Heterogeneous Asset Returns and Monetary Policy Redistribution*

Rajarshi Datta†

November 4, 2023

[latest version]

Abstract

In a distributional examination of monetary policy impacts, my study explores how changes in the federal funds rate affect short-term consumption dynamics through the wealth inequality channel. Differential returns and prices of housing and equity along with heterogeneous marginal propensities to consume out of income across households, cause uneven effects of monetary policy on individuals with different net wealth. Exploring the impacts unveils surprising results contrasting to existing literature: a 1% federal funds rate drop increases consumption of outright homeowners by more than double relative to mortgage holders (3.02% vs 1.43%), yields a 1.72% rise for older individuals with a 1.29% boost for younger ones. The middle 50-90% net wealth distribution gain nearly twice as much as the bottom 50% (1.51% vs 0.8%). The analysis unveils varying group susceptibilities to monetary policy, underscoring the diversified effects based on housing tenure, age, and borrowing constraints. Besides identifying winners and losers, I also study how the distribution affects the aggregate. A 1% reduction in the federal funds rate increases overall consumption by 1.63%. There also exists significant asymmetries at all levels with 1% increase curtailing aggregate consumption by merely 1.02%, signifying hurdles in achieving a 'soft landing.'

*I sincerely thank my advisors Professor Yu-Chin Chen & Professor Brian Greaney for their extensive time, guidance and effort with this project. I am grateful to my committee members Professor Fabio Ghironi & Professor Stephen Turnovsky. The project has benefited immensely from my discussions with Professor Chang-Jin Kim. I appreciate the feedback from my discussions with David Baqaee, Anusha Chari, Ippei Fujiwara, Domenico Giannone and participants in the MTI seminars at the Department of Economics. I thank the CSDE & Hyak supercomputer system at the University of Washington for providing required computational resources.

†Department of Economics, University of Washington. Savery Hall, 410 Spokane Ln, Seattle, WA 98105. Corresponding author email: rdatta2@uw.edu. First Draft - May 2022

1 Introduction

Recent interest from central banks lies in assessing wealth inequality's role in impacting short-run aggregate consumption via monetary policy transmission. A shift in the central bank rate triggers endogenous wealth transfers across wealth brackets. This redistribution leads to a net non-zero response on aggregate consumption due to the heterogeneous marginal propensities to consume (MPCs) across different groups, challenging traditional views of monetary policy transmission. The total consumption response is divided into five channels resulting from changes in real interest, nominal prices, and idiosyncratic earnings, quantifiable with seven sufficient statistics estimable from survey data. Auclert (2019) reveals that redistribution contributes to about one-third of the aggregate consumption response. This work rightly adjusts for asset maturities in quantifying household balance sheets, moving the conversation beyond the usual focus on asset prices, and showing a uniform response across returns and prices for all assets, notably housing and equity, to policy rate changes.

I empirically show that an unexpected one-time monetary policy shock yields diverse changes in prices and returns for housing, equity, and liquid assets. Housing, characterized by significant transaction costs, responds more slowly and with lesser persistence compared to equity. Given the wide variation in holdings of these primary assets across wealth distribution, different wealth deciles experience varying unrealized capital gains/losses from both nominal price (inflation or Fisher) and real interest rate channels. The decomposition of this overall effect into contributions from housing and equity also varies across the distribution.[1] Now, redistributive wealth transfers hinge on post-shock returns heterogeneity paired with existing household portfolio holdings. The specific gains and losses from monetary policy changes for various groups require a more precise calculation of exposures across the real interest rate and Fisher channels. This precision raises the question of a quantitatively significant impact on short-run general equilibrium aggregate consumption.

I create a model inspired by Auclert (2019) to scrutinize the one-time monetary policy surprise's impact on housing and equity compared to liquid assets on household consumption employing sufficient statistics. My model's three main contributions are: First, by conditioning my sufficient statistics on exogenous monetary policy, I distinctly isolate and analyze the impact on housing or equity. Second, my model's framework can extend to estimate

[1] See Kuhn and Ríos-Rull (2020) for a related discussion. They explore how SCF data can assess the joint distribution of earnings, income, and wealth in the United States and decompose contributions by income sources and asset classes.

new redistribution measures from sustained changes in the real interest rate. Third, it now adeptly manages asymmetric shocks.

Using liquid assets as a benchmark enhances the comparison with original findings. Additionally, I demonstrate the model's stability even in the context of durable goods and elastic labor supply, and its extension to incomplete markets, though these are more challenging to estimate empirically. The significance of the differential asset returns channel is evident in both the aggregate general equilibrium consumption response besides the individual redistributative effects from a policy rate change. These are unit-free elasticity measures, permitting comparison across models. I conduct limited policy counterfactuals, avoiding potential errors that afflict structural models. Given the substantial debate over the optimal econometric method for determining the conditional impact of a one-time monetary policy surprise on asset premia and prices, my model's flexibility in incorporating alternate estimates using preferred methodologies stands out.

I compute the sufficient statistics summarizing household exposures to real interest and Fisher channels from the CE survey which richly captures consumption alongside reasonably extensive data on household balance sheets. This allows me to estimate the household level *MPC* from an unexpected fiscal transfer. Key findings include: First, a 75bp rate cut by the Fed would boost aggregate consumption by 1% , a 15% higher elasticity compared to reducing the fed funds rate with identical returns for housing, equity, and cash, contrary to Auclert (2019). This results in a two-third share of redistribution effects, an overall increase of 33% relative to the mentioned source. My elasticity is three-fourths larger than a similar representative agent model. Conversely, a 75bp rate hike would drop aggregate consumption by only 0.76% , showing significant asymmetric effects. Second, I note the importance of the *IES* estimate for transmission in a RANK, finding a 63% increase accurately representing aggregate transmission to consumption. Given the stronger conditional impact on equity returns and prices, household exposures are amplified more for equity, raising instantaneous consumption response by 30% above the benchmark. In a contractionary shock, the lesser impact on housing wealth reduces the decline by nearly 19% (compared to 15% for equity).

Households, being forward-looking, anticipate the impact of transitory monetary surprises on asset prices and returns, leading to unrealized capital gains/losses. This impact, channeled through real interest and Fisher channels, boosts asset prices and potentially reduces debt payments, making households feel wealthier and increasing their consumption. Despite being unrealized, these gains, expected to be converted into liquid assets in the future, lead to higher *MPCs* out of current income, making them heterogeneous across the wealth distribution. My larger estimates reflect this, differing from literature focusing on realized wealth gains, particularly in housing.[2] This incorporation of returns heterogeneity indicates a significant rise in aggregate consumption, underscoring its essential role in effective estimation. The absence of such heterogeneity in *MPCs* out of income makes a representative agent counterpart with multiple asset returns ineffective for estimating aggregate consumption.

Monetary policy influences households' heterogeneous consumption responses based on borrowing constraints and wealth levels. Highly collateral-constrained households struggle to realize wealth changes and smooth consumption. My findings show homeowners with ample liquid assets and minimal housing debt have an elasticity of 2.4, significantly larger than the aggregate, as they face fewer constraints and can adapt to additional debt. In contrast, high-debt homeowners exhibit lower elasticity at 0.96, showing restrained consumption when rates decrease. An interest rate hike further exaggerates this consumption disparity between these groups, with similar trends observed across different age demographics. The middle-aged group, representing a significant portion of the sample, demonstrates a contrasting consumption response to federal rate changes compared to the aggregate. Monetary policy notably benefits those with more long-term liabilities like mortgages, contributing to higher *MPCs*, while households with a positive net nominal position (*NNP*), holding housing as both asset and debt, maintain inherently higher *MPCs*, albeit with a weaker correlation.[3]

From a policy standpoint, my exploration involves examining model predictions for expansionary and contractionary policies during specific economic times - the beginning of the pandemic and before the Global Financial Crisis (GFC), respectively. The robustness of the results for expansionary policy across years is noteworthy. When limiting asset maturities to a quarterly basis, the significance of returns heterogeneity is amplified, evidencing a 24% increase in 2019 (with a 67% share of redistribution). This evidence bolsters the Federal Reserve's aggressive quantitative easing strategies implemented during the pandemic onset. Assuming all mortgages were adjustable-rate, this would translate to a notable rise in both baseline and quarterly asset maturities. This observation advocates for reduced refinancing costs for a substantial population segment, particularly in challenging times, to expedite consumption recovery. Contrarily, around the GFC, the model fails to foresee sig-

[2] Paiella and Pistaferri (2017) report values in the range of 3-7.5% from home-equity channel, consistent with Mian and Sufi (2014). Di Maggio et al. (2020) reports *MPC* out of unrealized equity gains is in the range of 23% for bottom 50% and only 3% for the top 30%. *MPC* out of dividends is nearly 10 times higher than out of capital gains as estimated by Hartzmark and Solomon (2019). For more details and other comparisons see appendix D.

[3] Details of various elasticity values and responses are analyzed in the main text, showcasing the diverse impacts of monetary policy on different demographic and economic groups.

nificant additional consumption declines. Instead, it highlights an enhanced consumption response under an expansionary policy, given the overarching housing wealth gains surpassing equity. In essence, my paper underscores the interaction between three crucial elements - returns heterogeneity, asset maturity, and household portfolio diversity, demonstrating a more pronounced short-run influence on aggregate consumption from wealth inequality amid monetary policy shifts than previously assessed.

I acknowledge some limitations of my results, heavily reliant on detailed household balance sheet information. I suggest my findings to be conservatively downward-biased, and more in-depth future research is necessary to support the claims. One alternative could utilize PSID data for improved rich household sampling, despite the trade-off of limited consumption data. Additionally, while sufficient statistics have benefits, their utility in model-free environments is limited. A coordinated approach involving fiscal and monetary policy requires dependence on structural models. I aspire that my results spur the development of a HANK model with two illiquid assets bearing separate returns, despite anticipated complications. This path, although challenging, presents a valuable future extension.[4]

Related Literature - The paper contributes primarily to four main strands in the literature. An extensive empirical literature underscores the significant and diverse marginal propensities to consume (*MPC*) from unexpected fiscal transfers Jappelli and Pistaferri (2010); Johnson et al. (2006). I find aggregate *MPC* out of income is notably biased downwards without considering returns heterogeneity through unrealized wealth changes, emphasizing household balance sheets' critical role in determining aggregate consumption response.[5] I highlight the significance of these altered estimates in analyzing aggregate consumption response, comparing them with self-reported *MPCs* from the SHIW 2010 Jappelli and Pistaferri (2014).[6]

The debate on the impact of unexpected monetary policy shocks on real interest rates and asset prices involves mainly two approaches: structural VAR or local projections. Gertler and Karadi (2015) employs structural VAR with external instruments for assessing impact on

[4] Adding both returns and price heterogeneity would be even more difficult. I find that barring one or two cases, the interest rate channel is responsible for the majority of the variation. A suitable setup is Kaplan et al. (2018). Moreover, larger the returns gap, higher is the aggregate *MPC* as found by Kaplan and Violante (2020).

[5] A positive correlation between *MPCs* and return heterogeneity in household consumption, employment, and income responses during Covid-19 is documented Baker et al. (2020); Chetty et al. (2020).

[6] Maintaining the assumption of a uniform *MPC* out of income across asset classes, literature highlights *MPC* dependence on household balance sheet positions, especially housing Mian et al. (2013); Mian and Sufi (2014); Cloyne et al. (2020). For further details, see section 4.

credit costs, extending Mertens and Ravn (2013) and aligning with theoretical exercises by Auclert (2019). Conversely, Luetticke (2021) uses local projections for a 16-quarter impulse horizon, facing forecasting limitations.[7] I adopt the former for estimates of present discounted values of requisite variables since they are proved reliable and robust.[8]

The advantage of sufficient statistics lies in minimizing dependence on potentially error-prone structural models, while allowing simple policy counterfactuals application in a largely model-free environment. Auclert and Rognlie (2020) employs them to estimate income inequality's impact on aggregate demand, Auclert et al. (2018) for intertemporal *MPCs* and obtaining empirically consistent *IRFs*. Utilizing PSID data, Berger et al. (2018) assesses house prices' effect on consumption movements. I obtain precise aggregate-level estimates and by asset class, addressing issues like housing's significance in HANK Hedlund et al. (2017). Unlike the U.S., Holm et al. (2021) leverages rich Norwegian data for overall consumption response estimation. My reduced form approach proves superior, avoiding the large noise observed in studies like Coibion et al. (2017).[9]

Fourthly, I compare alternative approaches in the literature for targeting aggregate consumption, which often overlook returns heterogeneity. Whereas studies like Gornemann et al. (2021) employ structural models with reduced form idiosyncratic discount factors, I focus on estimating consumption response changes through the impact of monetary policy on household portfolios, as directly observed in data. My approach proves ample for conducting simple policy experiments that expand the aggregate influence of household wealth holdings' heterogeneity. Contrary to Kekre and Lenel (2021), which notes a subdued consumption rise and significant investment increase, my method more effectively handles the impact of monetary policy, showcasing a larger consumption response from differential asset returns.[10]

Layout - The rest of the paper is structured as follows. Section 2 lays down the procedures used to infer the impact of monetary policy shocks on requisite variables and subsequent

[7] Plagborg-Møller and Wolf (2021) highlights local projections' superiority for small time horizons, with issues and related empirical puzzles mitigated by Bayesian techniques in Miranda-Agrippino and Ricco (2021).

[8] Despite improvements by Paul (2020), issues with impulse response function persistence emerge. Gertler and Karadi (2015) offers robust, non-persistent results, compared in appendix A.2.

[9] Ampudia et al. (2018) and Leombroni and Rogers (2021) emphasize heterogeneous asset returns' substantial general equilibrium effects from consumption changes, observing portfolio rebalancing and life-cycle effects impacting labor supply and output through consumption.

[10] Monacelli and Colarieti (2022) presents a heteroskedastic NK model, and my results stand robust even in varied conditions, consistent with Kaplan and Violante (2020)'s findings on the relationship between the asset returns gap and *MPC*. Further details are discussed in section 5.2 and appendix C.

motivating evidence. The model and theoretical results are contained in Section 3. Section 4 details the measurement of the sufficient statistics from survey data while section 5 discusses the key findings. A final section 6 concludes. Robustness checks, proofs for model extensions and additional results are contained respectively in appendices A - F.

2 Empirical Methodology

I aim to discern the immediate effects of an unexpected monetary policy surprise on household balance sheets, especially its distinct effects on housing and equity. This helps me condition the sufficient statistics based on monetary policy. The effects of a real interest rate cut on the wealth distribution primarily manifests through the excess premia of these two asset classes and the associated price changes.[11] Another channel, albeit harder to pin down from data, is the immediate effect on idiosyncratic earnings. I emphasize the former two channels when gauging the immediate effect of monetary policy on household wealth distribution.

In section 4, I argue that capturing these changes is crucial for accurate household *MPC* measurements. Employing the SVAR method, I align with the specifications of Gertler and Karadi (2015). Given that my theoretical insights largely rely on a perfect foresight model, detailed in section 3, I look to present discounted values from Auclert (2015) for the most fitting empirical analogs. It's crucial to ensure stable and consistent *IRFs* over extended periods, a challenging endeavor with the local projections technique. While Luetticke (2021) uses a local projection exercise for similar variables, I juxtapose my findings against theirs in section 5. Our results, spanning 16 quarters and detailed in appendix A.3, exhibit qualitative similarities.

2.1 A structural VAR with external instruments approach

I require monthly data on excess premia and nominal asset prices for both housing and equity, alongside changes in the real interest rate and aggregate price level, which signify impacts

[11] I focus on excess returns and not real returns. Theoretically, I would normalize with the change in the real interest rate which is the change in the real return for the liquid asset. In reality, the return on the liquid asset varies nominally from the transitory monetary policy surprise. It is persistent because of which we need a measure of excess returns for the two assets before normalization of the PDVs.

for the benchmark liquid asset. I also incorporate industrial production to capture overall economic activity. This results in a 7-variable structural VAR, estimated with external instruments to identify monetary surprises. In the main text, I adopt a lag length of 7 to ensure stable *IRFs* over extended horizons. Lag and horizon length tests are in appendix A.1. Variable definitions and data sources mainly align with Luetticke (2021). However, I measure the housing premium differently, using monthly excess return data from Robert Shiller's house price index.[12] For a detailed estimation methodology, refer to section II of Gertler and Karadi (2015), using only their baseline specification approach.

The external instruments I utilize encompass surprises in the current and three-month-ahead monthly fed funds futures, as well as six-month, nine-month, and one-year-ahead futures on three-month Eurodollar deposits. My analysis spans from 1979:7 to 2012:6. Given that this study doesn't tackle forward guidance, the current fed funds futures surprise serves as the primary policy metric. A distinct advantage of this approach is the lack of necessity to incorporate the real interest rate separately. As indicated by Gertler and Karadi (2015) section C, the disparity between nominal and real rate shifts post a monetary policy surprise is minimal. Their Figure 4 reinforces the negligible influence of inflation on extended-term government bond rates.[13] I produce the *IRFs* for a one-standard deviation dip in the monetary policy surprise, focusing on expansionary effects. Figure 1 projects *IRFs* up to 4 years, while Figure 6 extends this to a 1000-month horizon. Results align with expectations: stock price and excess return *IRFs* are both swifter and more pronounced compared to housing. The normalized PDV assessments are tabled in Table 1.

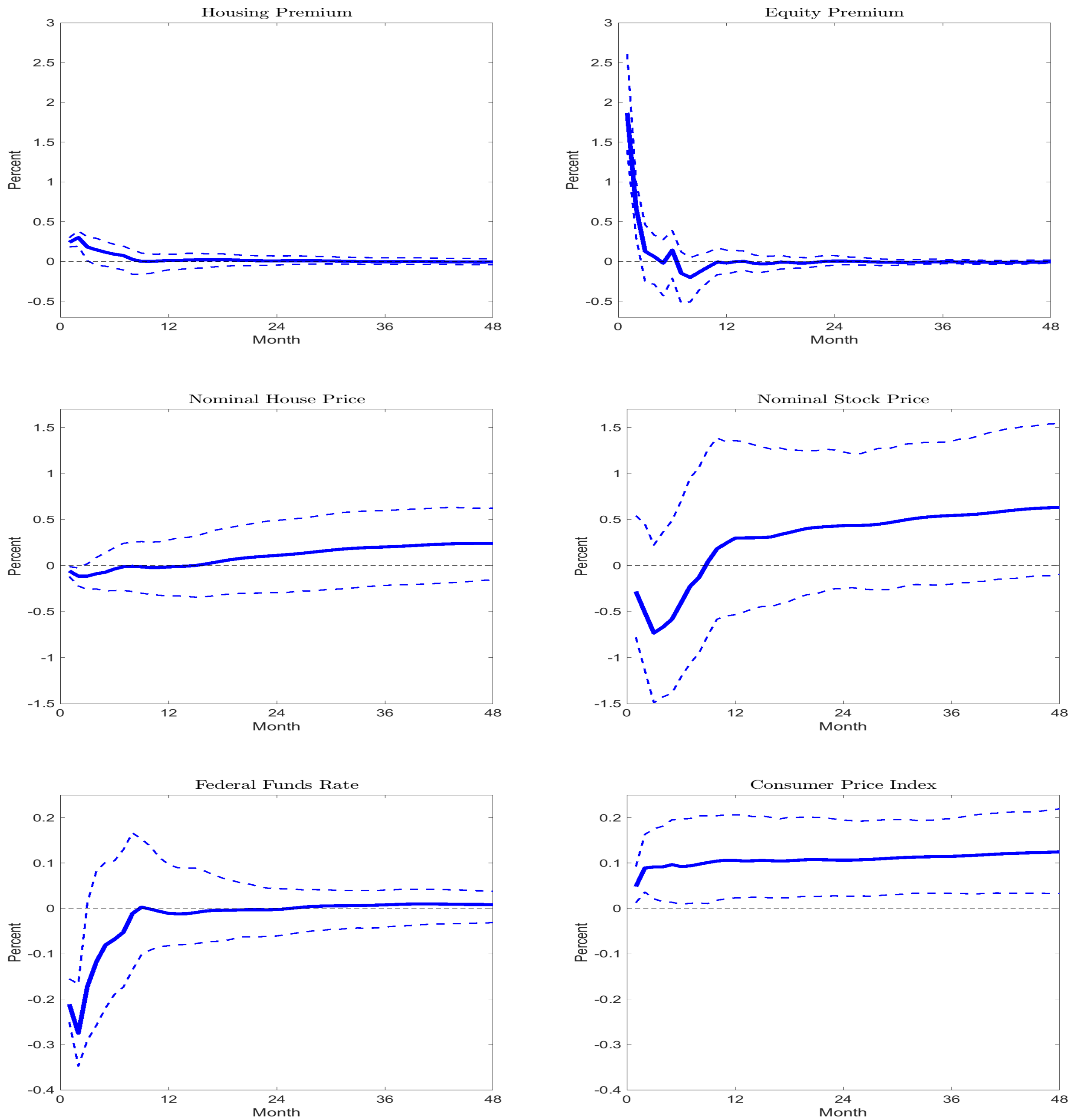
2.2 Unrealized Wealth Changes from Monetary Policy Shocks

Using the estimates in Table 1, I calculate the unrealized wealth changes from the SCF data to demonstrate that household wealth changes, as a percentage of gross wealth, are substantially different across gross wealth quantiles. I need to summarize the changes from the two channels - the real interest rate and the Fisher. Taking the SCF data for the interested year, I first calculate the gross (net) wealth and divide the sample into associated

[12] Excess returns on quarterly housing are computed in Luetticke (2021) following Gomme et al. (2011). Monthly data sources for the same are unavailable. Alternate monthly estimates can be calculated using rent changes, but full CPI rent data isn't available for the entire sample period, making substitutions unreliable. Appendix A.3 provides variable definitions.

[13] I've verified this minimal difference by introducing the real interest rate into our specification. This inclusion reduces the required lag length for stable outcomes. I value the IRF's stability over minor changes in PDV calculations when employing the real interest rate explicitly.

Figure 1: *IRFs* for an expansionary one time monetary policy for the requisite variables



Note - Derived for a one standard deviation decrease in the monetary policy surprise considered in Gertler and Karadi (2015) for VAR specification in section 2.1 which has seven variables and seven lags. *IRFs* generated for 1000 months ahead. 95 percent confidence bands computed using bootstrapping methods identical to Gertler and Karadi (2015).

Table 1: Present discounted value estimates from VAR based in section 2.1 using $\beta = 0.95$

Present Discounted Value at $t = 0$	Nominal House Price	Housing Premium	Nominal Stock Price	Equity Premium	Nominal House Price	Nominal Equity Price
Empirical	0.84	1.28	2.43	2.51	0.41	1.18
Normalized (Y/N)	**N (in%)**	Y	**N (in%)**	Y	Y	Y

Note - Specification used is detailed in 2.1. Results with $\beta = 0.95$ and one standard deviation positive monetary policy surprise for 1000 months ahead. Required for conditional impact of monetary policy. Most estimates normalized with respect to the liquid asset to make them comparable to the benchmark. See section 3.2 for more details and also section 4 for their use in measuring the sufficient statistics.

