_{N,t}^n$.

Similarly, the quadratic terms for sector O can be simplified to

$$-\left(\frac{\omega}{2}\right)\hat{y}_{O,t}^2+\omega y\hat{_{O,t}}a_{O,t}=-\left(\frac{\omega}{2}\right)\left[\tilde{y}_{O,t}^2-\left(\hat{y}_{O,t}^n\right)^2+2\hat{y}_{O,t}\hat{y}_t^n-2\hat{y}_{O,t}a_t\right]. \tag{A.23}$$

Next, we simplify the following quadratic terms as

$$\begin{aligned}&\left(\frac{1-\sigma}{2}\right)\left[(1-\omega)^2\hat{y}_{N,t}^2+\omega^2\hat{y}_{O,t}^2+2\omega(1-\omega)\,\hat{y}_{N,t}\hat{y}_{O,t}\right]\\ &\qquad-\frac{\phi}{2}\left[(1-\omega)^2\hat{y}_{N,t}^2+\omega^2\hat{y}_{O,t}^2+2\omega(1-\omega)\,\hat{y}_{N,t}\hat{y}_{O,t}\right]=\left(\frac{1-\sigma-\phi}{2}\right)\hat{y}_t^2.\end{aligned} \tag{A.24}$$

Using $(1-\omega)\,a_{N,t}+\omega a_{O,t}\equiv a_t$, the remaining terms in $(A.20)$ can be simplified to

$$\phi(1-\omega)^2\hat{y}_{N,t}a_{N,t}+\phi\omega(1-\omega)\,\hat{y}_{O,t}a_{N,t}+\phi\omega^2\hat{y}_{O,t}a_{O,t}+\phi\omega(1-\omega)\,\hat{y}_{N,t}a_{O,t}=\phi\hat{y}_ta_t.$$

Also, at flexi-price equilibrium $\hat{y}_t^n=\frac{1+\phi}{\sigma+\phi}a_t$ so

$$\phi\hat{y}_ta_t=\phi\left(\frac{\sigma+\phi}{1+\phi}\right)\hat{y}_t\hat{y}_t^n. \tag{A.25}$$

Combining $(A.22)$, $(A.23)$, $(A.24)$, and $(A.25)$, the welfare loss function is

$$\begin{aligned}\frac{\mathcal{W}}{U_C'C}\approx&-\left(\frac{1-\omega}{2}\right)\tilde{y}_{N,t}^2-\frac{\omega}{2}\tilde{y}_{O,t}^2+\frac{1-\sigma-\phi}{2}\hat{y}_t^2-(1-\sigma-\phi)\,\hat{y}_t\hat{y}_t^n\\ &-(1-\omega)\,d_{N,t}-\omega d_{O,t}+t.i.p+O\,\|\xi\|^3.\end{aligned}$$

Completing the squares in terms of aggregate output

$$\frac{\mathcal{W}}{U_C'C} \approx -\frac{1}{2}E_0\Sigma_{t=0}^{\infty}\beta^t\left[(1-\omega)\,\tilde{y}_{N,t}^2 + \omega\tilde{y}_{O,t}^2 + \left(\frac{\sigma+\phi-1}{2}\right)\tilde{y}_t^2 + 2\,(1-\omega)\,d_{N,t} + 2\omega d_{O,t}\right]$$
$$+\,t.i.p + O\,\|\xi\|^3\,. \tag{A.26}$$

In section (A.7.1), we show that $d_{j,t} = \sum_{t=0}^{\infty}\beta^t var_i p_{j,t}\,(i)$.
Based on Woodford (2003) Proposition 6.3, we know

$$\sum_{t=0}^{\infty}\beta^t var_i p_{j,t}\,(i) = \frac{1}{\chi_j}\sum_{t=0}^{\infty}\beta^t\pi_{j,t}^2,$$

where $\chi_j = \frac{(1-\theta_j)(1-\beta\theta_j)}{\theta_j}$. Therefore

$$\sum_{t=0}^{\infty}\beta^t\frac{\varepsilon_j}{2}var_i p_{j,t}\,(i) = \frac{\varepsilon_j}{2\chi_j}\sum_{t=0}^{\infty}\beta^t\pi_{j,t}^2. \tag{A.27}$$

Substituting for $d_{j,t}$ in $(A.26)$, the welfare loss function is

$$\frac{\mathcal{W}}{U_C'C} \approx -\frac{1}{2}E_0\Sigma_{t=0}^{\infty}\beta^t\Bigg[(1-\omega)\,\tilde{y}_{N,t}^2 + \omega\tilde{y}_{O,t}^2 + (\sigma+\phi-1)\,\tilde{y}_t^2$$
$$+\frac{\varepsilon_N}{\chi_N}(1-\omega)\,\pi_{N,t}^2 + \frac{\varepsilon_O}{\chi_O}\omega\pi_{O,t}^2\Bigg] + t.i.p + O\,\|\xi\|^3\,. \tag{A.28}$$