Figure 2: Estimated unrealized wealth gains as a percentage of gross wealth

Note - For a one unit decline in the real interest rate. The left panel summarizes the exposures to the real interest rate channel while the right summarizes the exposures to the Fisher channel.
Derived using portfolio wealth shares in the SCF data along with the PDV estimates in 1 for three separate returns. The mean of the change in wealth across quantiles is plotted on the y-axis.
The benchmark results in Auclert (2019) would lead to a mean growth of 1 uniformly across quantiles for both the real interest rate and Fisher channel.

Figure 3: Component wise unrealized wealth gains as a percentage of gross wealth

Note - Exact same exercise as in Figure 2 subdivided for housing and stocks. See corresponding notes for more details. Additionally, the benchmark results would lead to the same mean growth for both housing and stocks.

quantiles. Using the present discounted value estimates and the gross (net) wealth shares for housing, stocks and liquid assets, I can calculate the unrealized wealth change for each wealth decile for both excess premia and nominal price changes. Here, I present the results for 2001 (the year for which MPC will be estimated from the consumer expenditure survey). I follow it up with the results by wealth component, specifically housing and stocks. To demonstrate that the trend continues with latest available data, I present Figure 8 using SCF 2019.

Figure 2 shows that the mean wealth growth is not homogeneous across quantiles for both the real interest rate and Fisher channels. This is true for the year for which MPC will be estimated (suggesting more precise estimates are possible) and it is not a one-off event as evidenced by the latest data available. The total gains hides substantial heterogeneity as in Figure 3 for both housing and equity holdings. The former plays a prominent role for the Fisher channel, for particularly the agents at the bottom of the wealth distribution. Similarly, for those towards the top, especially for the top 10% , almost all the gains are from equity for both the channels. The findings are along expected lines, exacerbated by the existing household portfolio heterogeneity along the wealth distribution. For comparison, I present additional evidence to support my main exercise in section 3.2 in appendix A.4 for reported unrealized & realized wealth changes, both as percentage of net and gross wealth, as well as a comparison with having a common illiqiuid return for both housing and equity.

3 Model

The theoretical framework is identical to Auclert (2019) with the exception of the inclusion of ex-post return heterogeneity across asset classes. Specifically, I consider separate returns & prices for housing, equity and the liquid asset. The liquid asset serves as the benchmark to the original results. For more details, see section I and related mathematical appendices A.2 - A.8 of Auclert (2019).

3.1 Household Balance Sheets and wealth effects

The consumer has separable preferences over nondurable consumption $\{c_t\}$ and hours of work $\{n_t\}$. For simplicity, there is no uncertainty with the exception of a one time unexpected monetary policy shock that results in the equivalent change of the real interest rate by one unit. It is a perfect-foresight setup with the consumer rationally forecasting the entire time path of nominal wages $\{W_t\}$, overall price level $\{P_t\}$ as well as the individual prices & returns for each of the three separate assets. The household has a lifetime real earnings stream given by $\{y_t\}$. The consumer solves the following discrete time utility maximization problem. The time horizon may be finite or infinite and need not to be specified.

$$\max \sum_t \beta^t \{u(c_t) - (n_t)\} \text{ subject to}$$

$$\begin{aligned} P_t C_t = P_t y_t + W_t n_t + \left({}_{t-1}B_t\right) + \sum_{s\geq 1} \left({}_tQ_{t+s}\right)\left({}_{t-1}B_{t+s} - {}_tB_{t+s}\right) \\ + P_t\left({}_{t-1}b_t\right) + \sum_{s\geq 1}\left({}_tq_{t+s}\right) P_{t+s}\left({}_{t-1}b_{t+s} - {}_tb_{t+s}\right) \end{aligned} \tag{1}$$

The flow budget constraint (1) depicts the consumer household portfolio of assets in period t consisting of a portfolio of zero coupon bonds inherited from period $t-1$ as well as the ones carried over to the next period. ${}_tQ_{t+s}$ is the price at time t of nominal zero-coupon bond payable at time $t+s$. Analogously, ${}_tq_{t+s}$ denotes the price of a real zero-coupon bond with ${}_{t}B_{t+s}$ & ${}_{t}b_{t+s}$ denoting the respective quantities purchased. There is no arbitrage which is ensured by the Fisher equation for the nominal term structure, holding separately and across asset classes, broadly of the following form.

$$ {}_{t}Q_{t+s} = \left({}_{t}q_{t+s}\right) \frac{P_t}{P_{t+s}}, \quad \forall t, s $$

The flow budget constraints consolidate into an intertemporal budget constraint by either use of terminal condition or transversatility condition depending on whether the setup is under finite or infinite horizon.

$$ \sum_{t\geq 0} q_t c_t = \underbrace{\sum_{t\geq 0} q_t (y_t + w_t n_t)}_{w^H} + \underbrace{\sum_{t\geq 0} q_t \left(\left({}_{-1}b_t\right) + \left(\frac{{}_{-1}B_t}{P_t}\right) \right)}_{w^F} \equiv \quad w \tag{2} $$

Keeping the notation consistent, (2) depicts the present value of consumption equals the present value of wealth denoted by w which is the sum of present value of all future income w^H and the total present value of all financial wealth w^F. Ex-ante before the shock, the distinct portfolio shares of balance sheet components for the three separate asset with associated prices can be represented equivalently by the composite portfolio using arbitrage.[14] Since it matters post shock, I expand explicitly as housing h_t, equity s_t & liquid assets ℓ_t for real (analogously nominal) terms at time $t-1$.

$$ \left({}_{-1}b_t\right) \equiv \left({}_{-1}\ell_t\right) + \left({}_{-1}h_t\right) + \left({}_{-1}s_t\right) $$

$$ \left(\frac{{}_{-1}B_t}{P_t}\right) \equiv \left(\frac{{}_{-1}L_t}{P_t}\right) + \left(\frac{{}_{-1}H_t}{P_t}\right) + \left(\frac{{}_{-1}S_t}{P_t}\right) $$

These general consolidated nominal & real claims due in each period allows pursuit of the problem using sufficient statistics. Each component denotes the net stocks of assets viz. bank deposits, directly and indirectly held real estate and corporate equities over corresponding liabilities like credit card debt, mortgages (FRM or ARM), etc.

[14] To support the explicit addition of housing services inside the utility function, composition of balance sheets need to matter ex-ante by the incorporation of modeling instruments that support multiple assets viz. portfolio adjustment costs. This complicates the derivation of sufficient statistics at both the household & aggregate level. A compromise is to consider how the relative price of durables changes with that of nondurables. I show in appendix B.2, this only modifies the measurement of the redistribution from the real interest rate channel. The other two redistribution channels are unaffected despite ex-post returns heterogeneity.

3.2 Main Theoretical Exercise

Keeping the notation consistent, I denote real wage at time t as $w_t \equiv W_t/P_t$. For the benchmark, the initial real term structure is $q_t \equiv {}_0q_t$, the initial nominal term structure is $Q_t \equiv {}_0Q_t$ and I use the normalization $q_0 = Q_0 = 1$. Keeping balance sheet components fixed at $\left\{{}_{-1}B_t\right\}_{t\geq 0}$ and $\left\{{}_{-1}b_t\right\}_{t\geq 0}$, the one time unexpected unit decline in real interest rate causes the following changes relevant for the consumer's problem.

1. All nominal prices rise in proportion across asset classes - housing H, equities S and liquid assets L.

$$\frac{dP_{x,t}}{P_x} = \frac{dP_x}{P_x} \quad \text{with} \quad \frac{dP_H}{P_H} \neq \frac{dP_S}{P_S} \neq \frac{dP_\ell}{P_\ell} \quad \forall\, t \geq 0,\ x = \ell, S, H$$

2. All present-value real discount rates rise in proportion for each asset class.

$$\frac{dq_{x,t}}{q_x} = -\frac{dR_x}{R_x} \quad \text{with} \quad \frac{dR_H}{R_H} \neq \frac{dR_S}{R_S} \neq \frac{dR_\ell}{R_\ell} \quad \forall\, t \geq 0,\ x = \ell, S, H$$

3. More specifically, the above two points imply that the prices and returns of each wealth component differ in their magnitudes ex-post the shock. Normalizing the changes with respect to the liquid asset, I have the following relations.

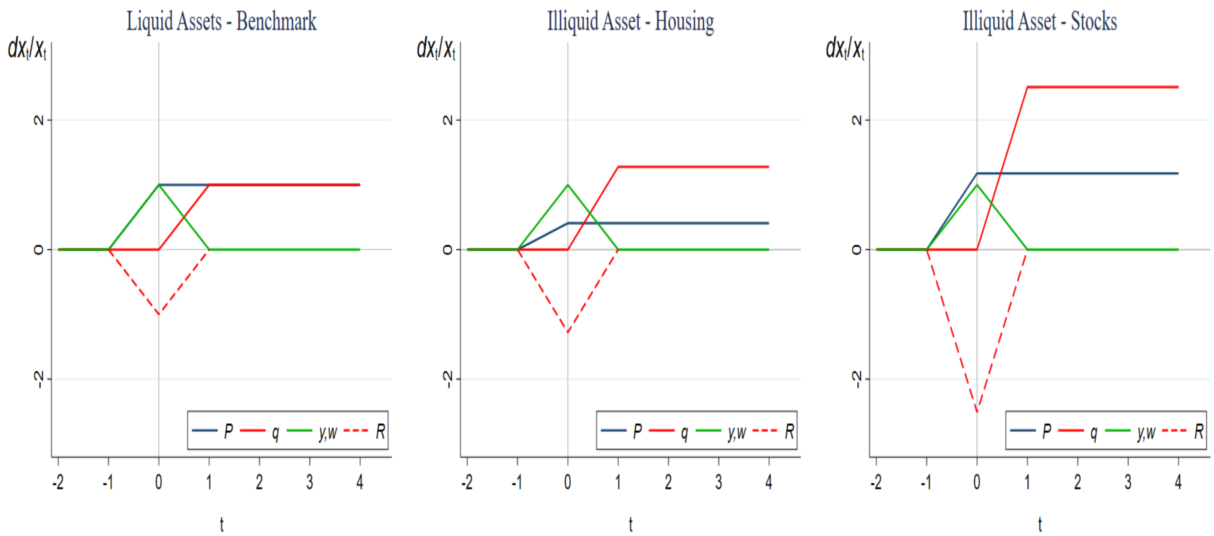
$$\frac{dR_H}{R_H} = \theta_1 \frac{dR}{R}, \quad \frac{dR_S}{R_S} = \theta_2 \frac{dR}{R}, \quad \frac{dP_H}{P_H} = \theta_3 \frac{dP}{P}, \quad \frac{dP_S}{P_S} = \theta_4 \frac{dP}{P}$$

$$\text{where} \quad \frac{dR_\ell}{R_\ell} = \frac{dR}{R} \quad \& \quad \frac{dP_\ell}{P_\ell} = \frac{dP}{P}$$

4. The Fisher equation holds for the new sequence of prices both across time & asset class and the agent's unearned income & real wage at $t = 0$ rise by dy & dw respectively.

In addition to the above, at the time of the shock, I quantify the relation between the prices of real zero-coupon bonds for housing with respect to the benchmark $q_{H,0} = \Theta_1 q_{L,0}$ & $q_{S,0} = \Theta_2 q_{L,0}$. Along with $\{\theta_i\}_{i=1(1)4}$, it gives the conditional impact of monetary policy on prices & returns of housing & equity relative to the benchmark liquid asset assumed by Auclert (2019). This particular variation is captured in a stylized version in the three panels of Figure 4 where the estimates are the present discounted values reported in Table 1. There is

Figure 4: The time paths of interest rates, prices and unearned income for the perfect foresight model across asset classes.



Note - The conditional changes on asset excess premia and nominal prices are normalized with respect to the liquid asset which serves as the benchmark. The exact values are obtained from Table 1 which summarize the instantaneous per unit exposures to the real interest rate and inflation change.

substantial heterogeneity across asset classes. These estimates are the theoretical analogue for the precise instantaneous response.

3.3 Defining Household Exposures

The net of consumption wealth change depends on the household exposure to the price change, summarized by its *NNP* and to the real interest rate change, summarized by its *URE*. I present the definitions of these two measures along with their economic implications in the presence of ex-post price & returns heterogeneity. I start by stating the net of consumption wealth change $d\Omega$ at the household level for the transitory shock as

$$d\Omega = dy + ndw - NNP\frac{dP}{P} + URE\frac{dR}{R} \tag{3}$$

The first term in equation (3) is the earnings change following the transitory shock. The second term is the product of the change in the individual balance sheets from the aggregate change in the overall price level dP. This is the *NNP* of the household affected by the Fisher channel and is given by

$$NNP \equiv \sum_{t\geq 0} Q_t \left\{ \left(\frac{{}_{-1}L_t}{P_0}\right) + \theta_3 \left(\frac{{}_{-1}H_t}{P_0}\right) + \theta_4 \left(\frac{{}_{-1}S_t}{P_0}\right) \right\} \tag{4}$$

In general, since debtors have higher $MPCs$ than creditors, we can expect $MPCs$ to decline as NNP rises. The conditional effect on nominal prices ex-post across asset classes leads to a larger heterogeneous household exposure to inflation. The third and final term is the household's URE which is the effect on the individual household from the aggregate change in the real interest rate dR at time t.

$$\begin{aligned} URE_t \equiv \Bigg\{ & y_t + w_t n_t + \left({}_{-1}\ell_t\right) + \left(\frac{{}_{-1}L_t}{P_t}\right) \\ & + \Theta_1\theta_1 \left[\left({}_{-1}h_t\right) + \left(\frac{{}_{-1}H_t}{P_t}\right)\right] + \Theta_2\theta_2 \left[\left({}_{-1}s_t\right) + \left(\frac{{}_{-1}S_t}{P_t}\right)\right] - c_t \Bigg\} \end{aligned} \tag{5}$$

The URE at any time t is viewed as the difference between all maturing assets (including income) and liabilities (including planned consumption). Following Auclert (2019), it remains the appropriate measure of exposure for the real interest rate channel. Households with negative net URE are net debtors with higher $MPCs$. they would benefit from expansionary monetary policy which raises price of future consumption relative to current consumption is equivalent to the decline in the price of the former to the latter. Similar to NNP, it marks the importance of considering separate asset classes for a more precise exposure of households to real interest rates. The altered definitions in (4) & (5) are theoretical counterparts to section 2.2. At any point of time, the flexibility of the expressions in (4) & (5) allows a clear comparison with the original results by substituting $\{\theta_i\}_{i=1(1)4} = \{\Theta_j\}_{j=1,2} = 1$.

Detailed mathematical derivations are included in appendix B.1. As in Auclert (2019), the updated theorem makes no assumption about the functional form of the utility (except that it is separable) or about the time horizon. It can be readily applied to general functional forms. Moreover, (4) & (5) are valid under persistent shocks. These results are stated in appendix B.1. The setup is also flexible to the additions of durable goods, a derivation for which is contained in appendix B.2. The current environment also encompasses market incompleteness where individual income is subject to idiosyncratic shocks as in appendix B.3.[15]

[15]Empirically, it would be very challenging to estimate the MPC accurately as a function of the these two specific balance sheet exposures at the individual level using survey data for the case of incomplete markets.

3.4 Evaluating Importance of Return Heterogeneity

The altered definitions of the household exposures preserves the structure of existing work allowing similar economy-wide aggregation as the benchmark for a large class of heterogeneous agent modeling setups. I restate the economy-wide consumption response to the first order idiosyncratic response from individual income dY_i along with aggregate variables dY, dP and dR in (6). γ_i is the elasticity of individual income to aggregate income & σ_i is the individual *IES*. In section 4, I describe how to emprically measure & quantify these relations between exposures & corresponding *MPCs*.

$$dC = \underbrace{\mathbb{E}_I\left[\frac{Y_i}{Y}\widehat{MPC}_i\right]dY}_{\text{Aggregate income channel}} + \underbrace{\gamma \mathrm{cov}_I\left(\widehat{MPC}_i, Y_i\right)\frac{dY}{Y}}_{\text{Earnings heterogeneity channel}} - \underbrace{\mathrm{cov}_I\left(\widehat{MPC}_i, NNP_i\right)\frac{dP}{P}}_{\text{Fisher channel}}$$

$$+ \left(\underbrace{\mathrm{cov}_I\left(\widehat{MPC}_i, URE_i\right)}_{\text{Interest rate exposure channel}} - \underbrace{\mathbb{E}_I\left[\sigma_i\left(1-\widehat{MPC}_i\right)c_i\right]}_{\text{Substitution channel}}\right)\frac{dR}{R} \tag{6}$$

$$\text{where } \widehat{MPC} = \frac{MPC}{1+wMPN} \geq MPC \quad \& \quad \gamma_i \approx \gamma \equiv \frac{\partial\left(\frac{Y_i}{Y}-1\right)}{\left(\frac{Y_i}{Y}-1\right)}\frac{Y}{\partial Y}$$

The above result shows that a set of seven sufficient statistics, all of which can be estimated from survey data having information on household balance sheets and consumption expenditures, completely characterizes the aggregate consumption response to the unexpected transitory shock. One way to evaluate is by comparing the economy-wide consumption response in both partial and general equilibrium. This forms the basis of results in section 5.2. The Representative agent counterpart has a single *MPC* which leads to all the covariance terms being 0 and three separate returns. It serves to isolate the importance of heterogeneity of *MPCs* for HANK models. Additionally, there is only one common *IES* σ.

$$dC = \widehat{MPC}dY - \sigma\left(1-\widehat{MPC}\right)C\frac{dR}{R} \quad \text{or} \quad \frac{dC}{C} = -\sigma\frac{dR}{R} \tag{7}$$

The class of sufficient statistics can also be estimated separately for housing and equity (which is important in its own regard as mentioned in section 1) by adding respective ex-post return & price heterogeneity relative to the benchmark. In summary, I therefore compare the results for 5 different models for the same one percent decline in the real interest rate and an accompanying one percent increase in inflation and aggregate income. This is denoted in the first panel of Figure 4 for the benchmark which is the liquid asset.

Second, one might be interested in quantifying the direct effects of monetary policy which is the interest rate elasticity of aggregate demand to the real interest rate.[16] Greater the proportion of unconstrained agents in the economy, larger is the response. The central bank's influence on aggregate demand is larger at this stage relative to second order price and income changes over which it has less control. It is given by the instantaneous consumption response to only the change in the real interest rate in partial equilibrium.

$$\frac{\partial C}{C}\frac{1}{\partial r} = \left(\underbrace{\mathrm{Cov}_I\left(MPC_i, \frac{URE_i}{\mathbb{E}_I[c_i]}\right)}_{\varepsilon_R \ <0} - \sigma \underbrace{\mathbb{E}_I\left[(1-MPC_i), \frac{c_i}{\mathbb{E}_I[c_i]}\right]}_{S \ >0} \right)$$

$$\sigma^* \equiv \frac{-\varepsilon_R}{S} = \frac{-\mathrm{Cov}_I\left(MPC_i, \frac{URE_i}{\mathbb{E}_I[c_i]}\right)}{\mathbb{E}_I\left[(1-MPC_i)\frac{c_i}{\mathbb{E}_I[c_i]}\right]}, \quad \because \sigma S \neq -\varepsilon_R \tag{8}$$

Focusing on the relevant term in (6), (8) shows the ratio of the *URE* & the corresponding substitution channel in a RANK. It is typically positive since the covariance between *URE* & *MPC* is negative (see section 3.3). Measuring σ^* does not depend on the value of *IES*, reported estimates for which can vary widely. One can simply redefine the *IES* parameter as the sum of σ^* & σ without amending the existing calibrated value of the latter. The model now gets more realistic partial consumption dynamics through its sole channel of transmission. The measure benefits applications where a RANK is preferred over the complexities of structural incomplete market models. The relevant results are in section 5.1 using analogous across model comparison as described in section 5.2.

4 Measuring the sufficient statistics from survey data

Assuming a common *IES* σ & elasticity of relative income to aggregate income γ, the estimable moments are the counterparts of (6). For convenience, I summarize their definitions by referring to Figure 5 from Auclert (2019) corresponding to (9). I map the theoretical

[16] The first generation of HANK models pioneered by Kaplan et al. (2018) report that direct effects typically never exceed on-third of the total impact. Extensive work has since been conducted to analyze the quantitative contributions of the interest rate channel primarily in structural models. Notwithstanding its limitations as detailed in section 4 of Auclert (2015), I approach the problem instead from the sufficient statistics approach which incorporate the conditional impact of monetary policy. The advantage is having an environment free of misspecification errors while being backed up by extensive micro-data.

definitions given by equations (4) & (5) to household survey data and the estimates from Table 1 using the consumer expenditure survey (CE) data from 1999-2002.

$$\frac{dC}{C} = (\mathcal{M} + \gamma\varepsilon_Y)\frac{dY}{Y} - \varepsilon_P\frac{dP}{P} + (\varepsilon_R - \sigma\mathcal{S})\frac{dR}{R} \tag{9}$$

For (10) - (11), C_i is all expenditure on consumption including rent & interest payments (non-durables) with robustness checks for durable expenditure, fraction $= 1 - \epsilon$. Assets A_i includes deposits & bonds while liabilities L_i is composed of primarily adjustable rate mortgages & credit cards. T_i is taxes net of transfers. Y_i is gross income from all sources - labor, dividend, and interest income, as well as realized capital gains.

$$NNP_i = (1 + NSP) \times S_i + LiqA_i - (1 + NHP) \times HL_i - NHL_i \tag{10}$$

$$\begin{aligned} URE_i = {} & Y_i - T_i - C_i + (1 + SPC) \times (1 + NEP) \times S_i + LiqA_i \\ & - (1 + HPC) \times (1 + NHP) \times HL_i - NHL_i \end{aligned} \tag{11}$$

I maintain the assumption of excluding reported unrealized capital gains from income. Equations (10) & (11) aim to incorporate ex-post returns & price heterogeneity from the Fisher and real interest rate channels. Accordingly, directly held net nominal positions of equity is weighed by the normalized stock price change (*NSP*). For housing, it is the normalized house price change (*NHP*). Analogously, the interest rate exposure is adjusted to include the normalized changes in equity premium & housing premium (*NEP* & *NHP*) with the corresponding changes in the nominal prices of these assets (*SPC* & *HPC*). The values are listed in Table 1 and expressed in appropriate units. The rest of the sufficient statistics are identically estimated. If one wishes, they can use their preferred estimates obtained using the method of their choice for Table 1 to measure (11) & (10).

The main estimating equation is of the form (12). I follow the exact same method as Auclert (2019) to estimate the *MPC* from a windfall fiscal transfer based on stratification of the population depending on the measure of household exposure. I present here the specification for the real interest rate channel. $c_{i,m,t}$ is household $i's$ consumption expenditures in month m and at date t, α_m is month fixed effects while $X_{i,t}$ are controls. R_{t+1} is the dollar amount of the rebate at $t+1$ & $QURE_{i,j}$ is a dummy indicating that household $i's$ *URE* in group $j = 1...J$. In each *URE* bin, the average normalized *URE*, $NURE_j$ is the average over households in group j of $\frac{URE_j}{\bar{c}}$ where $\bar{c}$ is average consumption expenditure in the sample. The household panel is resampled around 100 times with replacement by a Monte-Carlo procedure to minimize sampling uncertainty before calculating the sufficient statistic. In line with the logic in section 3.3 for the *URE* channel, the ex-post returns heterogeneity amplifies the exposures leading to higher *MPC* estimates for the lower quantiles. Both of these amplify the covariance which is the corresponding sufficient statistic. Analogous equations and intuition exist for the inflation & earnings heterogeneity channels.

$$C_{i,m,t+1} - C_{i,m,t} = \alpha_m + \beta X_{i,t} + \sum_{j=1}^{J} MPC_j R_{i,t+1} QURE_{i,j} + u_{i,t+1}$$

$$\widehat{\varepsilon}_r = \frac{1}{J}\sum_{j=1}^{J} MPC_j NURE_j - \left(\frac{1}{J}\sum_{j=1}^{J} MPC_j\right)\left(\frac{1}{J}\sum_{j=1}^{J} NURE_j\right) \;\; \& \;\; \widehat{S} = 1 - \left(\frac{1}{J}\sum_{j=1}^{J} MPC_j\right) \tag{12}$$

Following the discussion in section 3.3, to get the impact of changing estimates of *MPC*, I use a second survey data which has self-reported *MPCs*. The Survey of Household Income and Wealth (SHIW) 2010 is one of the very few publicly available sources that serves the purpose. I carry out the identical exercise as with the CE. I concede that the household portfolio heterogeneity and subsequent quantitative implications of monetary policy in section 2.2 are very different for US and Italian data. The exercise nevertheless gives implications from holding the heterogeneous *MPCs* at the household level invariant to adjusted balance sheet exposures.

I maintain the same assumptions as the benchmark case for dealing with durables and asset maturities. Alternate fiscal policy where the external sector (viz. the Government) withholds lumpsum transfer from the household sector rather than an instantaneous rebate gives the second set of sufficient statistics, labelled as the no rebate numbers. Issues of concern with the survey data centers around the limited information on household asset holdings. This is true for both the CE and SHIW data, both of which chronically under represent the rich. These pose more acute problems for my exercise since I require extensive household wealth information to quantify the role played by wealth inequality in measuring redistributative effects. To get an estimate of the scale of the problem and for further details, I refer the interested reader to section III. B, particularly Tables 2 and 3 as well as appendix C.6 of Auclert (2019).

Figure 5: Seven cross-sectional moments that determine consumption in (9)

	Definition	Name	Channel
$\mathcal{E}_R$	$\text{cov}_I\left(MPC_i, \frac{URE_i}{\mathbb{E}_I[c_i]}\right)$	Redistribution elasticity for R	Interest-rate exposure
$\mathcal{E}_R^{NR}$	$\mathbb{E}_I\left[MPC_i \frac{URE_i}{\mathbb{E}_I[c_i]}\right]$	—, no rebate	—
$\hat{S}$	$\mathbb{E}_I\left[(1-MPC_i)\frac{c_i}{\mathbb{E}_I[c_i]}\right]$	Hicksian scaling factor	Substitution
$\mathcal{E}_P$	$\text{cov}_I\left(MPC_i, \frac{NNP_i}{\mathbb{E}_I[c_i]}\right)$	Redistribution elasticity for P	Fisher
$\mathcal{E}_P^{NR}$	$\mathbb{E}_I\left[MPC_i \frac{NNP_i}{\mathbb{E}_I[c_i]}\right]$	—, no rebate	—
$\mathcal{E}_Y$	$\text{cov}_I\left(MPC_i, \frac{Y_i}{\mathbb{E}_I[c_i]}\right)$	Redistribution elasticity for Y	Earnings heterogeneity
$\mathcal{M}$	$\mathbb{E}_I\left[MPC_i \frac{Y_i}{\mathbb{E}_I[c_i]}\right]$	Income-weighted MPC	Aggregate income

Note - Essentially there are five sufficient statistics for the three channels along with the traditional income and substitution channels. To minimize the measurement errors with the sufficient statistics for interest rate and inflation, there are two corresponding numbers given in rows 2 and 5 respectively.

5 Results

Notwithstanding the limitations of the survey data, I intend to demonstrate using sufficient statistics that the conditional impact of transitory monetary policy is very different in the absence of returns heterogeneity. The overall magnitude of transmission to aggregate consumption depends extensively on the redistribuative channels, especially those arising from the real interest rate & nominal price changes.[17] Instead of relying on a structural model that could be prone to misspecification errors, the relatively restriction free theoretical framework of section 3 can be mapped to the empirics in section 4. Further, one can analyze the results by isolating the role of housing and equity taking into cognizance that returns heterogeneity interacts with portfolio heterogeneity, both within and across asset classes. The approach can also be used to conduct simple policy counterfactuals. As HANK models progress in their complexity they should remain consistent with the aggregate moments, derived specifically for the dimension of the wealth distribution that they seek to incorporate and explain.

[17]As mentioned in section 4, the unrealized capital gains reported in the survey data are excluded as the existing redistribution channels summarize the household exposures for the same. Instead, I focus on the best way to incorporate the conditional impact. One of the feasible channels of interest is returns heterogeneity that I focus exclusively on. To get an idea of how reported unrealized capital gains/losses affect wealth changes across wealth quantiles, see appendix A.4.

Table 2: σ^* across models for benchmark case with $\sigma = 0.5$ for expansionary policy

Measure	**Survey**	Auclert	Housing + Stock	Housing	Stocks
$\boldsymbol{\sigma^*}$	**CE**	0.36	0.58	0.54	0.53
% Change	**CE**	—	62.68	49.83	47.56
$\boldsymbol{\sigma^*}$	**SHIW**	0.18	0.13	0.11	0.20
% Change	**SHIW**	—	-31.25	-41.07	10.00

Note - Expansionary shock refers to the transitory unexpected one percent decline in the real interest rate. Column 1 are benchmark numbers using baseline calibration. Percentage change is with respect to the benchmark. Columns 2-4 add the additional conditional differential impact in asset excess premium/premia & price(s) on top of the benchmark.

Of course, there could be alternate channels that I do not consider that have similar impacts (I briefly compare the results in section 1). I choose the one that is both intuitive as well as easily verified with publicly available micro-data using appropriate techniques.

The section is broadly divided into 5 parts. First, as articulated in section 3.4, I present the enhancements in direct effects (section 5.1) and then the quantitative significance for aggregate consumption (section 5.2). I explain how intuitively the results are expected to be different from the additional dimension of heterogeneity. I stress on the importance of estimating *MPCs* out of unrealized wealth changes. I measure the asymmetric consumption response from a contractionary shock in 5.3. Next, I discuss how other dimensions of heterogeneity like housing tenure and demographics interact with heterogeneity in asset returns. I conclude the section by a brief discussion of model predictions in 5.5. Analogous to Auclert (2019), I present the updated sufficient statistics in appendix C.1 along with associated figures depicting covariance between the measures of redistribution and estimated *MPCs* qualitatively.

5.1 The interest rate elasticity of aggregate demand

To evaluate the efficiency of the refined sufficient statistics in capturing the conditional returns heterogeneity channel, I introduced two comprehensive measures in 3.4. The primary measure determines the aggregate demand's elasticity to the real interest rate, represented by the total of σ and σ^*. A sizable σ^* implies overlooking market incompleteness has led to significant underestimation of direct consumption impacts. The original model, which considered consistent asset class impacts, can be contrasted against three distinct cases. I can either include returns for both housing and equity or introduce them individually. Table 2 showcases both the magnitude and percentage change from the original in two scenarios - one with variable *MPCs* from CE data and another with stable *MPCs* from SHIW data. The combined returns yield the most substantial impact, highlighting the importance of factoring in unrealized wealth changes for complete redistribution. Even with housing's lower premia compared to equity, disregarding housing's unrealized wealth alterations prevents many from experiencing heightened *MPCs* from sudden wealth gains. These results accentuate the real interest rate's amplified role in redistribution within this framework, underlining the importance of both recognizing household portfolio variety and aligning it with asset return heterogeneity.[18]

As highlighted earlier, if policy nuances targeting specific asset classes aren't a concern, structural models should at least yield accurate aggregate responses. My metrics, designed for sharper estimations, are poised to be beneficial in this context. Aligning with previous outcomes, if *MPCs* aren't allowed to vary, the redistribution's utility (particularly from the real interest rate avenue) for overarching monetary transmission is essentially constrained, evident from the fourth row. Naturally, the comprehensive consumption response would integrate the indirect impacts, which I will address subsequently. Asset maturity related robustness checks are catalogued in appendix C.

5.2 Comparing the consumption response across models

I present the expansionary policy results and rank the response of aggregate consumption in partial and general equilibrium across models using only sufficient statistics.[19] Using equation (9) and the data from Figure 4, I compute the total percent change in general equilibrium.[20] From this, I derive the partial equilibrium response, and the RANK response is given by (7). Results interpretation is expanded upon in sections 5.2 and 5.3. For each data source, I tabulate the responses; for instance, Table 3 details various model results.

[18]While some may argue against the reliability of survey data, this paper's goal is to create a robust framework tied to empirical data to substantiate these critical assertions. Future work includes additional tests using the PSID data.

[19]This transitory shock results in a one-period response. Details on handling persistent real interest rate changes due to unexpected monetary policy surprises are in appendix B.1 and A.3.

[20]The use of the liquid asset benchmark evaluates the importance of returns heterogeneity compared to Auclert (2019). The updated household exposure definitions offer flexibility to consider or ignore additional sources like housing and stocks.

Table 3: Percent change in aggregate consumption for expansionary shock with $\sigma = 0.5$ & $\gamma = -0.5$ in CE data for benchmark case

Model with estimated *MPCs*	Consumption Response		In corresponding RANK	
	PE	GE	PE	GE
Auclert + House + Stock	0.90	1.34	0.33	0.77
Auclert + House	0.84	1.28	0.32	0.77
Auclert + Stock	1.06	1.52	0.33	0.79
Auclert	0.71	1.17	0.32	0.78

Note - Expansionary shock refers to the transitory unexpected one percent decrease in the real interest rate accompanied by an increase in the overall price level & aggregate income by one percent. Row 4 represent the benchmark numbers using baseline calibration and additionally setting the value of γ. Rows 1-3 add(s) the additional conditional differential impact in asset excess premium/premia & price(s) on top of the benchmark. Numbers represent the elasticity of aggregate consumption. Columns 2 and 3 refer to partial equilibrium and general equilibrium elasticities. RANK is counterpart of model in each row with constant *MPC*.

Analogous tables should be interpreted similarly. The parameters chosen are $\sigma = 0.5$ & $\gamma = -0.5$ with σ being consistent with the original model. Sensitivity tests for γ are in appendix C.

In Table 3, stock excess returns and price changes significantly outperform housing. Specifically, the high conditional impact of stocks results in the most substantial consumption increase from a one percent reduction in the real interest rate: approximately 30% and 50% higher in partial and general equilibrium compared to the initial findings. Examining the redistribution from the real interest rate, Fisher, and unearned income channels in general equilibrium, we find their combined share rises by 15% to 48% . The real interest rate and Fisher individually account for 3% and 12% increases. Including both these sources leads to an overall rise in consumption by 27% and 15% , with redistribution shares at 43% ; broken down, the two channels contribute 9% and 2% .

Emphasizing the redistribution channel boosts the overall monetary transmission, especially via the real interest rate and Fisher channels, due to heightened *MPCs* heterogeneity. The partial equilibrium response is also more substantial because the net income effect counters the impact. However, adding one or two returns to a RANK doesn't substantially assist in quantifying this transmission. Figure 11 panel (b) reveals a hump-shaped response when utilizing self-reported MPCs, causing decreased *MPCs* across the *URE* distribution, hence

Table 4: Percent change in aggregate consumption for expansionary shock with $\sigma = 0.5$ & $\gamma = -0.5$ in SHIW data for benchmark case

Model with fixed *MPCs*	Consumption Response		In corresponding RANK	
	PE	GE	PE	GE
Auclert + House + Stock	0.44	0.93	0.28	0.77
Auclert + House	0.43	0.92	0.28	0.77
Auclert + Stock	0.48	1.03	0.28	0.83
Auclert	0.51	0.97	0.28	0.74

Notes - For more details see notes in Table 3. Here identical exercise for SHIW data.

Table 5: σ^* across models for benchmark case with $\sigma = 0.5$ for contractionary policy

Measure	**Survey**	Auclert	Housing + Stock	Housing	Stocks
$\boldsymbol{\sigma^*}$	**CE**	0.36	0.39	0.26	0.16
% Change	**CE**	—	9.48	-27.01	-55.12
$\boldsymbol{\sigma^*}$	**SHIW**	0.18	0.25	0.27	0.16
% Change	**SHIW**	—	40.0	50.0	10.0

Note - Contractionary shock refers to the transitory unexpected one percent increase in the real interest rate. See notes in Table 2 for more details.

smaller consumption changes. As shown in Table 4, this reduction in consumption response across models aligns with prior explanations about the distribution shift pushing individuals to report lower *MPCs*.[21]

In the context of understanding the significance of no-rebate numbers, which shed light on the mismeasurement issue, I detail the outcomes for the four models across two datasets with heterogeneous *MPCs* in Table 23. These figures are empirically more trustworthy. Results indicate that incorporating returns heterogeneity, contingent on the shock, enhances redistribution to aggregate consumption, irrespective of if *MPCs* are static or variable based on the shock. The general equilibrium boost is 48% in CE and 73% in SHIW. Even solely

[21] Acknowledging previous caveats, the data and household portfolio heterogeneity aren't directly comparable for the identical shock. However, it provides insight into changing *MPCs* impacts. Even on the conservative side, the response from unrealized wealth effects would be considerably lower.

integrating the relative heterogeneity in housing returns, which empirically results in fewer unrealized wealth shifts relative to equity, sees boosts of 53% and 48% . An exception exists for the impact exclusive to equities in CE data, where aggregate consumption notably drops for both equilibria. When leaning on conservative redistribution estimates, no scenarios result in a negative aggregate consumption elasticity, a marked improvement over initial findings.

5.3 Response to a contractionary shock

Including the conditional impact of the shock on sufficient statistics allows me to mechanically generate results for the contractionary monetary policy. Empirically, the estimates in Table 1 reverse their signs. The contractionary one time monetary policy surprise produces symmetric changes in the prices and excess premia for housing & equity. I present results analogously for sections 5.1 and 5.2 for a transitory one percent increase in real interest rate. It highlights how heterogeneity in *MPCs* produces asymmetric responses in HANK models.[22] It also demonstrates the flexibility of the theoretical setup. Though all the signs are positive in Table 6 - Table 24, the elasticities (where applicable) correspond to an increase, and not decrease, in the real interest rate. The benchmark results are identical since the original results are unconditioned on the shock. The fact that the other estimates are substantially different from their counterparts in sections 5.1 and 5.2 highlight the scale of asymmetricity by asset class. I present additional results in appendix 5.2.

In Table 5, direct effects on stocks appear minimal since they experience the most significant wealth reductions. Consequently, the final consumption response from this channel is subdued due to associated lower *MPCs*. This pattern is mirrored in housing, albeit with less pronounced declines. Incorporating both stocks and housing results in a more marked decrease in consumption. Yet, assessing only the real interest rate channel can be misleading, as the final consumption response diminishes considerably, as evidenced in Table 6. Here, the Fisher channel counteracts the decline.

In the three analyzed cases, wealth reduction heightens the redistribution measure at the lower distribution end and diminishes it for the upper half. Due to the negative covariance, wealth declines result in smaller estimated *MPCs*. The product of these two factors results in a decrease smaller than that caused by the wealth change alone. The aggregate outcome is

[22] I refer to this growing literature briefly in section 1 in connection with my sufficient statistics approach.

Table 6: Percent change in aggregate consumption for contractionary shock with $\sigma = 0.5$ & $\gamma = -0.5$ in CE data for benchmark case

Model with estimated *MPCs*	Consumption Response		In corresponding RANK	
	PE	GE	PE	GE
Auclert + House + Stock	0.53	1.02	0.31	0.80
Auclert + House	0.46	0.95	0.31	0.80
Auclert + Stock	0.54	1.00	0.31	0.77
Auclert	0.71	1.17	0.32	0.78

Note - Contractionary shock refers to the transitory unexpected one percent increase in the real interest rate accompanied by a decrease in overall price level & aggregate income by one percent. See notes in Table 3 for more details.

influenced by existing household portfolio heterogeneity. The response is not only asymmetric, but redistribution also moderates the final consumption impact. Given that estimated unrealized wealth reductions are negative, equity takes precedence over housing; the former experiences the steepest declines and the least change in associated *MPCs*, thus amplifying the asymmetric response. As per Table 7, the associated consumption reductions are minimal for both equilibria, outperforming the benchmark model's decline by 35% and 18% for partial and general equilibrium, respectively. Integrating both housing and equity leads to a more modest decrease, surpassing the benchmark model's decline by up to 25% and 12% in partial and general equilibrium respectively.

Crucially, we must re-estimate the associated *MPCs*. Table 7 indicates larger declines when solely considering wealth changes. Here, diminished wealth, as gauged by the redistribution measure, leads to heightened *MPCs*. The net consumption response results from the combination of a smaller *MPC* decrease and the related wealth reduction. For completeness, results accounting for sampling error are in Table 24. With constant *MPCs*, some aggregate consumption elasticity values appear counter-intuitive. The absence of a pronounced negative correlation between redistribution and *MPC* in the SHIW, unlike in the CE, seems to be a factor. In the final model using CE data, consumption declines are 81% and 52% less than baseline estimates. Only with housing does the asymmetric response inverse, causing a greater consumption drop. A potential reason might be the minimal wealth declines for agents who predominantly have their wealth in housing, given that their usual *URE* is negative.

Table 7: Percent change in aggregate consumption for contractionary shock with $\sigma = 0.5$ & $\gamma = -0.5$ in SHIW data for benchmark case

Model with fixed *MPCs*	Consumption Response		In corresponding RANK	
	PE	GE	PE	GE
Auclert + House + Stock	0.53	1.16	0.28	0.91
Auclert + House	0.53	1.16	0.28	0.91
Auclert + Stock	0.46	1.01	0.28	0.83
Auclert	0.51	0.97	0.28	0.74

Note - Contractionary shock refers to the transitory unexpected one percent increase in the real interest rate accompanied by a decrease in overall price level & aggregate income by one percent. See notes in Table 4 for more details.

5.4 Interaction with other dimensions of heterogeneity

The substantial surge in aggregate consumption arises from the expectation that households will eventually convert their wealth changes into liquid assets. But if significant financial constraints impede these future realizations, the resultant rise in consumption might be more subdued. Two key constraints are housing tenure and demographics. Homeowners have lower leverage compared to mortgage holders, and renters often carry substantial non-housing debt. Younger individuals typically amass more debt, primarily for housing, whereas the middle-aged and elderly generally have less. This section delves into how specific wealth changes from ex-post return heterogeneity interact with these two household facets. The more unconstrained a household, the likelier they'll boost current consumption from unrealized wealth gains, leading to a more pronounced aggregate reaction. There are other relevant factors intersecting with balance sheet effects, but they're more challenging to scrutinize in this context.

Following Cloyne et al. (2020), I categorize households into three groups based on housing tenure: outright homeowners, mortgage holders, and renters. Demographic distinctions align with Wong (2019). I assess the change in general equilibrium instantaneous responses for these household groups with return heterogeneity compared to benchmark figures in Auclert (2019). Further results on implied *IRFs* concerning demographics and housing tenure can be found in appendix E. As indicated in Table 8, mortgage owners don't necessarily see an

Table 8: Percent change in aggregate consumption relative to benchmark with $\sigma = 0.5$ & $\gamma = -0.5$ for CE data by housing tenure

Housing Tenure	**Outright Homeowner**	**Mortgage Holder**	**Renter**	**All**
Sample Size (in %)	26.27	40.65	33.08	–
Expansionary Shock	18.49	3.73	0.93	15.68
Contractionary Shock	-26.83	-14.14	-8.43	-12.67

Note - Numbers represent the percentage change in aggregate consumption elasticity in general equilibrium for the model in section 3 from estimates of the benchmark model for housing tenure sample given by columns 2-4 without ex-post returns heterogeneity. For details regarding the shock please see associated table notes in Table 3 & Table 6.

increased consumption response from amplified wealth changes due to return heterogeneity. Instead, outright homeowners, with lower debt by choice and fewer constraints, register a much more prominent response. Renters, typically less endowed to take on substantial debt, exhibit minor absolute elasticities in both models, even with a notable percentage increase. Table 9 illustrates age-based responses. Drawing a loose comparison to Table 4 in Wong (2019), though methodologies differ significantly, the elderly and middle-aged demonstrate a higher consumption response compared to the young in terms of aggregate elasticities. This aligns with the understanding that older individuals, facing fewer financial constraints and having shorter lifespans, are likely to liquidate gains faster. Conversely, the young, being potentially more financially constrained, might see muted effects from unrealized wealth gains after a positive shock.

5.5 Policy Experiments

To quantify the interaction of wealth inequality with/without ex-post returns heterogeneity, I calibrate the household balance sheets for different years and assume that consumption expenditures remain similar as 2001 CE. I analyze both expansionary and contractionary monetary policy. I use SCF data for 2007 and 2019 to target the GFC and the pandemic respectively. Of particular interest is a contractionary policy around 2007 to approximate the tightening of the interest rate that preceded the collapse of the housing bubble. Similarly,

Table 9: Percent change in aggregate consumption relative to benchmark with $\sigma = 0.5$ & $\gamma = -0.5$ for CE data by demographic group

Demographics	**Young** (25-34 yrs)	**Middle** (35-64 yrs)	**Old** (64-75 yrs)	**All**
Sample Size (in %)	33.64	54.67	11.69	–
Expansionary Shock	10.99	20.81	49.31	15.68
Contractionary Shock	-7.39	-30.59	-70.34	-12.67

Note - Numbers represent the percentage change in aggregate consumption elasticity in general equilibrium for the model in section 3 from estimates of the benchmark model for demographics sample given by columns 2-4 without ex-post returns heterogeneity. For details regarding the shock please see associated table notes in Table 3 & Table 6.

faced by the pandemic, the Fed undertook massive quantitative easing that is akin to an exogenous expansionary surprise in my setup. For mortgage design, I look at a widespread prevalence of adjustable rate mortgages (ARMs). In the US, most fixed rate mortgages carry an option for low cost refinancing (either cash-out or no cash-out). These can be approximated by assuming a greater share of mortgages being ARMs. The results vary significantly if I shorten asset maturity.