A.7.1 Second-order approximation of price dispersion

We know that

$$\hat{l}_{j,t} = (\hat{y_{jt}} - \alpha_{jt} + d_{jt}),$$

where

$$d_{jt} = log\int_0^1\left(\frac{P_{jt}(i)}{P_{jt}}\right)^{-\varepsilon_{jt}}di. \tag{A.29}$$

We use the second-order approximation of $\left(\frac{P_{jt}(i)}{Pjt}\right)^{1-\varepsilon_j}$, where $\hat{p}_{jt}(i) = p_{jt}(i) - p_{jt}$ is approximated around zero such that

$$\left(\frac{P_{jt}(i)}{P_{jt}}\right)^{1-\varepsilon_j} = exp(1-\varepsilon_j)\,(p_{jt}(i) - p_{jt}) = exp(1-\varepsilon_j)\,(\hat{p}_{jt}(i))\,.$$

The second-order approximation is

$$\left(\frac{P_{jt}(i)}{P_{jt}}\right)^{1-\varepsilon_j} \approx 1 + (1-\varepsilon_j)\,(\hat{p}_{jt}(i)) + \frac{1}{2}(1-\varepsilon_j)^2\,(\hat{p}_{jt}(i))^2\,. \tag{A.30}$$

From the definition of sectoral price index, $P_{jt} = \left(\int_0^1 P_{jt}(i)^{1-\varepsilon_j} di\right)^{\frac{1}{1-\varepsilon_j}}$, we have

$$1 = \left(\int\limits_0^1 \left(\frac{P_{jt}(i)}{P_{jt}}\right)^{1-\varepsilon_j} di\right)^{\frac{1}{1-\varepsilon_j}}.$$

Taking Expectations of both sides of A.30

$$E_i\left(\left(\frac{P_{jt}(i)}{P_{jt}}\right)^{1-\varepsilon_j}\right) \approx E_i\left[1 + (1-\varepsilon_j)\left(\hat{p}_{jt}(i)\right) + \frac{1}{2}(1-\varepsilon_j)^2 \hat{p}_{jt}(i)^2\right],$$

where E_i denotes the expectations operator with respect to good i. This can be further simplified to

$$E_i \hat{p}_{jt}(i) \approx -\frac{1}{2}(1-\varepsilon_j) E_i\left(\hat{p}_{jt}(i)^2\right) = -\frac{1}{2}(1-\varepsilon_j) Var_i \hat{p}_{jt}(i). \tag{A.31}$$

Next, we do a second order approximation of $\left(\frac{P_{jt}(i)}{P_{jt}}\right)^{-\varepsilon_j}$ in d_{jt}

$$\left(\frac{P_{jt}(i)}{P_{jt}}\right)^{-\varepsilon_j} \approx 1 - \varepsilon_j \hat{p_{jt}}(i) + \frac{1}{2}\varepsilon_j^2 \hat{p_{jt}}(i)^2. \tag{A.32}$$

Finally, substitute equations (A.31) and (A.32) into equation (A.19) to get the second order approximation of d_{jt}

$$d_{jt} \approx log\left\{\int_0^1 \left[1 - \varepsilon_j \hat{p}_{jt}(i) + \frac{1}{2}\varepsilon_j^2 p_{jt}(i)^2\right] di\right\},$$

which further simplifies to

$$d_{jt} \approx \frac{\varepsilon_j}{2} var p_{jt}(i).$$

A.8 Parameters

Table A.10: Parameters and standard deviation of shocks

Parameter		Value
Discount factor	β	0.99
Inverse IES	σ	1
Inverse Frisch elasticity of labour supply	ϕ	5
Elasticity of substitution between goods (N)	ε_N	9
Elasticity of substitution between goods (O)	ε_O	9
Price stickiness in sector N	θ_N	0.75
Price stickiness in sector O	θ_O	0.75
Cost-push shock persistence in sector N	ρ_{u_N}	0.8
Cost-push shock persistence in sector O	ρ_{u_O}	0.8
Technology shock persistence in sector N	ρ_{a_N}	0.9
Technology shock persistence in sector O	ρ_{a_O}	0.9
Share of housing in consumption	ω	0.5
Overweighting paramater	δ	0.3
Cost-push shock in N standard deviation	σ_{u_N}	1
Cost-push shock in O standard deviation	σ_{u_O}	1

Notes: This table shows the parameter values used in Figures 2 and 3 in the main text. We have kept the two sectors, O and N, to be symmetric and other parameter values are from Galí (2015).