Using CE data and examining the *MPC* channel, I analyze aggregate consumption elasticity in general equilibrium. In 2019, a 1% decrease in real interest rate led to a 16% increase in aggregate consumption with a 51% redistribution rate. At quarterly maturity, these values rise to 24% and 67% . With all mortgages as ARMs, the figures are 30% and 58% , but jump to 53% and 79% for quarterly maturity. This data supports the Federal Reserve's early pandemic monetary expansion. More ARMs enhance wealth gains, particularly elevating *MPC* for constrained households. Similar policies had even stronger effects in 2007. The outcome is shaped by housing and equity market dynamics, where increased housing wealth results in higher consumption response, despite lower returns per unit.[23]

The model counterfactual improvements in the aggregate consumption response for contractionary policy, in line with section 5.3. In 2007, a contractionary shock would have lead to

[23]From 2004-2007, housing outperformed equity. Post-GFC, equity rebounded faster, and by 2019, housing's relative share declined. See Kuhn and Rıos-Rull (2020). Short-term wealth inequality can affect consumption due to limited redistribution.

an improvement in aggregate consumption by 9%. Having only returns for housing would improve by 14%. Having ARMs and/or restricting to quarterly maturity does not improve upon the results. Full results are reported in Table 27 - Table 28, appendix F. These experiments are of course limited. The reduced form model free environment has limited appeal vs alternately estimating complex structural models with micro-data. Recently, there has been significant progress in bayesian estimation of HANK models. However, I have demonstrated the importance of treating ex-post return heterogeneity seriously when the primary purpose is analyzing aggregate moments of consumption from aggregate monetary policy surprises.

6 Conclusion

Overlooking the differential monetary policy effects on housing and equity leads to significant underestimation of aggregate consumption through redistribution. While previous studies have focused on heterogeneities like discount factors or risk-taking propensities, these approaches often miss the mark. Specifically, they don't fully capture *MPCs* from unrealized wealth shifts, resulting in RANK-like consumption responses. My research stands out due to two distinctions: I utilize a transmission mechanism based on publicly available asset data, and I show that larger disparities in asset returns bolster aggregate consumption. Using a perfect foresight model, I demonstrate a 15% increase in aggregate consumption, with redistribution contributing 43% from a 1% decrease in the federal funds rate. Remarkably, this outperforms a RANK model by about 74% , highlighting the versatility and foundational clarity of my theoretical approach. The effect is asymmetric with consumption declining by only 12% when the Fed raises rates by 1% instead. I also document how various groups win and lose depending on interactions of housing tenure and age respond asymmetrically with monetary policy.

However, limited data on household assets, especially equity in CE, remains challenging. Future research could leverage the more detailed PSID dataset, albeit with some limitations in consumption data. My methodology's primary advantage lies in its practical, data-driven approach. For example, my model posits that a proactive pandemic policy, treating all mortgages as ARMs, would have spurred a 30% rise in aggregate consumption. This effect was even more potent in 2007 when housing gains overshadowed equity. This suggests that wealth inequality exerts a more immediate influence on consumption than previously thought. Given the robust data support, it's evident that distinct asset returns carry more weight than other sources of heterogeneity. Moving forward, constructing a HANK model incorporating both housing and equity as separate illiquid assets could offer a holistic policy exploration avenue.

References

Ampudia, Miguel, Dimitris Georgarakos, Jiri Slacalek, Oreste Tristani, Philip Vermeulen, and Giovanni Violante (2018) "Monetary policy and household inequality."

Auclert, Adrien (2015) "Monetary Policy and the Redistribution Channel."

——— (2019) "Monetary policy and the redistribution channel," *American Economic Review*, 109 (6), 2333–67.

Auclert, Adrien and Matthew Rognlie (2020) "Inequality and Aggregate Demand."

Auclert, Adrien, Matthew Rognlie, and Ludwig Straub (2018) "The intertemporal keynesian cross,"Technical report, National Bureau of Economic Research.

Baker, Scott R, Robert A Farrokhnia, Steffen Meyer, Michaela Pagel, and Constantine Yannelis (2020) "Income, liquidity, and the consumption response to the 2020 economic stimulus payments,"Technical report, National Bureau of Economic Research.

Berger, David, Veronica Guerrieri, Guido Lorenzoni, and Joseph Vavra (2018) "House prices and consumer spending," *The Review of Economic Studies*, 85 (3), 1502–1542.

Bu, Chunya, John Rogers, and Wenbin Wu (2021) "A unified measure of Fed monetary policy shocks," *Journal of Monetary Economics*, 118, 331–349.

Chen, Hui, Michael Michaux, and Nikolai Roussanov (2020) "Houses as ATMs: mortgage refinancing and macroeconomic uncertainty," *The Journal of Finance*, 75 (1), 323–375.

Chetty, Raj, John N Friedman, Nathaniel Hendren, Michael Stepner, and The Opportunity Insights Team (2020) *How did COVID-19 and stabilization policies affect spending and employment? A new real-time economic tracker based on private sector data*: National Bureau of Economic Research Cambridge, MA.

Cloyne, James, Clodomiro Ferreira, and Paolo Surico (2020) "Monetary policy when households have debt: new evidence on the transmission mechanism," *The Review of Economic Studies*, 87 (1), 102–129.

Coibion, Olivier, Yuriy Gorodnichenko, Lorenz Kueng, and John Silvia (2017) "Innocent Bystanders? Monetary policy and inequality," *Journal of Monetary Economics*, 88, 70–89.

DeFusco, Anthony A and John Mondragon (2020) "No job, no money, no refi: Frictions to refinancing in a recession," *The Journal of Finance*, 75 (5), 2327–2376.

Di Maggio, Marco, Amir Kermani, and Kaveh Majlesi (2020) "Stock market returns and consumption," *The Journal of Finance*, 75 (6), 3175–3219.

Gertler, Mark and Peter Karadi (2015) "Monetary policy surprises, credit costs, and economic activity," *American Economic Journal: Macroeconomics*, 7 (1), 44–76.

Gomme, Paul, B Ravikumar, and Peter Rupert (2011) "The return to capital and the business cycle," *Review of Economic Dynamics*, 14 (2), 262–278.

Gornemann, Nils, Keith Kuester, and Makoto Nakajima (2021) "Doves for the rich, hawks for the poor? Distributional consequences of systematic monetary policy,"Technical report, ECONtribute Discussion Paper.

Hartzmark, Samuel M and David H Solomon (2019) "The dividend disconnect," *The Journal of Finance*, 74 (5), 2153–2199.

Hedlund, Aaron, Fatih Karahan, Kurt Mitman, and Serdar Ozkan (2017) "Monetary policy, heterogeneity, and the housing channel," in *2017 Meeting Papers*, 1610.

Holm, Martin Blomhoff, Pascal Paul, and Andreas Tischbirek (2021) "The transmission of monetary policy under the microscope," *Journal of Political Economy*, 129 (10), 2861–2904.

Jappelli, Tullio and Luigi Pistaferri (2010) "The consumption response to income changes," *Annu. Rev. Econ.*, 2 (1), 479–506.

——— (2014) "Fiscal policy and MPC heterogeneity," *American Economic Journal: Macroeconomics*, 6 (4), 107–36.

Johnson, David S, Jonathan A Parker, and Nicholas S Souleles (2006) "Household expenditure and the income tax rebates of 2001," *American Economic Review*, 96 (5), 1589–1610.

Kaplan, Greg, Benjamin Moll, and Giovanni L Violante (2018) "Monetary policy according to HANK," *American Economic Review*, 108 (3), 697–743.

Kaplan, Greg and Giovanni L Violante (2020) "The Marginal Propensity to Consume in Heterogeneous Agents Models,"Technical report, Working Paper. Princeton University.

Kekre, Rohan and Moritz Lenel (2021) "Monetary policy, redistribution, and risk premia,"Technical report, National Bureau of Economic Research.

Kuhn, Moritz and José-Victor Rios-Rull (2020) "2019 Update on the US Earnings, Income, and Wealth Distributional Facts: A View from Macroeconomics."

Leombroni, Matteo and Ciaran Rogers (2021) "Household Portfolios, Monetary Policy and Asset Prices," *Monetary Policy and Asset Prices (November 10, 2021).*

Luetticke, Ralph (2021) "Transmission of monetary policy with heterogeneity in household portfolios," *American Economic Journal: Macroeconomics*, 13 (2), 1–25.

Mertens, Karel and Morten O Ravn (2013) "The dynamic effects of personal and corporate income tax changes in the United States," *American economic review*, 103 (4), 1212–47.

Mian, Atif, Kamalesh Rao, and Amir Sufi (2013) "Household balance sheets, consumption, and the economic slump," *The Quarterly Journal of Economics*, 128 (4), 1687–1726.

Mian, Atif and Amir Sufi (2014) "What explains the 2007–2009 drop in employment?" *Econometrica*, 82 (6), 2197–2223.

Miranda-Agrippino, Silvia and Giovanni Ricco (2021) "The transmission of monetary policy shocks," *American Economic Journal: Macroeconomics*, 13 (3), 74–107.

Monacelli, Tommaso and Roberto Colarieti (2022) "Monetary Policy with Heterogenous Risk."

Paiella, Monica and Luigi Pistaferri (2017) "Decomposing the wealth effect on consumption," *Review of Economics and Statistics*, 99 (4), 710–721.

Paul, Pascal (2020) "The time-varying effect of monetary policy on asset prices," *Review of Economics and Statistics*, 102 (4), 690–704.

Plagborg-Møller, Mikkel and Christian K Wolf (2021) "Local projections and VARs estimate the same impulse responses," *Econometrica*, 89 (2), 955–980.

Romer, Christina D and David H Romer (2004) "A new measure of monetary shocks: Derivation and implications," *American Economic Review*, 94 (4), 1055–1084.

Wieland, Johannes F and Mu-Jeung Yang (2020) "Financial dampening," *Journal of Money, Credit and Banking*, 52 (1), 79–113.

Wong, Arlene (2019) "Refinancing and the transmission of monetary policy to consumption," *Unpublished manuscript*, 20.

Appendix

A Robustness to Monetary Policy Shock

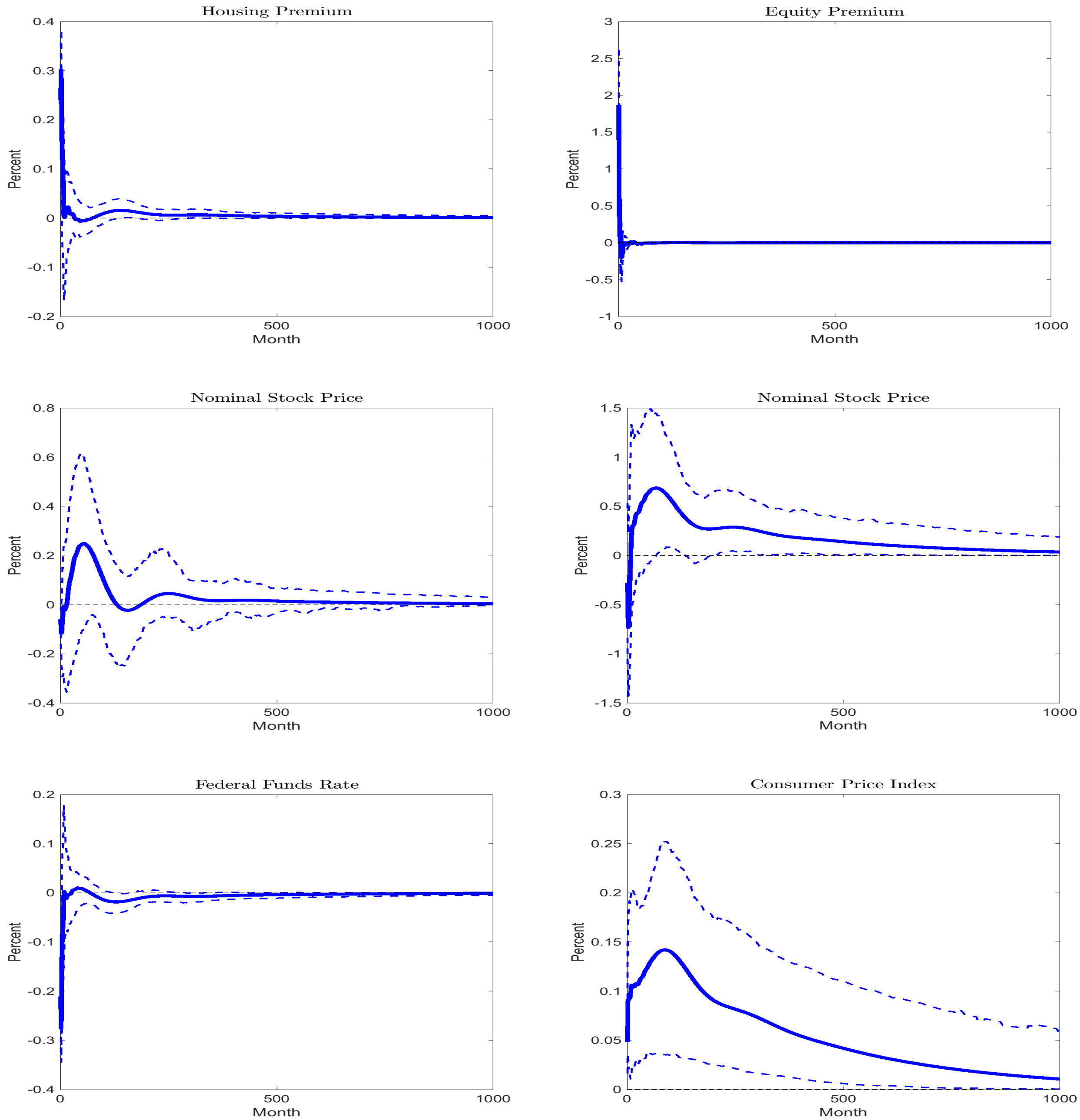
A.1 Alternate Specifications of SVAR used

The baseline specification in section 2.1 uses 7 variables and 7 lags. The *IRFs* for the full horizon of 1000 months ahead is shown in Figure 6. The choice of the horizon ensures that the *IRFs* are still consistent and the persistence is negligible. The mainstay of my quantitative findings depends on the actual numerical estimates of the present discounted values of the excess premia to housing and equity along with their nominal price changes in Table 1. These summarize the conditional impact of the one time shock to a monetary policy surprise for housing and equity.

Robustness to alternate values of the discount factor for the same model with the IRF horizon fixed at 1000 is presented in Table 10. In general, increasing β leads to higher housing premia and lower equity premia indicating that the changes are more persistent for housing and slower to respond to the shock. This is consistent with the explanation of housing being slower to respond due to its higher degree of illiquidity. Though the values for the nominal prices seem substantially higher, normalized versions are similar. The third row with $\beta = 0.975$ is of significance. Auclert (2019) has two kinds of agents with heterogeneity in discount factor for his structural model. Calibrating to the more impatient agent could tilt the balance of overall gains in favor of housing and will have very different policy implications. On the aggregate, the results will be quantitatively stronger since agents with housing tend to have negative *URE* and moderate *NNP*, both of which contribute to higher household *MPC* from the real interest rate and Fisher channels respectively.

Next, I check the sensitivity to choice of lag length in the SVAR specification used in Table 11. Again, consistent with my explanation for housing being in general slower to respond than equity, I report higher values of housing premia as the lag length reduces. Beyond 9 lags for the 7 variables, the *IRFs* are no longer consistently estimated and tend to diverge as the horizon increases. There is also higher persistence. The overall trend is not very different. The price changes are affected more leading to possibly higher estimates from the Fisher channel. I do not present any results for horizon length. Firstly, even though increasing

Figure 6: *IRFs* for complete horizon of 1000 months ahead for requisite variables for expansionary shock



Note - Derived for a one standard deviation decrease in the monetary policy surprise considered in Gertler and Karadi (2015) for VAR specification in section 2.1 which has seven variables and seven lags. The graph for the log of industrial production has not been shown. The first 48 months corresponding to 16 quarters is shown in Figure 1. 95 percent confidence bands computed using bootstrapping methods identical to Gertler and Karadi (2015).

Table 10: Sensitivity of PDV estimates to choice of β.

Present Discounted Value at $t = 0$	Nominal House Price	Housing Premium	Nominal Stock Price	Equity Premium	Nominal House Price	Nominal Equity Price
$\beta = 0.935$	0.26	1.25	0.48	2.63	0.17	0.33
$\beta = 0.965$	2.06	1.23	6.58	2.35	0.67	2.13
$\beta = 0.975$	3.64	1.33	12.39	2.16	0.81	2.76
$\beta = 0.99$	0.80	1.74	38.63	1.37	0.80	3.44

Note - For VAR specification, see section 2.1 - $\beta = 0.975$ is the second discount factor used by the structural model in Auclert (2015) besides the benchmark of $\beta = 0.95$ used in the main text. The lag length is fixed at 7. *IRFs* are generated for 1000 months ahead.

the number of periods 5 or 10 times hardly makes any difference to the PDVs since the *IRFs* are already converging. Second, for some specifications, this would lead to inconsistent estimation of the *IRFs* at very large horizons.

I analyze alternate specifications of the SVAR in along with different lag lengths. Here I present a subset of my results in Table 12. I observe that not having all the four variables together leads to higher responses for the stock price and equity premia. However, the changes are less accurate since all the requisite variables are not in the same SVAR. Moreover, there is influence of other variables which are not directly related viz. the excess bond premium. For specification 1, I have a SVAR of 6 variables. The first 4 are the log of consumer price index, log of industrial production, the federal funds rate and the excess bond premium (identical to used in Gertler and Karadi (2015)). The last two are either the asset excess premia or their nominal price changes. For specification 2, I have the SVAR of 5 variables with the four common variables and the last variable can be any of the 4 of interest. For both the cases, I ensure there is little persistence for 1000 months ahead. The *IRFs* are also consistent and do not diverge after a finite horizon. One can envision a specification which involve estimating the 4 requisite variables with the rest of the variables in the specification of Gertler and Karadi (2015). My arguments against this are three fold. First, their motivation was studying credit costs while mine is looking at the conditional

Table 11: PDV estimates using alternate lag lengths for 1000 months ahead

Lag Length used	Nominal House Price (in%)	Housing Premium	Nominal Stock Price (in%)	Equity Premium	Nominal House Price Norm.	Nominal Equity Price Norm.
8	0.74	1.28	3.79	2.34	0.33	1.71
6	0.75	1.29	4.37	2.36	0.30	1.78
4	1.84	1.57	3.81	4.12	0.70	1.45
1	1.65	1.77	2.32	1.41	1.77	2.48

Note - To be compared with results in Table 1. Specification used is detailed in 2.1. Results with $\beta = 0.95$ and one standard deviation positive monetary policy surprise. Beyond a lag length of 9, the *IRFs* are not consistent and do not converge at the given horizon of 1000 for the given specification.

impact on asset excess premia & prices, not on their borrowing costs since households do not adjust their portfolios. Secondly, adding extra variables which are not directly expected to be related is counter-intuitive. Thirdly, increasing the number of variables needs shortening of the lag length for consistent *IRFs*. Otherwise, I need to reduce the horizon length drastically which gives PDVs incompatible with the model. Either compromise is not desirable. The effect is more pronounced for housing since the response is slower and more persistent. For all the above robustness checks, the data sources and duration are the same as defined in the main text.

A.2 SVAR with exogenous variables and updated data

A recent alternative developed by Paul (2020) to the external instruments SVAR of Gertler and Karadi (2015) is integrating the data for monetary policy surprises directly into the vector autoregressive model as an exogenous variable (VARX). He shows analytically that his approach consistently identifies the true relative impulse responses. This holds even when the surprises contain measurement error that is orthogonal to all other variables. The major advantage is the extension of this constant parameter VARX for estimating a time-varying parameters using standard methods. I restrict my attention for ease of comparison with the constant parameter VARX. I use the same 7 variables used for the specification in section 2.1 for monthly frequency. The data is updated till 2017 month 9. Notwithstanding the limitations with the approach as listed in footnote 8, I show the corresponding estimates in

Table 12: PDV estimates using alternate specifications & lag lengths

Specification and lag length	Nominal House Price (in%)	Housing Premium	Nominal Stock Price (in%)	Equity Premium	Nominal House Price Norm.	Nominal Equity Price Norm.
Alt Spec 1 with 6 lags	1.24	1.26	19.23	4.45	0.48	7.44
Alt Spec 1 with 11 lags	1.25	0.76	17.77	3.63	0.59	8.36
Alt Spec 2 with 5 lags	3.55	1.14	16.44	5.09	2.60	7.06
Alt Spec 2 with 10 lags	6.05	1.17	23.55	3.70	3.45	10.96

Note - For 1000 months ahead using techniques of Gertler and Karadi (2015) - to be compared with results in Table 1. The base line specification is explained in 2.1. The data is the same. Results with $\beta = 0.95$ and one standard deviation positive monetary policy surprise. Beyond certain lags, *IRFs* no longer consistent as before.

Alt Spec 1 refers to 2 VARs are estimated with the original specification of Gertler and Karadi (2015). For one, commercial spread is replaced with equity premium and mortgage spread is replaced with housing premium. For the second, replace the two by stock price & house price respectively.

Alt Spec 2 refers to a VAR with federal funds rate, consumer price index, industrial production, excess bond premium and a fifth variable. The fifth variable is housing premium, equity premium, nominal house price and nominal stock price.

Table 13: Present discounted value estimates from VAR based in section A.2 using $\beta = 0.95$

Present Discounted Value at $t = 0$	Nominal House Price	Housing Premium	Nominal Stock Price	Equity Premium	Nominal House Price	Nominal Equity Price
Empirical	0.17	1.07	0.77	1.77	3.52	3.71
Normalized (Y/N)	**N (in%)**	Y	**N (in%)**	Y	Y	Y

Note - Monthly data for monetary policy surprises updated till 2017-9. For more details see associated notes in Table 1.

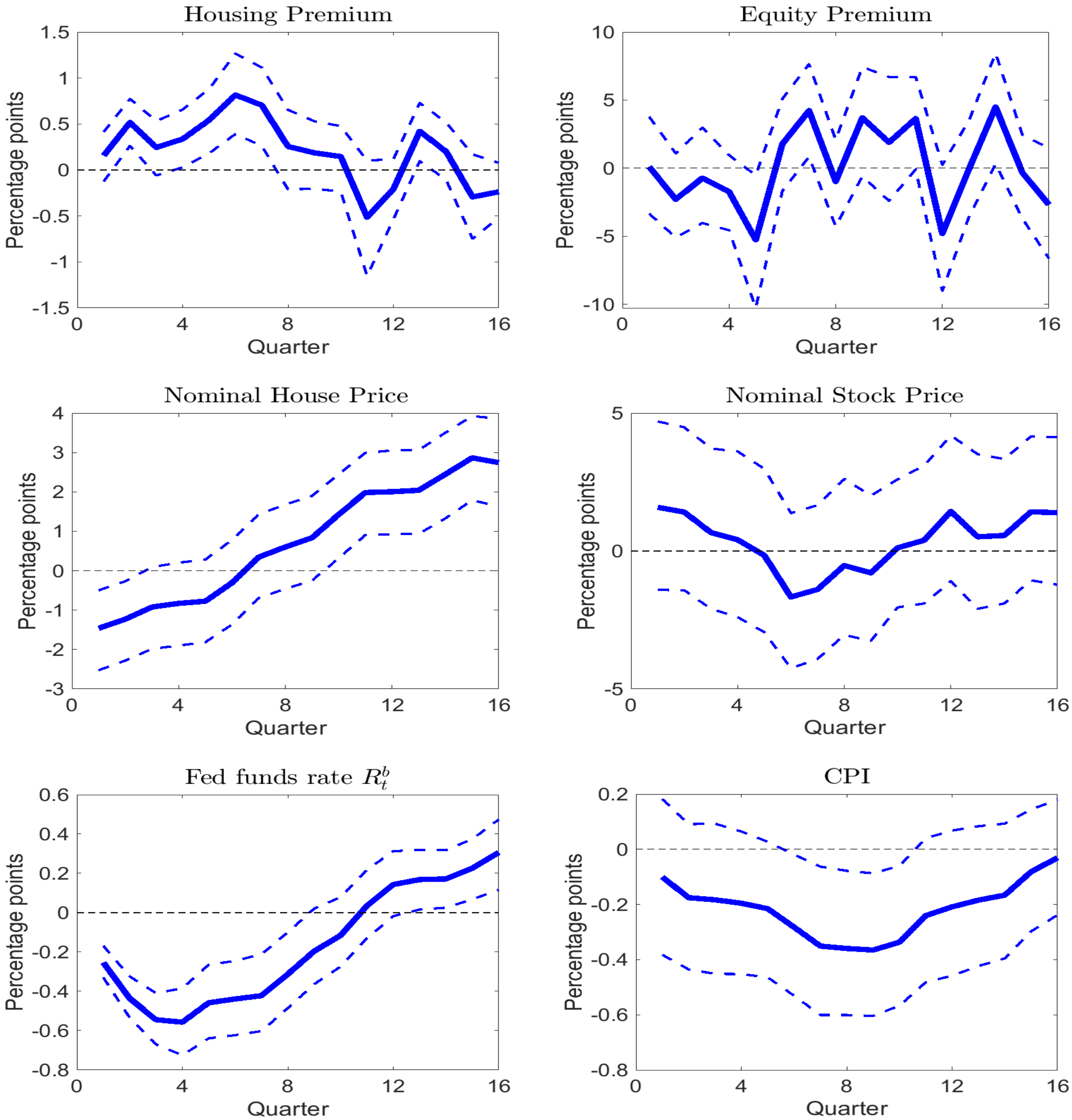
Table 1 for the same horizon of 1000 months ahead in Table 13. Aggregate consumption in general equilibrium is 21% higher for a one-time unexpected positive monetary policy surprise of comparable magnitude, of which redistributive effects account for 13%. Among the three redistribution channels, the real interest rate channel accounts for 8% while the Fisher channel accounts for 6%. Asymmetric effects are stronger with a negative surprise producing a 26% smaller decline in aggregate consumption in general equilibrium.

A.3 Local Projections

I compare the main quantitative results with the local projection technique that does not rely on an explicit SVAR specified for the underlying data generating process. As mentioned in section 1, the biggest drawback is the very short time horizon of less than 100 months ahead for the generated *IRFs*. Since Luetticke (2021) studies similar trends economically for the interested variables, as a comparison I repeat my exercise using his technique and data which I mention briefly here. For more details, see section IV A of his paper. With the exception of the housing premium which is not available at monthly frequency, I follow his definitions and sources at monthly frequency for the main text.

At the aggregate level, to estimate the impact of the monetary policy shock on returns by asset class, Luetticke (2021) requires aggregate quarterly data for stock & house prices, federal funds rate, asset premia along with data on monetary policy shocks. Stock prices is measured by S&P 500. House prices come from the Case-Shiller S&P U.S. National Home Price Index (CSUSHPINSA) divided by the all-items CPI (CPIAUCSL). For the rest, he uses

Figure 7: *IRFs* for equivalent 16 quarters from Luetticke (2021) using local projection method



Note - For a one standard deviation positive monetary policy surprise for the Romer and Romer (2004) shock series. Results to be compared with Figure 1. Data range is 1983Q1 to 2007Q4. Bootstrapped 90% confidence bands are shown in the dashed lines (block bootstrap).

national accounts data provided by the Federal Reserve Bank of St. Louis. The housing premium is measured as the excess realized return on housing. This is composed of the rent-price-ratio, $R_{h,t}$, in t plus the quarterly growth rate of house prices in $t+1$, $\frac{H_{t+1}}{H_t}$, over the nominal rate, R_t^B, (converted to a quarterly rate):

$$LP_t = \frac{R_{h,t}}{H_t} + \frac{H_{t+1}}{H_t} - (1 + R_t^B)^{\frac{1}{4}}$$

Rents are imputed on the basis of the CPI for rents on primary residences paid by all urban consumers (CUSR0000SEHA) fixing the rent-price-ratio in 1983Q1 to 4%. The equity premium is the growth rate of Wilshire 5000 Total Market Full Cap Index (WILL5000INDFC) minus the federal funds rate. Finally, the convenience yield, a measure of liquidity in financial markets, is equal to the Moody's Seasoned Aaa Corporate Bond Yield (AAA) minus 10-Year Treasury Constant Maturity Rate (GS10). He uses monetary shocks identified by Wieland and Yang (2020) that improve on the original shock series by Romer and Romer (2004) for 1983Q1 to 2007Q4. The impulse responses of the endogenous variables Υ at time $t+j$ to monetary shocks, ε_t^R , at time t are estimated using horizon-specific single regressions by local projections, in which the endogenous variable shifted ahead is regressed on the current normalized monetary shock $\overline{\varepsilon}_t^R$ (with standard deviation 1), a constant, time trend, and controls $\mathbf{X_{t-1}}$. These controls are specified as the lagged normalized monetary shock R_{t-1}^B and the log of GDP Y_{t-1} , consumption C_{t-1}, investment I_{t-1}, and of lagged monetary shocks $\varepsilon_{t-1}^R, \varepsilon_{t-2}^R$:

$$\Upsilon_{t+j} = \beta_{j,0} + \beta_{j,1}t + \beta_{j,2}\overline{\varepsilon}_t^R + \beta_{j,3}\mathbf{X}_{t-1} + \nu_{t+j},\ j = 0...15$$

The *IRFs* for the baseline 16 quarters is presented in Figure 7 for the expansionary shock. The major drawback is the high persistence which impacts the present discounted values substantially since the estimates for 17 quarters and beyond do not have negligible magnitude. Secondly, the inflation seems to decrease for the majority of the time period while the housing premium is larger than the equity premium at $t = 0$. The corresponding PDVs are presented in the first row of Table 14. The results are counter-intuitive for especially the equity premium. Also, housing tends to respond faster than equity. As an additional sensitivity check, I use alternate measures of monetary policy surprises. A major issue is data availability for the shock and therefore the estimates cannot be widely compared. The motivation for including them is to argue that the robustness checks for the SVAR will produce similar results as the ones in the main text. Using the estimates for local projections

Table 14: Robustness of PDV estimates from local projections

Present Discounted Value at $t = 0$	Nominal House Price (in%)	Housing Premium	Nominal Stock Price (in%)	Equity Premium	Nominal House Price Norm.	Nominal Equity Price Norm.
Luetticke 16 quarters for 1969-2007	4.45	1.14	3.58	-0.31	1.81	1.46
Luetticke 32 quarters for 1969-2007	13.62	1.09	1.19	-2.17	7.11	0.62
Gertler & Karadi 16 quarters for 1990-2012	1.67	0.82	5.01	-1.07	7.26	21.84
BRW Unified 16 quarters for 1994-2015	5.60	1.5249	-33.60	11.12	1.65	-9.88

Note - To be compared with results in Table 1. Using local projections technique of Luetticke (2021) with $\beta = 0.95$ for alternate horizons & alternate shock sources. For a one standard deviation positive monetary policy surprise. The estimates for the first row correspond to the *IRFs* in Figure 7. Monetary policy surprises for the first two rows correspond to Romer and Romer (2004). For the third row it is identical to the one used in this paper. For the fourth row, it uses the estimates in Bu et al. (2021).

could have vastly different quantitative implications and it seems that the SVAR is better suited than a local projection technique for the current question of interest.

However, if I ignore the robustness issues and use the baseline specification of Luetticke (2021) and repeat the exercise with the estimates in the first row of Table 14, I find that the aggregate results are qualitatively similar. Only the results by asset class are substantially different in keeping with the intuition since the numerical estimates for housing are relatively better to equity, especially for the interest rate channel.

I only present the results for the CE data since this involves changing estimates of *MPCs* which is the quantitatively significant channel. I report that excess sensitivity over a RANK with calibrated *IES* of 0.5 from the real interest rate change reported in Table 15 declines by roughly 17% as compared to Table 2. The general equilibrium consumption response from

Table 15: σ^* across models for benchmark case with $\sigma = 0.5$ in CE data

Measure	**Shock**	Auclert	Housing + Stock	Housing	Stocks
$\boldsymbol{\sigma^*}$	**Expansionary**	0.36	0.52	0.54	0.30
% Change		—	45.55	49.83	-16.08
$\boldsymbol{\sigma^*}$	**Contractionary**	0.36	0.43	0.38	0.32
% Change		—	18.60	4.92	-11.66

Note - Using Local projections method of Luetticke (2021) for 16 quarters. First two rows to be compared with first two rows of Table 2 while the last two rows are to be compared with first two rows of Table 5.

Table 16: Aggregate consumption for expansionary shock in CE data

Model with estimated *MPCs*	Consumption Response		In corresponding RANK	
	PE	GE	PE	GE
Auclert + House + Stock	0.82	1.26	0.32	0.77
Auclert + House	1.06	1.51	0.32	0.77
Auclert + Stock	0.87	1.33	0.32	0.78
Auclert	0.71	1.17	0.32	0.78

Note - Numbers are in percent with $\sigma = 0.5$ & $\gamma = -0.5$. Using local projections of Luetticke (2021) for 16 quarters. To be compared with Table 3. For details on expansionary shock, see notes in Table 3.

the first row of Table 16 is only around 8% higher vs being 15% higher in the main text from Table 3.

The asymmetric response is now substantially reduced for the main model with both housing and equity return heterogeneity from the first row of Table 17. Aggregate consumption would decrease by only around 2% less compared to 12% in general equilibrium in the main text in Table 6. For partial equilibrium, the corresponding numbers are around 6% & 25% respectively. This is true across asset classes. Since housing is responding more relative to equity in this case, the declines in wealth are also more from the increase in the real interest rate. Since agents with majority of housing have higher *MPCs*, they lead to much higher overall consumption decline reducing the magnitude of the asymmetric effect.

Table 17: Aggregate consumption for contractionary shock in CE data

Model with estimated *MPCs*	Consumption Response		In corresponding RANK	
	PE	GE	PE	GE
Auclert + House + Stock	0.67	1.15	0.31	0.78
Auclert + House	0.58	1.06	0.31	0.79
Auclert + Stock	0.64	1.10	0.32	0.78
Auclert	0.71	1.17	0.32	0.78

Note - Numbers are in percent with $\sigma = 0.5$ & $\gamma = -0.5$. Using local projections of Luetticke (2021) for 16 quarters. To be compared with Table 6. For details on contractionary shock, see notes in Table 6.

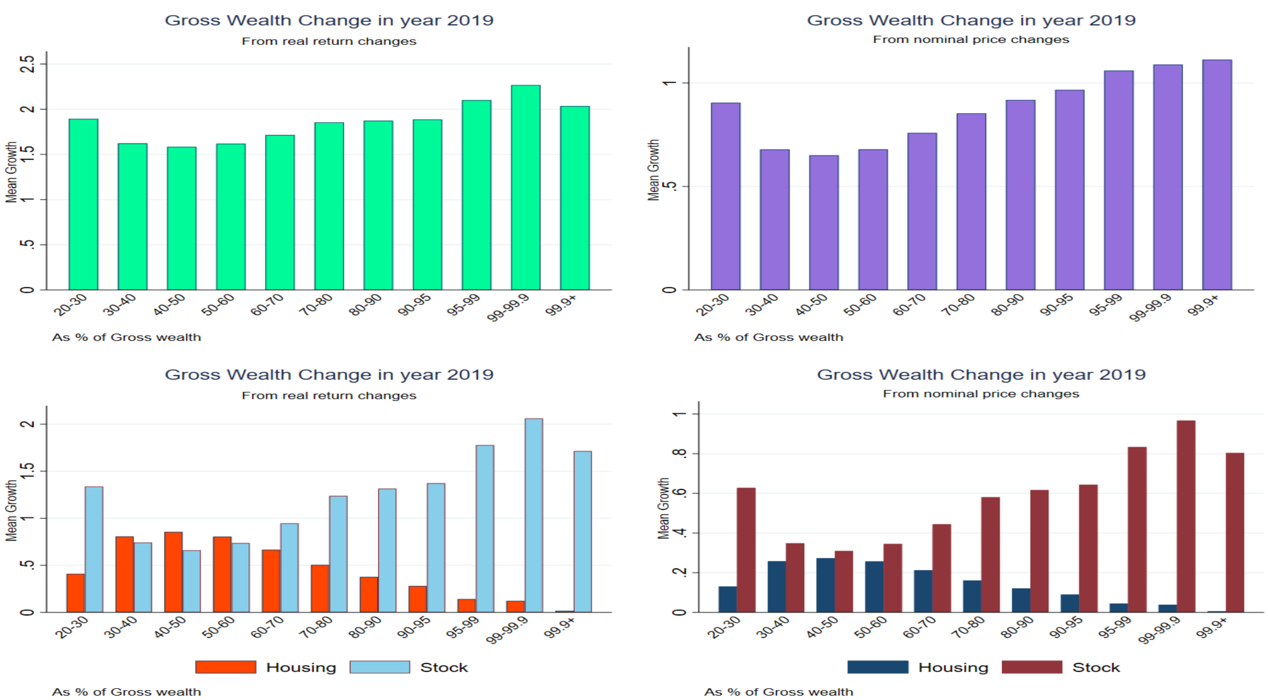
A.4 Unrealized/Realized wealth changes from SCF data

In this section, I present additional motivating graphs to support my claim that the conditional impact of expansionary monetary policy produces very different impacts across the wealth distribution form the real interest rate and the Fisher channel. It is also not a one off effect in only the interested year of 2001. From Figure 8, it is clear that even with the latest data, the motivation holds true. Intuitively, since households have different portfolio asset shares, the instantaneous changes reflect the heterogeneity of across class asset holdings.[24] For comparison, I depict the survey reported numbers for realized and unrealized capital gains/losses from the SCF data for the two years 2001 and 2019 in Figure 9. I also break them down by housing and equity. These are however not the conditional instantaneous impacts for the transitory monetary policy surprise and therefore not directly comparable. The motivation behind including them is to show that even under the unconditional setup where ex-ante returns on housing and equity are equal to the liquid asset as in the benchmark results, there is substantial differences across the gross wealth quantiles. It is not uniformly 1 across quantiles.

Lastly, the literature on structural modeling has so far treated housing and equity as the same illiquid asset with both earning the same conditional return and experiencing the same

[24]In reality, the returns on debt is different from asset for both housing and equity. Getting similar conditional estimates to reflect within asset class portfolio heterogeneity separately at the aggregate level is hard.

Figure 8: Estimated Unrealized wealth changes from SCF 2019



Note - From the interest rate & Fisher channels. For more details, see notes in Figure 2 and Figure 3.

price change ex-post the monetary policy surprise. For a concrete example, I refer to the 2 - asset canonical HANK model of Kaplan et al. (2018) who consider only the real interest rate channel. Even then the estimated conditional impacts ex-post are very different for some quantiles, especially for those towards the top of the net wealth distribution as evidenced by Figure 10. To get the quantitative impact on the aggregate *MPCs* more accurately, we need two separate illiquid assets. There remains significant theoretical and computational hurdles in developing such a model and proves to be exciting for future work.

B Proofs of Results & Theoretical Model Extensions

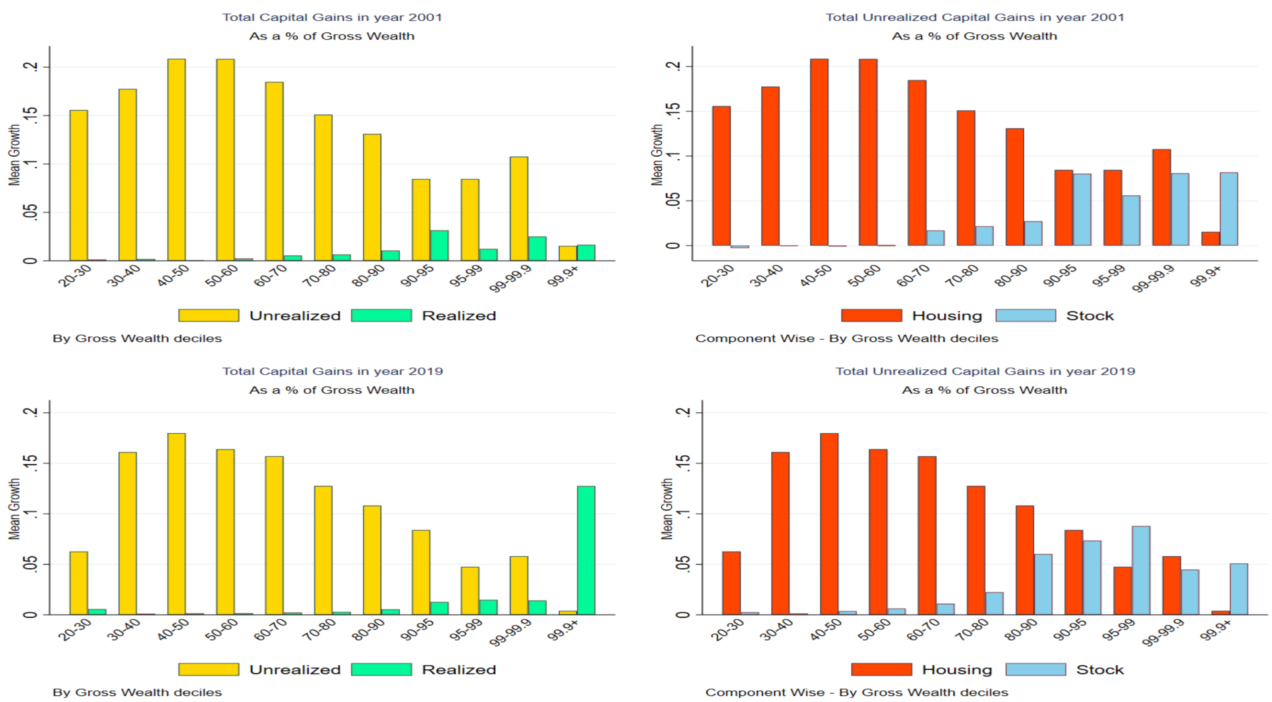
The experiment presented in section 3.2 is essentially listing the changes that occur in the standard representative-agent New Keynesian model following the one-period change in monetary policy. As mentioned in section 3.1, the general and flexible approach to representing complex household balance sheets in terms of consolidated nominal claims $\left({}_{-1}B_t\right)$ & real claims $\left({}_{-1}b_t\right)$ at the beginning of each period allows me to extend sufficient statistics to incorporate ex-post returns heterogeneity.

In section B.1, I first present the mathematical expressions for arriving at equations (4) & (5) which lead to the main theoretical result for measuring aggregate consumption in (6). I restrict myself to only the principal points of departure in the context of my theoretical framework in section 3. Next, I show that the results hold with the addition of durable goods as a percentage of varying expenditure of household consumption in section B.2. Finally, I show that these results can also be extended to encompass mafrket incompleteness in section B.3. For the complete step by step derivation, see Auclert (2019) appendices A.2 - A.8 for more details. I keep the notation as consistent as possible. Any explicit departures are explained.

B.1 Deriving *NURE* and *NNP* for the perfect foresight model

As laid out in section 3.2, to incorporate the conditional impact of monetary policy on housing and equity through the differential asset returns. I treat the liquid asset as the benchmark and normalize the corresponding changes in the other two asset classes. Mathematically, the

Figure 9: Survey reported unrealized & realized wealth changes



Note - For the total wealth change and component wise from SCF 2001 & 2019 using the reported numbers in the data. The drawback is that these changes cannot account for the instantaneous monetary policy shock.

differences to the real interest rate and Fisher channels relevant for household measures of exposures can be captured by the values of $\{\theta_i\}_{i=1}^4$ & $\{\Theta_j\}_{j=1}^2$. Setting all of them to be 1 gives back the original results which acts as the benchmark. As stated in the main text, there is no change in the conditional impact of the idiosyncratic earnings post the transitory monetary policy surprise across asset classes by assumption. They can be incorporated theoretically under this modified setup in a similar manner. Measuring the corresponding estimates are much harder. I therefore focus on only the household exposures summarizing the real interest rate channel which is defined as the *URE* and the one for the Fisher channel which is defined as the *NNP*.

The setup is described mathematically in section 3.1. Normalizing $q_{\ell,1} = q_1 = 1$ and letting $q_{\ell,0} = q_0$ vary for the liquid asset as

$$\frac{dq_{\ell,0}}{q_{\ell,0}} = \frac{dq_0}{q_0} = \frac{dR}{R} = \frac{dR_\ell}{R_\ell} \tag{B.1}$$

Then at time $t = 0$ when the one time shock is realized, only the values of y_0, w_0 & q_0 vary with the sequence in prices $\{P_{\ell,t} = P_t\}$. Equation (B.1) shows that a rise in the relative price of future goods from the positive monetary policy surprise relative to a current good is the same as a fall in the price of that current good relative to all future goods.The corresponding variations for housing and equity are normalized and given by the relations in section 3.2. The expenditure function is defined as

$$e(q_0, w_0, \mathcal{U}) = \min \left\{ \sum_t q_t(c_t - w_t n_t) \quad \text{s.t.} \quad \sum_t \beta_t \{u(c_t) - v(n_t)\} \geq \mathcal{U} \right\} \tag{B.2}$$

The compensated demands for time 0 consumption and hours are c_0^h & n_0^h. The version of Shepherd's lemma relevant for the proof are

$$\begin{aligned} e_{q_0} &= c_0 - w_0 n_0 \\ e_{w_0} &= -q_0 n_0 \end{aligned}$$

Ex-ante, the composition of household balance sheets do not matter as reflected by (B.3). Ex-post the shock at $t = 0$, the conditional impacts on the prices and returns lead to the following definition of unearned wealth from the variation as in (B.4)

$$\begin{aligned}\widetilde{\omega} &\equiv \sum_{t\geq 0} q_t \left(y_t + ({}_{-1}b_t) + \left(\frac{{}_{-1}B_t}{P_t}\right)\right) \\ &= \sum_{t\geq 0} q_t \left(y_t + ({}_{-1}h_t) + \left(\frac{{}_{-1}H_t}{P_t}\right) + ({}_{-1}s_t) + \left(\frac{{}_{-1}S_t}{P_t}\right) + ({}_{-1}\ell_t) + \left(\frac{{}_{-1}L_t}{P_t}\right)\right) \end{aligned} \tag{B.3}$$

$$\begin{aligned} d\widetilde{\omega} \;&=\; \left(y_t + ({}_{-1}\ell_0) + \left(\frac{{}_{-1}L_0}{P_0}\right)\right) dq_{L,0} + \left(({}_{-1}h_0) + \left(\frac{{}_{-1}H_0}{P_0}\right)\right) dq_{H,0} + \left(({}_{-1}s_0) + \left(\frac{{}_{-1}S_0}{P_0}\right)\right) dq_{S,0} \\ &+ q_0 dy_0 - \sum_{t\geq 0} q_t \left(\frac{{}_{-1}L_t}{P_t}\right) \frac{dP_{L,t}}{P_{L,t}} - \sum_{t\geq 0} q_t \left(\frac{{}_{-1}H_t}{P_t}\right) \frac{dP_{H,t}}{P_{H,t}} - \sum_{t\geq 0} q_t \left(\frac{{}_{-1}S_t}{P_t}\right) \frac{dP_{S,t}}{P_{S,t}} \end{aligned} \tag{B.4}$$

Using the normalized relations defined previously and simplifying everything in terms of the change in the benchmark liquid asset.

$$\begin{aligned} d\widetilde{\omega} \;&=\; \left(y_0 + ({}_{-1}\ell_0) + \left(\frac{{}_{-1}L_0}{P_0}\right)\right) dq_{L,0} \\ &+ \left(({}_{-1}h_0) + \left(\frac{{}_{-1}H_0}{P_0}\right)\right) \Theta_1\theta_1 q_{L,0}\frac{dq_{L,0}}{q_{L,0}} + \left(({}_{-1}s_0) + \left(\frac{{}_{-1}S_0}{P_0}\right)\right) \Theta_2\theta_2 q_{L,0}\frac{dq_{L,0}}{q_{L,0}} \\ &+ q_0 dy_0 - \sum_{t\geq 0} q_t \left(\frac{{}_{-1}L_t}{P_t}\right) \frac{dP_{L,t}}{P_{L,t}} \\ &- \sum_{t\geq 0} q_t \left(\frac{{}_{-1}H_t}{P_t}\right) \theta_3 \frac{dP_{L,t}}{P_{L,t}} - \sum_{t\geq 0} q_t \left(\frac{{}_{-1}S_t}{P_t}\right) \theta_4 \frac{dP_{L,t}}{P_{L,t}} \end{aligned} \tag{B.5}$$

Using the Fisher Equation $\frac{q_t}{P_t} = \frac{Q_t}{P_0}$ and the fact that $\frac{dP_t}{P_t} = \frac{dP}{P}$ is a constant I rewrite $d\widetilde{\omega}$ from (B.5) in terms of the household exposures conditioned on the shock.

$$\begin{aligned} d\widetilde{\omega} \;&=\; \left\{ y_0 + ({}_{-1}\ell_0) + \left(\frac{{}_{-1}L_0}{P_0}\right) + \Theta_1\theta_1 \left[({}_{-1}h_0) + \left(\frac{{}_{-1}H_0}{P_0}\right)\right] + \Theta_2\theta_2 \left[({}_{-1}s_0) + \left(\frac{{}_{-1}S_0}{P_0}\right)\right]\right\} dq_0 \\ &+ q_0 dy_0 - \sum_{t\geq 0} q_t \left\{ \left(\frac{{}_{-1}L_t}{P_t}\right) + \theta_3 \left(\frac{{}_{-1}H_t}{P_t}\right) + \theta_4 \left(\frac{{}_{-1}S_t}{P_t}\right)\right\} \frac{dP_t}{P_t} \end{aligned} \tag{B.6}$$

The consumer's net nominal position *NNP* can be defined as the present value of the nominal assets. It summarizes the relevant measure of the household's balance sheet to the nominal price changes from the Fisher channel. The consumer's unhedged interest rate exposure URE can be defined as the difference between all maturing assets and liabilities at a point of time. Analogously, it summarizes the relevant measure of household's balance sheet to the nominal price changes from the real interest rate channel. Conditioned on the transitory unexpected shock, they can be defined as

$$\begin{aligned} NNP &= \sum_{t\geq 0} q_t \left\{ \left(\frac{{}_{-1}L_t}{P_t} \right) + \theta_3 \left(\frac{{}_{-1}H_t}{P_t} \right) + \theta_4 \left(\frac{{}_{-1}S_t}{P_t} \right) \right\} \\ &\equiv \sum_{t\geq 0} Q_t \left\{ \left(\frac{{}_{-1}L_t}{P_0} \right) + \theta_3 \left(\frac{{}_{-1}H_t}{P_0} \right) + \theta_4 \left(\frac{{}_{-1}S_t}{P_0} \right) \right\} \end{aligned} \tag{B.7}$$

$$\begin{aligned} URE_0 \equiv & \left\{ \omega_0 n_0 + y_0 + ({}_{-1}\ell_0) + \left(\frac{{}_{-1}L_0}{P_0} \right) \right. \\ & \left. + \Theta_1 \theta_1 \left[({}_{-1}h_0) + \left(\frac{{}_{-1}H_0}{P_0} \right) \right] + \Theta_2 \theta_2 \left[({}_{-1}s_0) + \left(\frac{{}_{-1}S_0}{P_0} \right) \right] - c_0 \right\} \end{aligned} \tag{B.8}$$

Equation (B.7) for NNP uses Fisher equation for equivalence with (4). Equation (B.8) is the URE at time $t = 0$ for equation (5) which is defined for any time period. Equation (B.6) now can be rewritten as identical to (A.10) in Auclert (2019).

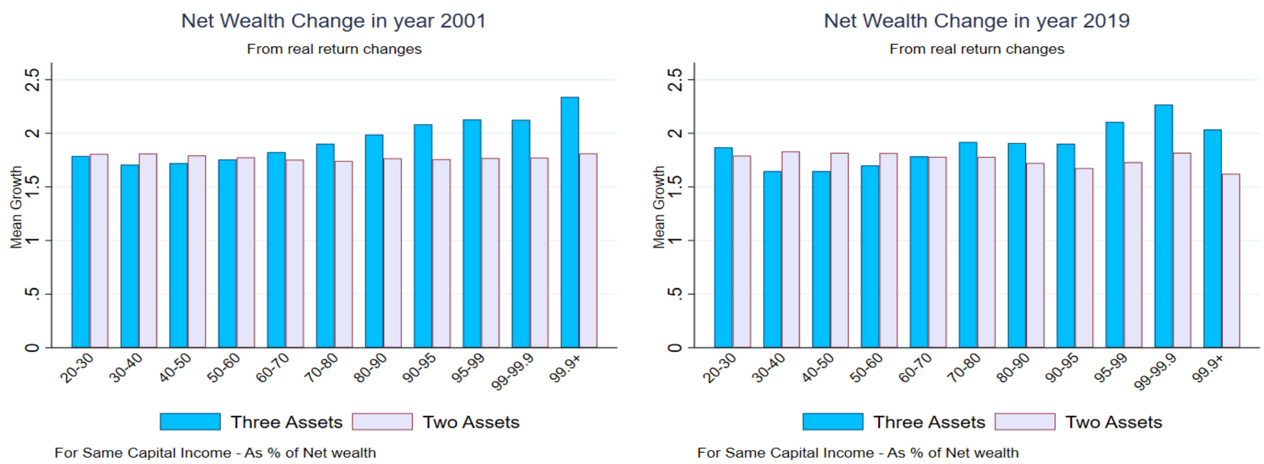
$$d\widetilde{\omega} = (URE + c_0 - w_0 n_0)\, dq_0 + q_0 dy_0 - q_0 NNP \frac{dP}{P} \tag{B.9}$$

The corresponding indirect utility function that attains the new $\widetilde{\omega}$ using equation (B.2) is also identical to (A.11)

$$V(q_0, w_0, \widetilde{\omega}) = \max \left\{ \sum_t \beta_t \{u(c_t) - v(n_t)\} \quad \text{s.t.} \quad \sum_t q_t(c_t - w_t n_t) = \widetilde{\omega} \right\} \tag{B.10}$$

Using the definitions of Shepherd's Lemma with the resulting Marshallian demands, Slutsky's theorems can be applied. After following the steps for aggregation, the final result is given by (6) which also holds for persistent changes in the real interest rate with the constant changes being replaced with their time subscripts. Since the transitory monetary policy shock actually produces persistent changes in the real interest rate, the framework can be used to emprically estimate the per period consumption response form each period conditional impacts to the returns and prices instead of using the constant PDVs for the one time instantaneous response. See appendix A.3 for one example. I leave it to discretion in selecting the horizon of the consumption IRF cognizant of the assumption that households

Figure 10: Estimated Unrealized wealth changes from SCF data



Note - Three assets are the liquid asset, housing and equity. Two assets are liquid asset and a combined illiquid asset. The return on the latter is the same as the return from the representative portfolio of housing and equity held in equal amounts. The aim is to show that assuming housing and equity to be a single illiquid asset as in Kaplan et al. (2018) leads to underestimation of the gains from the real interest rate channel. See notes in Figure 2 for more details.

cannot adjust their portfolios of asset holdings for any of the three assets. The setup is also flexible to alternate utility functions as well as aggregate uncertainty.

B.2 Presence of Durable Goods

Keeping the setup identical to A.5, I look at the wealth changes arising from incorporating durable goods in the framework. The consumer durables expenditure does not affect the balance sheet at time $t = 0$ since it is given. Since consumers do not adjust their balance sheets at for the instantaneous response to the shock, durable expenditures theoretically have no bearing on ex-post asset holdings. Empirically, they only alter how consumption will be measured at the household level. Ex-ante, balance sheets and durables expenditure can be correlated but that does not affect my exercise either theoretically or empirically since the starting point is taking the balance sheets at $t = 0$ as given. Before the shock, the composition of balance sheets does not matter.

By expanding the household wealth into the three assets held, let Ω be defined as

$$\Omega \equiv \sum_{t\geq 0} q_t \left\{Y_t + \left({}_{-1}\ell_t\right) + \left({}_{-1}h_t\right) + \left({}_{-1}s_t\right) - C_t - p_t I_t\right\} \tag{B.11}$$

where p_t is the price of durables relative to nondurables. The exogenous variation in the benchmark liquid asset for dR, dP & dY in (B.11) produces the change in net wealth as

$$\begin{aligned} d\Omega &= dY - IdP - \sum_{t\geq 0} dq_t \left\{Y_t + \left({}_{-1}\ell_t\right)\frac{dR_\ell}{R_\ell} + \left({}_{-1}h_t\right)\frac{dR_H}{R_H} + \left({}_{-1}s_t\right)\frac{dR_S}{R_S} - C_t - p_t I_t\right\} \\ &= dY - IdP - \sum_{t\geq 0} q_t \left\{Y_t + \left({}_{-1}\ell_t\right) + \left({}_{-1}h_t\right)\theta_1 + \left({}_{-1}s_t\right)\theta_2 - C_t - p_t I_t\right\}\frac{dR}{R} \\ &= dY - pI_0\frac{dp}{p} + \left(\underbrace{Y_0 + \left({}_{-1}\ell_0\right) + \left({}_{-1}h_0\right)\Theta_1\theta_1 + \left({}_{-1}s_0\right)\Theta_2\theta_2 - C_0 - p_0 I_0}_{URE}\right)\frac{dR}{R} \end{aligned} \tag{B.12}$$

In (B.12), C_0 is specifically consumption of nondurables while $p_0 I_0$ is the consumption of durables. Total consumption is the sum of durables and non durables. (B.12) assumes that the relative price of durables to nondurables do not change post the transitory unexpected monetary shock. Since ex-post price of housing is different from the aggregate change in the CPI following section 3.2, accommodative monetary policy in my setup causes additional capital wealth loss from the increase in the relative price of durables. While the changes for the nondurables and housing services are not equivalent in terms of utility in general, these two effects could be consolidated into a single one, we can restrict ourselves to variations that feature a constant elasticity of the durable-good price to the nondurable real interest rate

$$\epsilon_{pR} \equiv -\frac{\partial p}{p}\frac{R}{\partial R}$$

which leads to the general definition of URE from (B.12)

$$d\Omega = dY + \left(\underbrace{Y_0 + \left({}_{-1}\ell_0\right) + \left({}_{-1}h_0\right)\Theta_1\theta_1 + \left({}_{-1}s_0\right)\Theta_2\theta_2 - C_0 - p_0 I_0\left(1 - \epsilon_{pR}\right)}_{URE^\epsilon}\right)\frac{dR}{R} \tag{B.13}$$

Empirically, as in section 4, URE is measured with consumption being total sum of durables and nondurables with the benchmark case of $\epsilon_{pR} = 0$. The rest of the derivation and results follow identically consistent with the definition of URE in (B.12) & (B.13).

B.3 Incomplete Markets

The environment for the extension to incomplete markets is identical to section I.C of Auclert (2019). The consumer faces idiosyncratic income uncertainty and restrictions on the number of assets traded. The consumer faces an idiosyncratic process for real wages $\{w_t\}$ and unearned income $\{y_t\}$. The choice variables are consumption c_t and labor supply n_t to maximize the expected utility function. As in the perfect foresight model, the horizon need not be specified.

$$\mathbb{E}\left[\sum_t \beta^t \{u(c_t) - v(n_t)\}\right]$$

Market incompleteness is modeled in a general form. Ex-ante as in the complete markets setup, the composition of the balance sheets does not matter. Only the measures of household exposures unconditionally are pinned down exactly before the one time unexpected monetary policy surprise at $t = 0$. To consider the changes in consumption from the changes in the current unearned income dy, current real wage dw and the real interest rate dR.

I keep the assumption that this variation in asset prices adjusting to reflect the change in discounting alone given here by (B.14) for $j = 1, , ..., N^x$ for any of the N^x, $\forall\, x = \{\ell, H, S\}$ assets that can be considered belonging to the class of assets for liquid, housing and equity.

$$dQ^x/Q^x = dS_j^x/S_j^x = -dR^x/R^x \;\; \forall \;\; x = \{\ell, H, S\} \tag{B.14}$$

$$dQ^\ell/Q^\ell = dQ/Q = dS_j/S_j = -dR/R = -dR^\ell/R^\ell = dS_j^\ell/S_j^\ell \tag{B.15}$$

$$dS_j^H/S_j^H = -dR^H/R^H = -\theta_1 dR/R \;\;\&\;\; dS_j^S/S_j^S = -dR^S/R^S = -\theta_2 dR/R \tag{B.16}$$

$$dP_H/P_H = \theta_3 dP_\ell/P_\ell \;\;\&\;\; dP_S/P_S = \theta_4 dP/P \;\;\text{with}\;\; dP_\ell/P_\ell = dP/P = d\Pi/\Pi \tag{B.17}$$

$$Q_H = \Theta_3 Q_\ell = \Theta_3 Q \;\;\&\;\; Q_S = \Theta_4 Q_\ell = \Theta_3 Q \tag{B.18}$$

Specifically (B.15) refers to the benchmark change for the liquid asset while (B.16) - (B.18) refers to the normalized relations for housing and equity analogous to section 3.2 conditioned on the transitory monetary policy surprise. Additionally, if $MPC = \partial c/\partial y$ and both the marginal propensities to work and save are similarly defined as responses to current income transfers then the final aggregate consumption can be represented in terms of the sufficient statistics by (6). My interest in this context is to ensure that amended definitions of household exposures to real interest rate and the Fisher channels to account for the conditional impact in the presence of market incompleteness remain consistent.

The aim is to show that equations (A.53) & (A.54) have to continue to hold analogous to equations (A.19) & (A.20) in the perfect foresight model (as proved in section B.1). There are two cases required to be proved separately. In the first case, the consumer is at the binding borrowing limit and spends all income or the consumer is hand-to-mouth. Here, the solution is on the boundary. In the second case, the consumer problem has an interior solution. Two sub cases are to be proved for the second case.

Case I. Binding borrowing limit and hand-to-mouth consumers.

The problem is a static choice between c and n. For ease of comparison, I restate some of the definitions. Q is the nominal price, δ is the nominal bonds holding while λ is the real bonds holding. θ denotes portfolio shares, $\mathbf{d}$ are real dividends while $\mathbf{S}$ denote the real prices. Z is the measure of net wealth of the consumer. The consumption of the agent at the borrowing limit or being hand-to-mouth is given by

$$c = wn + Z \quad \text{where } \; Z = z + (1 + Q\delta)\frac{\lambda}{\Pi} + \theta \cdot (\mathbf{d} + \mathbf{S}) + \frac{\overline{D}}{R} \tag{B.19}$$

Using $d\mathbf{S} = -\frac{S}{R}dR, dQ = -\frac{Q}{R}dR$ and $d(\frac{1}{\Pi}) = -\frac{1}{\Pi^2}d\Pi = -\frac{1}{\Pi}\frac{dP}{P}$ along with relations (B.15) - (B.18), if the agent is at the borrowing limit then splitting the household balance sheets by asset class.

$$\begin{aligned} Z &= z + (1 + Q_\ell S_\ell + Q_H\delta_H + Q_S\delta_S)\left(\frac{\lambda_\ell + \lambda_H + \lambda_S}{\Pi}\right) + \theta(\mathbf{d} + S_\ell + S_H + S_S) + \frac{\overline{D}}{R} \\ \implies \quad dZ &= dz \quad + \quad \text{Price Effect} \quad + \quad \text{Real Interest Rate Effect} \end{aligned} \tag{B.20}$$

The price effect in (B.20) for the Fisher channel is derived as

$$\begin{aligned} \text{Price Effect} \;&=\; -\left(1 + Q_\ell\delta_\ell\frac{dP_\ell}{P_\ell} + +Q_H\delta_H\frac{dP_H}{P_H} + Q_S\delta_S\frac{dP_S}{P_S}\right)\frac{\lambda}{\Pi} \\ &=\; -\frac{\lambda}{\Pi}\left\{1 + (\delta_\ell + \theta_3\Theta_3\delta_H + \theta_4\Theta_4\delta_S)\right\}\frac{dP}{P} \\ &=\; -\underbrace{\frac{\lambda}{\Pi}\left(1 + \delta_{m_1}Q\right)}_{\text{NNP}}\frac{dP}{P} \end{aligned} \tag{B.21}$$

The real interest rate effect in (B.20) for the rela interest rate channel is derived as

$$
\begin{aligned}
\text{Price Effect} &= \frac{\left(\lambda_\ell \frac{dR_\ell}{R_\ell} + \lambda_H \frac{dR_H}{R_H} + \lambda_S \frac{dR_S}{R_S}\right)}{\Pi} Q\delta \\
&\quad + \frac{\lambda}{\Pi}\left(Q_\ell \delta_\ell \frac{dR_\ell}{R_\ell} + Q_H \delta_H \frac{dR_H}{R_H} + Q_S \delta_S \frac{dR_S}{R_S}\right) + \theta \cdot \mathbf{S} - \frac{\overline{D}}{R} \\
&= \left(Q\delta \frac{(\lambda_\ell + \lambda_H \theta_1 + \lambda_S \theta_2)}{\Pi} + \frac{\lambda}{\Pi}\left(\delta_\ell + \theta_1 \Theta_3 \delta_H + \theta_2 \Theta_4 \delta_S\right) \theta \cdot \mathbf{S} - \frac{\overline{D}}{R}\right)\left(-\frac{dR}{R}\right) \\
&= \underbrace{\left(\lambda_m \delta \frac{Q}{\Pi} + \delta_{m_2} \lambda \frac{Q}{\Pi} + \theta \cdot \mathbf{S} + \frac{\overline{D}}{R}\right)}_{-\text{URE}}\left(-\frac{dR}{R}\right) \qquad \text{(B.22)}
\end{aligned}
$$

Using (B.21) & (B.22), the variation in income given by (B.20) is given by

$$
dZ = dz - \underbrace{\frac{\lambda}{\Pi}\left(1 + \delta_{m_1} Q\right)}_{\text{NNP}} \frac{dP}{P} + \underbrace{\left(\lambda_m \delta \frac{Q}{\Pi} + \delta_{m_2} \lambda \frac{Q}{\Pi} + \theta \cdot \mathbf{S} + \frac{\overline{D}}{R}\right)}_{-\text{URE}}\left(-\frac{dR}{R}\right) \qquad \text{(B.23)}
$$

If the agent is hand-to-mouth, then (B.23) still applies for (B.24) as the consumer is still making a static choice for consumption and labor supplied given the budget constraint in (B.19) and $MPS = 0$. The rest of the steps are identical.

$$
dZ = dz \quad \& \quad NNP = URE = 0 \qquad \text{(B.24)}
$$

Case II. a) Interior solution with $N = 0$, all variables changing

The derivation till equation (A.65) is identical. The borrowing constraint is not binding and the value function is concave at the interior optimum. For this case, the updated notation to show that (6) still holds is given by the mapping

$$
q \equiv Q, \quad z \equiv y + \frac{\lambda}{\Pi}, \quad a = \lambda', \quad b_1 = \delta_{m_1} \frac{\lambda}{\Pi}, \quad b_2 = \delta_{m_2} \frac{\lambda}{\Pi}
$$

Using the benchmark relation for the liquid asset $\frac{dP}{P} = \frac{d\Pi}{\Pi}$ and $\frac{dQ}{Q} = -\frac{dR}{R}$ gives

$$
dz = dy - \frac{\lambda}{\Pi}\frac{dP}{P}, \quad db_1 = -\delta_{m_1} \frac{\lambda}{\Pi}\frac{dP}{P}, \quad db_2 = -\delta_{m_2} \frac{\lambda}{\Pi}\frac{dP}{P} \quad \text{and} \quad \frac{dq}{q} = -\frac{dR}{R}
$$

Then, the variation in the net wealth change from the two channels is given by

$$\begin{aligned} dz + qdb_1 - (a-b_2)dq &= dy - \frac{\lambda}{\Pi}\frac{dP}{P} - q\delta_{m_1}\frac{\lambda}{\Pi}\frac{dP}{P} - \left(\lambda' - \delta_{m_2}\frac{\lambda}{\Pi}\right) dQ \\ &= dy - \underbrace{\frac{\lambda}{\Pi}\left(1+\delta_{m_1}Q\right)\frac{\lambda}{\Pi}}_{\text{NNP}}\frac{dP}{P} + \underbrace{\left(\lambda' - \delta_{m_2}\frac{\lambda}{\Pi}\right)Q}_{\text{URE}}\frac{dR}{R} \end{aligned} \tag{B.25}$$

(B.25) is essentially of the form of (B.23) where the borrowing limit does not bind and can be directly used to derive the result form (A.63) & (A.65).

Case II. b) For $N > 0$, only interest rate changing and no bonds

For this case, there is no change in the wages and all the change in consumption come from the balance sheet changes. The result for the final consumption change of the form in (6) is proved by considering the following Lemma structured analogously to Lemma A.2.

Lemma: *Let (θ, Y, R, Θ) be the solution to the following consumer choice problem under concave preferences over current consumption $u(c)$ and initial balance sheet holdings $W(\theta')$*

$$\max_{c,\theta'} \quad u(c) + W(\theta') \;\; s.t. \;\; c + (\theta' - \theta)\Theta\mathbf{S} = Y + \theta\mathbf{d} \;\; \text{where} \;\; \frac{dS}{dR} = -\frac{\mathbf{S}}{R},$$

$$(\theta' - \theta)\Theta\mathbf{S} = \sum_j s_j(\theta^j - \theta'^j)\theta_j, \quad \theta_j \in \{\theta_\ell = 1, \theta_H = \theta_1, \theta_S = \theta_2\}$$

$$\textit{Then, to the first order,} \quad dc = MPC\left(dY + URE\frac{dR}{R}\right) - \sigma(c)c(1-MPC)\frac{dR}{R}$$

$$\textit{where} \;\; \sigma(c) \equiv -\frac{u'(c)}{cu''(c)} \;\; \textit{is the local} \;\; IES \;\; \& \;\; MPC = \frac{\partial c}{\partial Y} \;\; \textit{and} \;\; URE = Y + \theta\mathbf{d} - c$$

The first order conditions characterizing the solution are given by

$$S^i u'(Y + \theta\mathbf{d} - (\theta' - \theta)\Theta\mathbf{S}) = W_{\theta^i}(\theta') \;\; \forall\, i = 1, 2, ..., N \tag{B.26}$$

First considering the increase in income alone and differentiating along (B.26) gives

$$S^i u''(c)\left(1-\sum_j \underbrace{S^j\theta_j\frac{d\theta'^j}{dY}}_{\eta^j}\right)=\sum_j W_{\theta^i\theta^j}(\theta')\frac{d\theta'^j}{dY}\ \ \forall\, i \implies \sum_j\left(\frac{1}{S^iS^j}W_{\theta^i\theta^j}(\theta')+u''(c)\right)\eta^j=u''(c) \tag{B.27}$$

Defining matrix M with elements m_{ij}, the system can be represented in matrix form as

$$m_{ij}\equiv\frac{1}{S^iS^j}W_{\theta^i\theta^j}(\theta')+u''(c) \implies M\eta=u''(c)\mathbf{1} \implies \eta=u''(c)M^{-1}\mathbf{1}$$

$$\text{where}\ \ \sum\eta^j=\sum S^i\theta_j\frac{d\theta'^j}{dY}=\frac{d}{dY}\sum S^j(\theta^j-\theta'^j)\theta_j$$

which now leads to identical equations (A.68) and (A.69) as follows

$$MPC=\frac{dc}{dY}=1-\sum_j\eta^j=1-u''(c)m \tag{B.28}$$

$$\text{where } m \text{ is defined as }\ m\equiv\mathbf{1}M^{-1}\mathbf{1} \tag{B.29}$$

Considering a change in the real interest rate by dR. Differentiating along (B.26) by separately considering the three asset classes in the the household balance sheet.

$$\begin{aligned}\frac{dS^i}{dR}u'(c)+S^iu''(c)\Bigg\{&-\sum_j S^j\frac{d\theta'^j}{dR}-\frac{dS^\ell}{dR^\ell}(\theta'^\ell-\theta^\ell)\\ &-\frac{dS^H}{dR^H}(\theta'^H-\theta^H)-\frac{dS^S}{dR^S}(\theta'^S-\theta^S)\Bigg\}=\sum_j W_{\theta^i\theta^j}(\theta')\frac{d\theta'^j}{dR}\ \ \forall\, i\end{aligned} \tag{B.30}$$

Using the subset of the relations assumed in equation (B.14) relevant for the real interest rate channel

$$\frac{dS^L}{S^L}=-\frac{dR}{R},\ \ \frac{dS^H}{S^H}=-\frac{dR_H}{R_H}=-\theta_1\frac{dR}{R},\ \ \frac{dS^S}{S^S}=-\frac{dR_S}{R_S}=-\theta_2\frac{dR}{R} \tag{B.31}$$

substituting the conditional impacts from (B.31) in (B.30) and rewriting as

$$\frac{dS^i}{dR}u'(c)+S^iu''(c)\left\{-\sum_j S^j\frac{d\theta'^j}{dR}-\sum_j\frac{S^j}{R}(\theta'^j-\theta^j)\theta_j\right\}=\sum_j W_{\theta^i\theta^j}(\theta')\frac{d\theta'^j}{dR}\ \ \forall\, i \tag{B.32}$$

Defining $\gamma^j \equiv S^j \frac{d\theta'^j}{dR}$ such that it solves

$$\sum m_{ij}\gamma^j = -\frac{1}{R}u'(c) + u''(c)\sum_j \frac{S^j}{R}(\theta'^j - \theta^j)\theta_j \ \ \forall\, i$$

$$\text{In matrix form, } \ M\gamma = \left(\frac{1}{R}u'(c) + u''(c)\sum_j \frac{S^j}{R}(\theta'^j - \theta^j)\theta_j\right)\mathbf{1}$$

$$\implies \gamma = \left(\frac{1}{R}u'(c) + u''(c)\sum_j \frac{S^j}{R}(\theta'^j - \theta^j)\theta_j\right)M^{-1}\mathbf{1} \tag{B.33}$$

Differentiating with respect to R in the budget constraint defined as $c+(\theta'-\theta)\Theta\mathbf{S} = Y+\theta\mathbf{d}$,

$$\frac{dc}{dR} = -\sum_j S^j\frac{d\theta'^j}{dR} + \sum_j \frac{S^j}{R}(\theta'^j - \theta^j)\theta_j = -\sum_j \gamma^j + \sum_j \frac{S^j}{R}(\theta'^j - \theta^j)\theta_j \tag{B.34}$$

Substituting (B.33) and using $m = M^{-1}\mathbf{1}$ from (B.29), (B.34) can be rewritten as

$$\frac{dc}{dR} = -\left(\frac{1}{R}u'(c) + u''(c)\sum_j \frac{S^j}{R}(\theta'^j - \theta^j)\theta_j\right)m + \sum_j \frac{S^j}{R}(\theta'^j - \theta^j)\theta_j \tag{B.35}$$

Substituting $u'(c) = -c\sigma(c)u''(c)$ in (B.35) and rearranging terms,

$$\frac{dc}{dR} = -\sigma(c)\frac{c}{R}u''(c)m + \sum_j \frac{S^j}{R}(\theta'^j - \theta^j)\theta_j(1 - u''(c)m) \tag{B.36}$$

Substituting the expression for MPC from (B.28), (B.36) can be written as

$$\frac{dc}{dR} = \sigma(c)\frac{c}{R}(1 - MPC) + \sum_j \frac{S^j}{R}(\theta'^j - \theta^j)\theta_j MPC \tag{B.37}$$

The second term on the RHS of (B.37) can be simplified using the defined budget constraint $c + (\theta' - \theta)\Theta\mathbf{S} = Y + \theta\mathbf{d}$ as follows

$$\begin{aligned}\sum_j \frac{S^j}{R}(\theta'^j - \theta^j)\theta_j MPC &= \frac{1}{R}\sum_j S^j(\theta'^j - \theta^j)\theta_j MPC = \frac{1}{R}\left[(\theta' - \theta)\Theta\mathbf{S}\right]MPC \\ &= \frac{1}{R}\left[Y - \theta\mathbf{d} - c\right]MPC = \frac{1}{R}URE\cdot MPC \end{aligned} \tag{B.38}$$

where I have used the consistent definition of URE being the net wealth defined by considering all present and future assets & liabilities. Now, using (B.38), the real interest rate impact on consumption from (B.37) can be written as

$$\frac{dc}{dR} = \sigma(c)\frac{c}{R}(1 - MPC) + \frac{1}{R}URE \cdot MPC \tag{B.39}$$

Now considering the entire change from the simultaneous income and real interest rate, using (B.28) along with (B.39), the lemma is proved

$$dc = MPC\left(dY + URE\frac{dR}{R}\right) - \sigma(c)c(1 - MPC)\frac{dR}{R} \tag{B.40}$$

Using the result of the lemma from (B.40), the result for labor supply dn can be proved analogously. Given the restrictions of fixed balance sheets and only transitory shocks, following appendix A.7 using the lemma for both consumption and labor supply, the aggregation follows identically. This proves that (6) holds under general market incompleteness and completes all the required proofs for model extensions.

C Sufficient Statistics - Additional Results

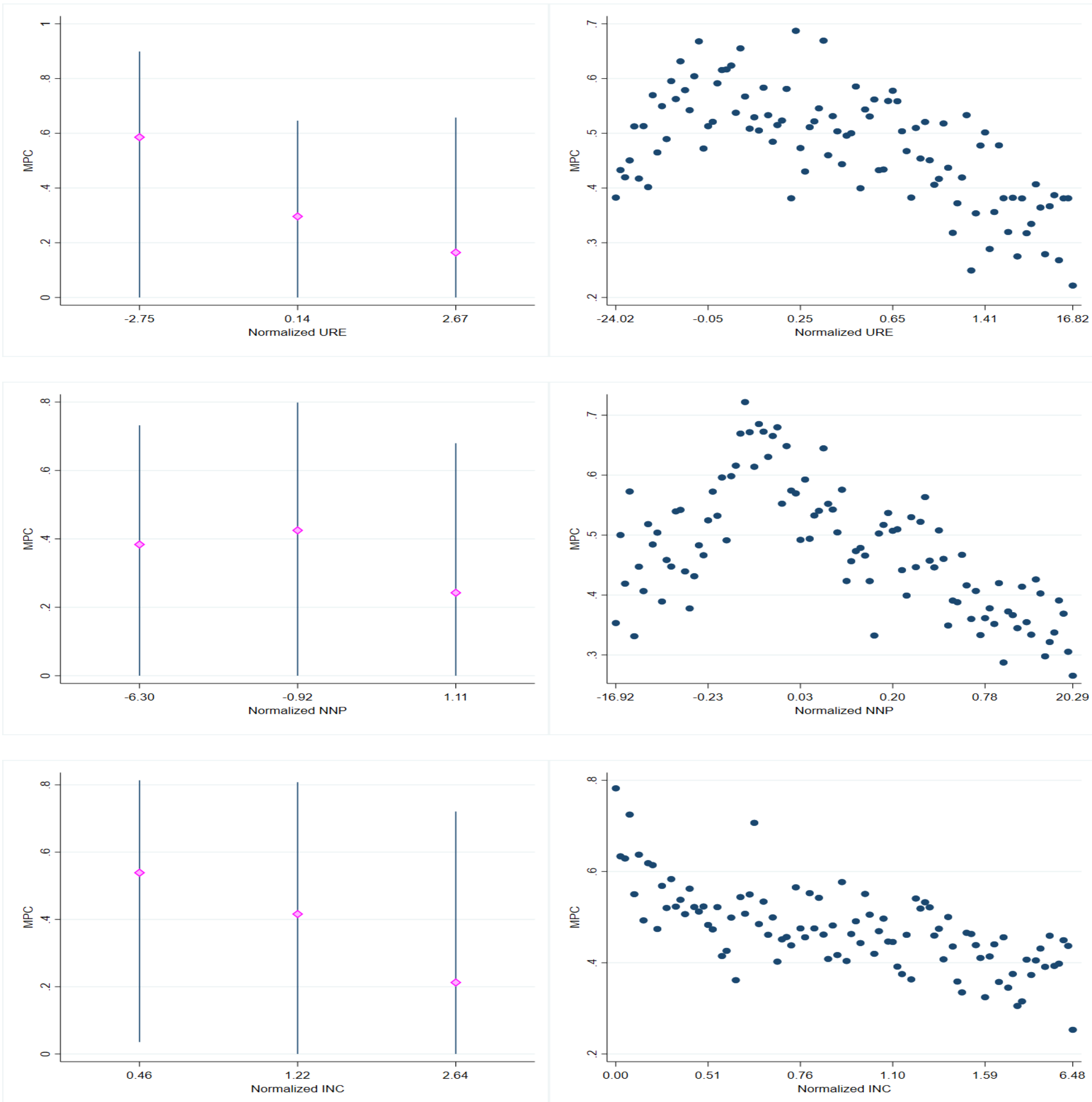
C.1 Redistribution elasticities relative to benchmark

The differential impacts on prices & returns to housing and equity leads to the entire distribution of household exposure from both the real interest rate and Fisher channels to flatten. The capturing of longer tails not only makes them more accurate but also amplifies the exposures as revealed by panel (a) of Figure 11 for the CE data.[25] The distribution for earnings shifts slightly to the left. It is consistent since the survey reported numbers for unrealized capital gains are not included as they do not reveal any information about transitory monetary policy. Panel (b) compares the response in SHIW data assuming that agents face the exact same shock and are not directly comparable. However, both the panels visually indicate that there is a negative correlation between *URE, NIC* & associated *MPCs* when conditioned on the shock. The relation is slightly less pronounced for *NNP*. The majority of US households own housing despite having mortgages and the net position on housing

[25]Looking at Figure 11 seems it is possible to have similar graphs for only housing or equity wealth. However, following the same empirical method to estimate *MPCs* could involve substantial error on ignoring significant parts of household portfolio. Differences across the distribution in that case would be erroneously attributed to asset maturity. I comment on this issue in section 1.

Figure 11: Marginal Propensities to Consume and Redistribution Channels in survey data

(a) For CE data (b) For SHIW data



Note - The normalization follows the definition of 12 for both the datasets. In SHIW, *MPCs* are self-reported. The number of bins to estimate *MPC* in CE as a function of household exposure is 3.

Table 18: Cross - sectional moments for the two surveys corresponding to Figure 5

Survey:	CE		SHIW	
	Estimate	95 percent CI	Estimate	95 percent CI
$\widehat{\varepsilon_R}$	-0.38	[-0.94,0.17]	-0.07	[-0.15,0.01]
$\widehat{\varepsilon}_R^{NR}$	-0.38	[-0.94,0.18]	0.08	[0.00,0.16]
$\widehat{\mathcal{S}}$	0.65	[0.38,0.92]	0.56	[0.52,0.59]
$\widehat{\varepsilon_P}$	-0.13	[-0.90,0.63]	-0.06	[-0.13,0.02]
$\widehat{\varepsilon}_P^{NR}$	-0.85	[-1.75,0.06]	-0.10	[-0.17,-0.03]
$\widehat{\varepsilon_Y}$	-0.12	[-0.34,0.10]	-0.05	[-0.06,-0.03]
$\widehat{\mathcal{M}}$	0.44	[-0.06,0.94]	0.49	[0.47,0.51]

Note - The final version of the model in section 3 is used which includes separate conditional impact to both houses and equity. The robustness is ensured by re-sampling the panel 100 times with replacement to reduce errors.

is likely to be positive. They occupy the middle quantiles of wealth distribution and are expected to have higher *MPCs*. I maintain the benchmark assumptions regarding asset maturity and number of bins used to estimate the *MPCs* from CE data. The estimates along with their 95% confidence interval for the two surveys are presented in Table 18. Compared to previous results, the point estimates are considerably larger for the two channels of interest. The earnings heterogeneity channel remains more or less same since it uses reported measures. The focus here is on the unrealized conditional changes on household balance sheets. The standard substitution and wealth effects present in a RANK do not show any appreciable improvement. On average, the confidence intervals admit more negative values for the *URE* & *NNP* channels. Even larger negative covariance between *MPCs* & interest rate channels is possible. This leads to bigger consumption responses conditioned on these unrealized changes arising from the differential effects to housing & equity. In general, expansionary monetary policy tends to benefit agents who have more liabilities (primarily with longer maturities eg mortgages - negative *URE*) than assets (with shorter maturity eg stocks and bonds - positive *URE* since the former have higher *MPCs* than the latter. On the contrary, once the *MPCs* are not allowed to change, the new estimates of redistribution elasticities are much smaller in absolute value. In this case, unrealized increases in wealth

Table 19: Variation of redistribution elasticity estimated with asset maturity assumption

		Duration scenario				
		Quarterly	Short	Benchmark	Long	Annual
$\widehat{\varepsilon_R}$	CE	-0.99	-0.56	-0.38	-0.38	-0.39
		[-2.29,0.31]	[-1.40,0.29]	[-0.94,0.17]	[-0.81,0.04]	[-0.80,0.01]
	SHIW	-0.08	-0.14	-0.07	-0.05	-0.03
		[-0.27,0.12]	[-0.25,-0.03]	[-0.15,0.01]	[-0.11,0.01]	[-0.10,0.03]

Note - exactly similar process as described in Table 18. See corresponding notes for more details. For description of maturities, see Auclert (2019) Table 2.

without corresponding increase in MPC, for majority of the distribution, mechanically reduces the negative covariance. Results in Table 19 highlight the relative importance of the asset maturity channel for $\widehat{\varepsilon}_R$. The updated results show no major changes in the overall trend on comparison with the original estimates. Consistent with the previous explanation, the estimates diminish in SHIW data. The role of asset returns enhances the impacts across horizons only when associated *MPCs* are changing. Even at quarterly horizon, commonly assumed in most structural models, not accounting for returns heterogeneity underestimates the targeted moment by almost 100 percent. Structural models would atleast need to match the updated sufficient statistics to get an accurate aggregate impact. If the model is misspecified, then the errors would simply compound. This holds even if the model is not relevant for analyzing policy initiatives from the incorporation of return heterogeneity. Another striking result from Table 18 is the vastly improved performance with respect to the no-rebate numbers. These act as the lower bound for these point estimates. Accounting for the measurement error leads to even higher magnitudes while preserving the expected sign and prevents counter-intuitive positive covariances that sometimes appear in Auclert (2019). A requisite discussion in this context has been included in section 5.2. Additional results are included in section C.2.

C.2 Additional results for comparing aggregate changes

To get an idea of the impact of asset maturity on aggregate consumption, one can directly see the impact on the redistribution elasticity from the real interest rate which is the only chang-

Table 20: Sensitivity of σ^* to Asset Maturity under expansionary policy in CE

Measure	Maturity	Auclert	Housing + Stock	Housing	Stocks
$\boldsymbol{\sigma^*}$ **% Change**	**Quarterly**	0.86	1.52	1.28	1.50
		–	77.23	48.59	74.55
	Short	0.75	0.86	0.89	0.85
		–	14.87	18.97	13.13
	Long	0.34	0.58	0.42	0.58
		–	70.07	20.84	67.49
	Annual	0.36	0.60	0.45	0.59
		–	66.96	24.15	64.43

Note - Results with $\sigma = 0.5$. To be compared with the first two rows of Table 2. See associated table notes for more details.

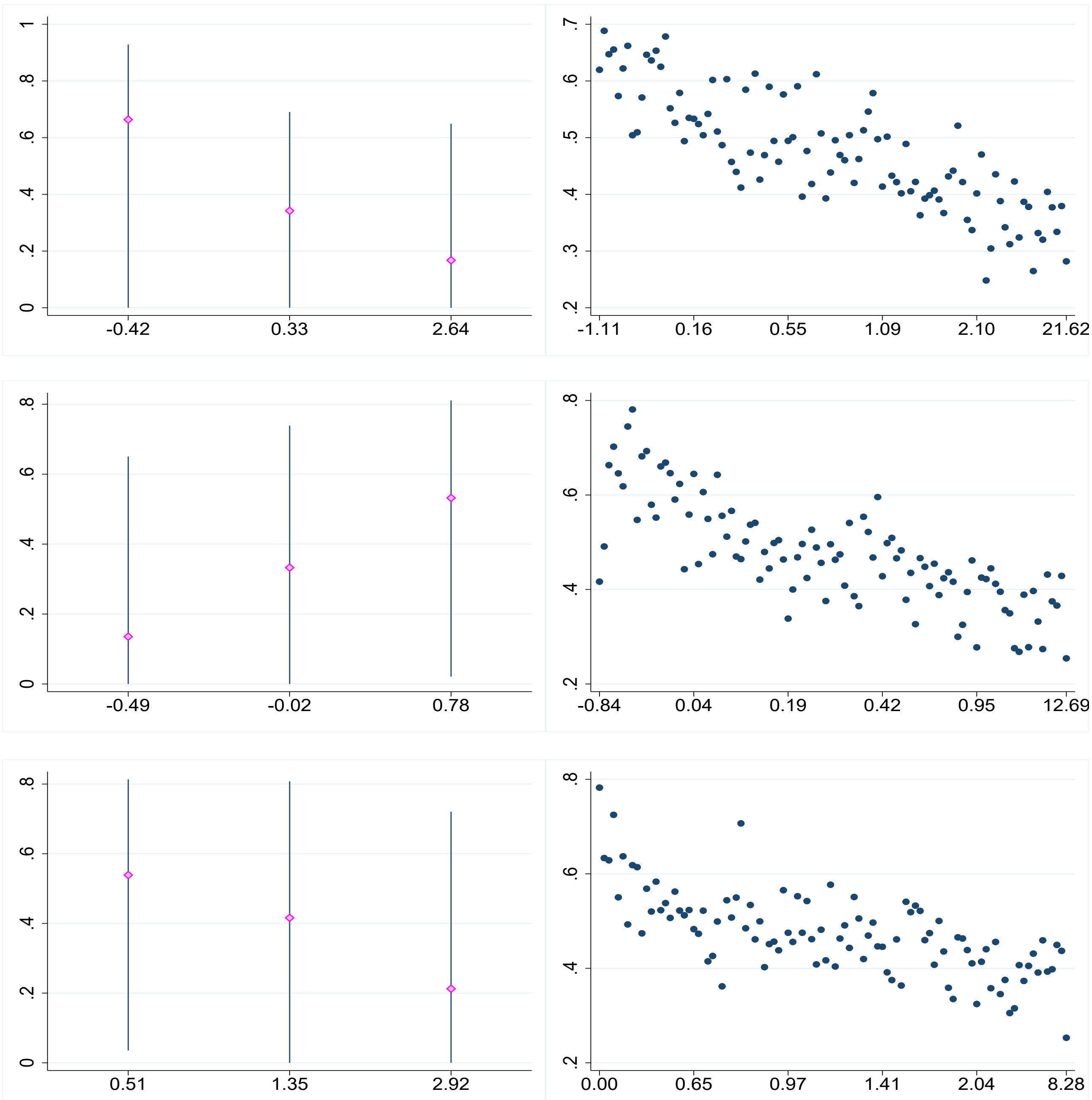
ing sufficient statistic on altering the maturities. The first two rows of Table 20 correspond to length of assets being shorter than the benchmark while the last two rows correspond to lengths being higher. Compared to the main text results in Table 2, the impact increases by around 15% in the quarterly horizon. This is of interest to structural models which typically assume quarterly or shorter asset maturities. The direct effects rise as asset maturity shortens and is robust in general to changing thee asset maturity. Surprisingly, the effects are almost equal at the short horizon. I also present the corresponding estimates keeping the *MPC* fixed in Table 21 and find as before there is much lesser variation and in fact the effects decline when compared to the benchmark.

For the sake of completeness, I present the results analogous for the contractionary shock. From Figure 12, the trend for the *URE* is similar while the trend for the *NNP* reverses since the entire distribution shifts leftward by a large magnitude from the wealth declines from the Fisher channel. The data for the SHIW now show clearer patterns of declining *MPC* with increased *URE* & *NNP* as intuitively expected. As stated before, since the two data sources are not strictly comparable, this would not qualify as an improvement. Comparing the redistribution elasticities for the negative shock in Table 22 with the ones in Figure 5, the asymmetric response is felt strongly for both the real interest rate and the Fisher channels. Owing to the new distribution of the *NNP* with its associated *MPC*, there is an increase in

Figure 12: *MPC* vs Redistribution Channels in survey data for contractionary shock

(a) For CE data

(b) For SHIW data



Note - Contractionary shock uses PDV estimates for one standard deviation rise in the monetary policy surprise. For more details, see associated notes in Figure 11

Table 21: Sensitivity of σ^* to Asset Maturity under expansionary policy in SHIW

Measure	**Maturity**	**Auclert**	**Housing + Stock**	**Housing**	**Stocks**
$\boldsymbol{\sigma^*}$	**Quarterly**	0.29	0.14	0.13	0.31
% Change		–	-50.89	-57.03	6.25
$\boldsymbol{\sigma^*}$	**Short**	0.36	0.09	0.23	0.36
% Change		–	-75.45	-36.16	0
$\boldsymbol{\sigma^*}$	**Long**	0.13	0.25	0.07	0.15
% Change		–	96.43	-43.88	14.29
$\boldsymbol{\sigma^*}$	**Annual**	0.11	0.05	0.04	0.13
% Change		–	-50.89	-67.26	16.67

Note - Results with $\sigma = 0.5$. To be compared with the last two rows of Table 2. See associated table notes for more details.

the consumption on raising the interest rate through the Fisher channel. The final impact on the aggregate consumption depends on the interaction of all the channels and is explained in section 5.3.

Since the asymmetric response to the interest rate channel is the strongest and intuitive, I look at its sensitivity to asset maturity. Shortening the time frame leads to far less reduction in aggregate consumption from direct effects across maturities. On comparing with Table 19, the differences are most pronounced for the quarterly and short horizons. The asymmetric response to consumption increases in strength as the asset maturity shortens which is another feature of interest for structural models.

The value of γ is expected to be negative since idiosyncratic incomes are expected to be countercyclical. I take a wide range of permissible values and check the percentage change in the general equilibrium consumption from the main model which features separate returns to both housing and equity. I compare the baseline and the no-rebate numbers for both the shocks. The numbers in Table 26 also indicate the magnitude of the asymmetric response with varying γ. In general as incomes become strongly counter-cyclical, the overall aggregate consumption response weakens since the net change from the income effects from the earnings heterogeneity channel start opposing the added substitution effects from equation (9). The degree of asymmetric response depends on the updated elasticities and gamma doe snot play

Table 22: Cross - sectional moments corresponding to Figure 5 for a contractionary shock

Survey:	CE		SHIW	
	Estimate	95 percent CI	Estimate	95 percent CI
$\widehat{\varepsilon_R}$	-0.24	[-0.55,0.07]	-0.14	[-0.18,-0.10]
$\widehat{\varepsilon}_R^{NR}$	0.09	[-0.33,0.51]	0.54	[0.49,0.58]
$\widehat{\mathcal{S}}$	0.61	[0.33,0.89]	0.55	[0.53,0.58]
$\widehat{\varepsilon}_P$	0.08	[-0.03,0.20]	-0.08	[-0.10,-0.05]
$\widehat{\varepsilon}_P^{NR}$	0.11	[-0.01,0.24]	0.24	[0.22,0.26]
$\widehat{\varepsilon_Y}$	-0.13	[-0.38,0.11]	-0.06	[-0.08,-0.04]
$\widehat{\mathcal{M}}$	0.49	[-0.06,1.94]	0.60	[0.60,0.65]

Note - Contractionary shock uses PDV estimates for one standard deviation rise in the monetary policy surprise. See associated notes in Table 18 for more details.

Table 23: Comparison for expansionary shock with $\sigma = 0.5$ & $\gamma = -0.5$ for no-rebate numbers

Model Consumption Response	Estimated *MPCs*		Fixed *MPCs*	
	PE	GE	PE	GE
Auclert + House + Stock	1.62	2.06	0.33	0.82
Auclert + House	1.68	2.12	0.21	0.70
Auclert + Stock	0.61	1.07	0.10	0.65
Auclert	0.93	1.39	0.01	0.47

Notes - No rebate numbers refer to withholding the instantaneous transfers post the windfall transfer by other sector of the economy from the household sector. For more details see notes in Table 3.

Table 24: Comparison for contractionary shock with $\sigma = 0.5$ & $\gamma = -0.5$ for no-rebate numbers

Model Consumption Response	Estimated *MPCs*		Fixed *MPCs*	
	PE	GE	PE	GE
Auclert + House + Stock	0.17	0.66	-0.48	0.16
Auclert + House	1.00	1.49	0.21	0.84
Auclert + Stock	0.89	1.35	-0.17	0.38
Auclert	0.93	1.39	0.01	0.47

Note - Contractionary shock refers to the transitory unexpected one percent increase in the real interest rate accompanied by a decrease in overall price level & aggregate income by one percent. See notes in Table 23 for more details.

Table 25: Variation of $\widehat{\varepsilon_R}$ with asset maturity assumption for a contractionary shock

		Duration scenario				
		Quarterly	Short	Benchmark	Long	Annual
$\widehat{\varepsilon_R}$	CE	-0.14	-0.07	-0.24	-0.17	-0.21
		[-0.73,0.45]	[-0.6,0.46]	[-0.55,0.07]	[-0.41,0.07]	[-0.42,0.00]
	SHIW	-0.27	-0.27	-0.14	-0.10	-0.08
		[-0.35,-0.20]	[-0.34,-0.19]	[-0.18,-0.10]	[-0.13,-0.07]	[-0.11,-0.06]

Note - Contractionary shock uses PDV estimates for one standard deviation rise in the monetary policy surprise. See associated notes in Table 19 for more details.

Table 26: Sensitivity of general equilibrium consumption to value of γ

	Expansionary		Contractionary	
Value of γ	**Baseline**	**No-rebate**	**Baseline**	**No-rebate**
-1.5	-15.33	-9.94	10.04	8.58
-1.25	-11.79	-7.62	7.72	6.58
-1.00	-8.07	-5.20	5.28	4.48
-0.75	-4.14	-2.67	2.71	2.29
-0.40	1.72	1.10	-1.13	-0.95
-0.25	4.38	2.78	-2.87	-2.40
-0.1	7.14	4.52	-4.67	-3.90
-0.01	8.83	5.59	-5.78	-4.82

Note - Calculates the percentage changes relative to the general equilibrium consumption for the main model described in section 3 for the CE data with $\gamma = -0.5$. Numbers for negative shock show improved response if positive. The second and third columns use the results from the first row in Table 4 & Table 23 respectively. Similarly, the fourth & fifth columns correspond to Table 7 & Table 24 respectively. For more details, see associated notes.

any significant role since the earnings heterogeneity channel is almost similar to the original results.

D Comparing *MPC* estimates with previous results

The consumption at the household level from the one time unexpected monetary policy surprise is essentially product of the household income times its *MPC* out of income. We can decompose this total effect into five separate channels as in (6). Each channel is again the product of the aggregate change times its associated *MPC*. The economy wide aggregate *MPC* out of income is the first two terms of the same equation. I compare these estimates with existing results for the *MPC* out of fiscal transfers.[26] The aggregate *MPC* out of income is 44% (vs 46% in the benchmark). Common estimates in the literature range from 15-25% .

[26]The estimation of MPCs requires a one time unexpected fiscal transfer. So these estimates are directly comparable. See section 4 for more details, specifically (12).

The higher numbers are primarily due to the enhanced effects of unrealized wealth changes from the separate redistribution channels on the household estimate of MPC out of income.

One of the assumptions regarding the theoretical exercise is that consumers cannot adjust their portfolios post the shock. Therefore, they cannot directly realize the wealth gains in exchange of transaction costs. The effect of balance sheets on the MPC out of income are a result of wealth changes from holdings of housing, equity and/or liquid assets. I also compare the aggregate MPC out of income with the estimates of MPC out of realized wealth changes for both housing and equity. I lay out previous numerical estimates in footnotes 2 and 6. Owing to large transaction costs, MPC out of home-equity based borrowings are much smaller than corresponding estimates out of realized wealth changes from equity. Estimating unrealized wealth changes from housing wealth is quite infeasible. Besides other estimates, Hartzmark and Solomon (2019) also estimate that the MPC out of dividends (equivalent to MPC out of realized wealth changes in equity) is 40-60% for top 50% of the wealth distribution.

I compare the model-implied elasticity of consumption to house price shocks as developed by Berger et al. (2018) given by

$$\eta = \frac{dC}{d(PH)} \times \frac{PH}{C} \equiv MPC \times \frac{(1-\delta)PH}{C} \tag{D.1}$$

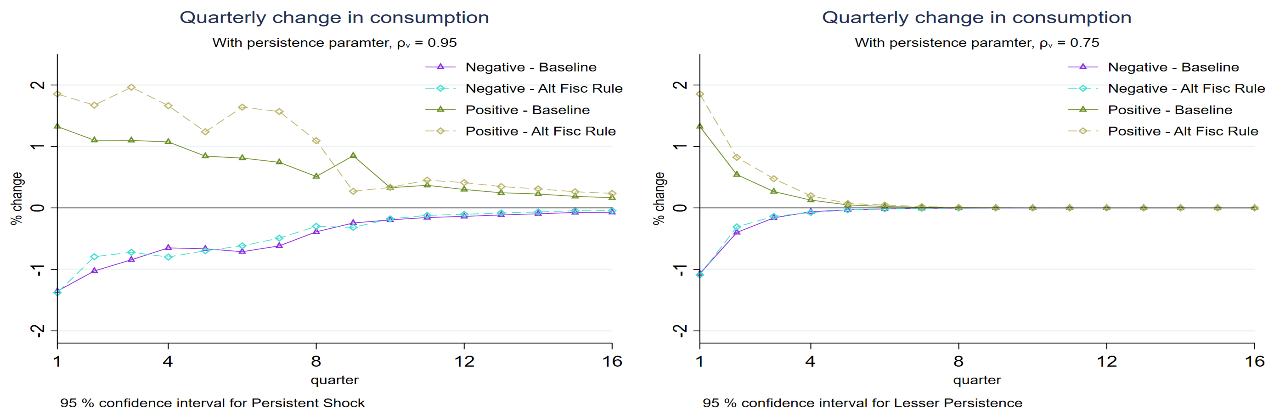
which is the sufficient statistic. For permanent house price changes of 4.59% ad $\delta = 2\%$, they calculate the theoretical elasticity to be $\in (0.23, 0.3)$. For my model with an implied aggregate MPC out of income of 44% , using the permanent house price change of 4.59% leads to $\eta = 0.45$. If I use the estimated housing price change rather than the permanent shock in housing prices then estimate of $\eta = 0.36$, both being more or less similar.

Lastly, I also compare the estimates of MPC out of income with the MPC out of realized housing wealth changes in Mian and Sufi (2014). They find that the elasticity of consumption from housing net worth shock is 0.6 - 0.8 across counties when they have the housing net worth shock of

$$\text{HNW\_shock} = \left(\Delta \log p^{H,i}_{06-09} \times H^i_{2006}\right) / NW^i_{2006} \approx 10\% / NW^i_{2006} \tag{D.2}$$

Their average marginal MPC out of housing wealth is 5-7 cents. The most comparable estimates are for a negative shock and using a model with only housing returns heterogeneity and without any income change is roughy 0.59.

Figure 13: General equilibrium aggregate consumption response for different shocks



Note - Consumption change is corresponding to (9) for the model presented in section 3. Positive shock refers to the decline in the real interest by one percent for $t = 1$. Negative shock analogously refers to the increase in the real interest rate by one percent for $t = 1$. From $t = 2$, the one time change declines by ϕ in absolute magnitude. Inflation and aggregate income both change by the same amount as the change in the real interest rate for all $t \geq 1$. Baseline refers to the benchmark model where fiscal transfers are instantaneously rebated. Alt Fisc Rule refers to the case where fiscal transfers are not instantaneously rebated.

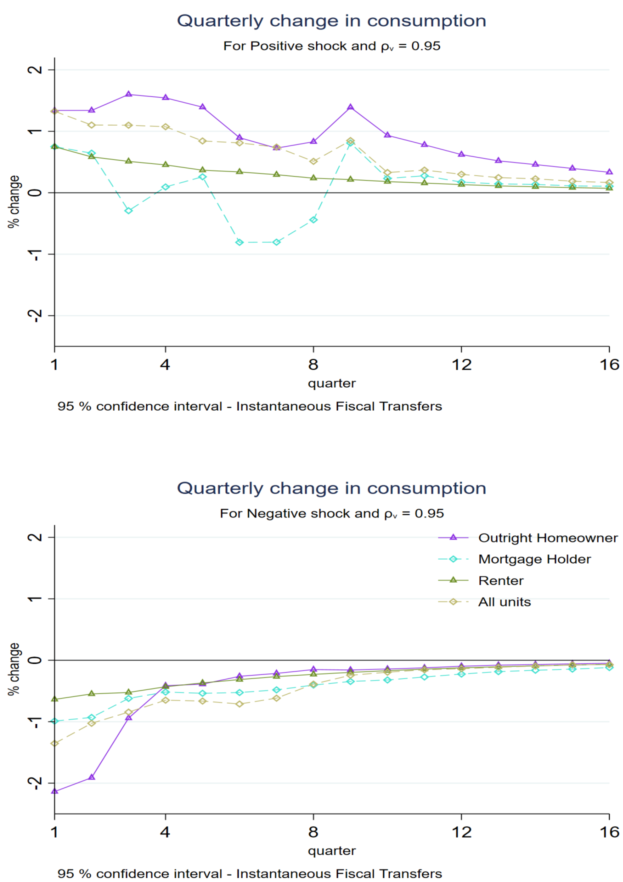
E Implied aggregate consumption *IRFs*

The flexibility of the sufficient statistics approach allows for measuring implied *IRFs* in line with the theoretical results in appendix B.1 beyond the instantaneous response in section 5.2 from the same transitory unexpected monetary policy surprise. The key assumption is that households cannot adjust their portfolios during the entire horizon of the response. A major motivation is the need to have *IRFs* for interested aggregate variables without relying on structural models that can study only a subset of the myriad redistribution channels. Empirically, this might be inconsistent with the evidence for households in especially top 10% of the wealth distribution. Since substantial proportion of the households have a major fraction of their wealth tied up in housing with high transaction costs, their portfolio rebalancing is much less frequent. I present the results here for 16 quarters ahead.

To estimate the results, firstly I need the PDV estimates for each of the 16 quarters ahead. One way to obtain them would be using the local projections approach detailed in appendix A.3. It is more robust than a SVAR for smaller time horizons. However, due to the nature of the exercise involved (section 3.2), the SVAR remains a superior method since consumers are theoretically forecasting infinitely ahead in the future for each quarter. Second, I need externally specified exogenous changes for the real interest rate, inflation and aggregate income for 16 quarters ahead. I start with unit changes as used in section 3.4 for the instantaneous response. From the second quarter onwards, the one time change declines by a common persistence parameter ϕ for all the three changes. As an extension to section 5.4, I also follow the same process to derive the implied *IRFs* for additional dimensions of heterogeneity. The purpose of this section is demonstrate the flexibility and usefulness of the sufficient statistics approach. Other possible specifications for exogenous changes in the aggregate real interest rate, inflation and income can be used. An interesting example in this context would be Taylor rules where the consumption deviations proxy for the output gap. In the interest of space and brevity, I do not include these additional results here. In summary, conditional on ex-post returns heterogeneity, sufficient statistics can be used in computing the aggregate general consumption for any quarter post the one time unexpected shock provided we maintain the assumption that consumers do not alter their balance sheets. I contrast the results for shocks of different persistence in Figure 13 using the general equilibrium aggregate consumption elasticity to the nominal interest rate. The increase in consumption declines slowly for the first year post the shock before dampening by the end of three years for a highly persistent shock in the left panel. The revaluation of consumer balance sheets is different for each individual quarter compared to the cumulative response for the instantaneous response. As can be seen from Figure 1, the increased valuation of stock and housing assets is higher immediately post the shock before declining gradually. Consumers, especially those who are unconstrained, would realize these gains at some point in the future leading to a rise in consumption today. The gains would be quantitatively large for the initial number of quarters. The logic is exactly the same as with the instantaneous response, the only exception being that the quantitative differences are different for each individual quarter.

The asymmetries are also sharper when comparing with the response for the negative shock. Consumption declines far less for the first two years from the shock. Since the revaluation affects both the debt and asset side of the balance sheets, consumers experience smaller declines in net wealth depending on both across and within class heterogeneity in their asset holdings leading to a far smaller decline in consumption. Both the results pertain to the baseline model where the government instantaneously refunds the transfers. The responses do not show the typical hump shape response oft observed empirically from VAR analysis where consumption responds with a lag and increases post a few quarters after the shock. Withholding fiscal transfers from households however does not solve the problem and produce a hump-shaped response in consumption despite being expected to constrain households and dampening the increase in consumption. The results also depend on the persistence of the shock. If the persistence is less, the wealth changes are smaller and taper

Figure 14: General equilibrium aggregate consumption *IRFs* by housing tenure



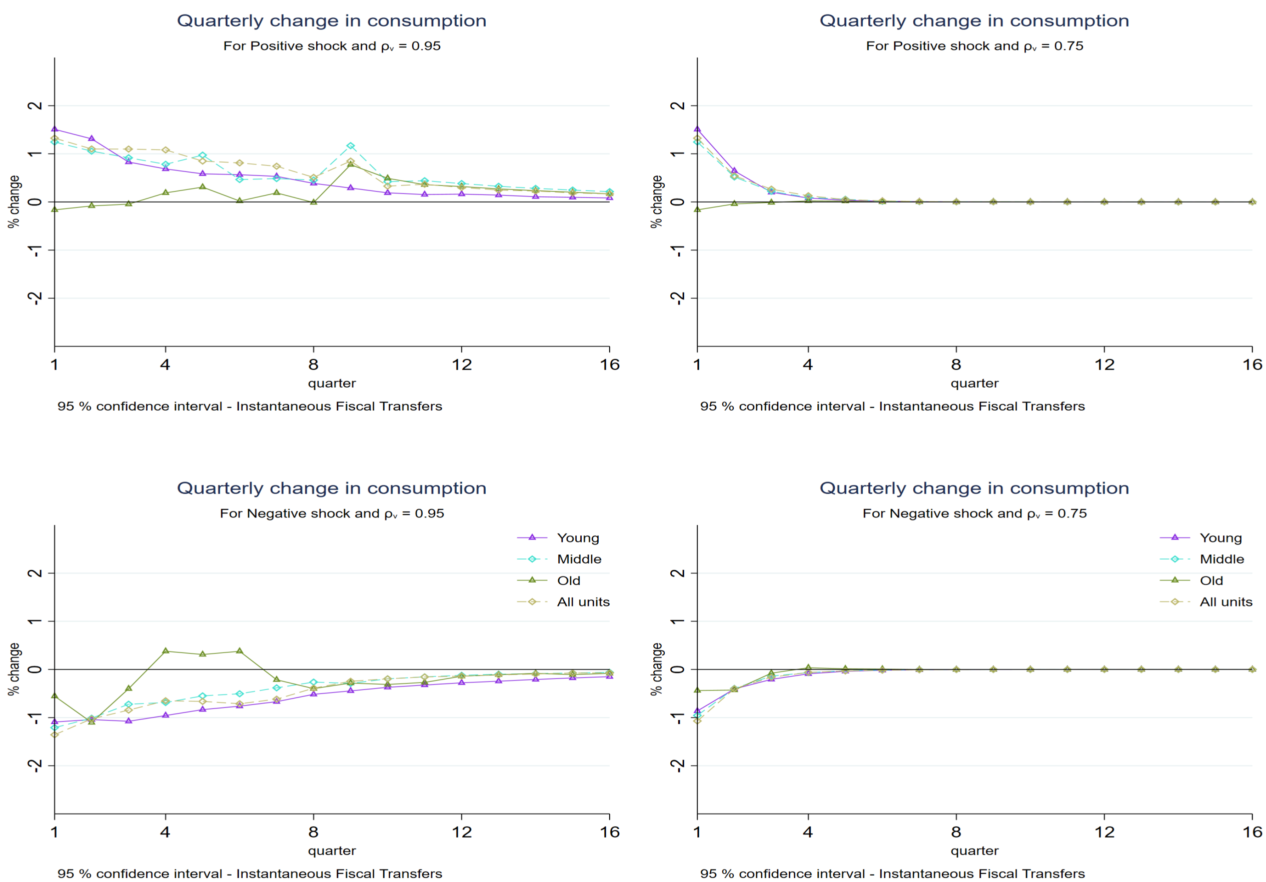
Note - For all the cases, fiscal transfers are instantaneously rebated. Housing tenure is as defined in section 5.4. For more details see associated notes in Figure 13.

off sooner. Subsequently, consumption responses are dampened across shocks irrespective of the nature of fiscal policy in the model. There is also very little asymmetry for the negative shock of equal magnitudes.

Analogous to section 5.4, I present the results by housing tenure in Figure 14. I only use the baseline model where fiscal transfers are instantly rebated to households. Since outright homeowners are expected to be having higher positive liquid asset holdings, they are significantly less constrained. Similarly, mortgage holders are expected to be more constrained compared to the former. Accordingly, the consumption response for the same increase in returns & prices ex-post for the three classes of assets produces higher unrealized wealth gains for the former. Outright homeowners have a consistently higher response than the aggregate while for mortgage holders, the consumption response is similarly below aggregate. For a negative shock of exact same magnitude, the response is now strongly asymmetric with homeowners reducing their consumption higher since they see the largest decrease in their asset values. Being substantially closer to the borrowing limit prevents a similar consumption reduction for mortgage holders due to inherently higher *MPCs*. The intuition and results for section 5.4 applies here as well. Renters have much smaller changes and their consumption response is essentially uniform across quarters and depends only on the aggregate decrease in the real interest rate, increase in inflation and earnings quarter by quarter. Their response displays almost negligible asymmetry. Reducing the persistence of the shock understandably dampens the overall deviations from the steady state.

Analogous results by demographics are presented in Figure 15. The differences from the aggregate response are far less compared to the response by housing tenure. The response for old people is also highly asymmetric as observed for the negative shock in the bottom left panel. Young are expected to much more constrained than middle while old is expected to be the least constrained. The behavior of the old is kind of an outlier. In the left panel for the highly persistent shock, the response for the old is the least. Accordingly, the logic should have led to old people having the highest consumption elasticities. One possible reason could be bequests which means old do not increase consumption despite lesser savings. Reducing the persistence of the shock leads to nearly indistinguishable responses from the aggregate. The model is far less successful in exploiting the balance sheet differences based on age.

Figure 15: General equilibrium aggregate consumption *IRFs* by demographics



Note - For all the cases, fiscal transfers are instantaneously rebated. Demographics is as defined in section 5.4. For more details see associated notes in Figure 13.

F Results for Policy Experiments

I explore the interaction between wealth inequality and the presence of returns heterogeneity, conditional on the shock, using simple experiments. I restrict to comparing instantaneous responses only. The results for this section can be similarly presented in line with the methodology for section E. I target the household portfolios using SCF data for 2007 before the GFC and then again for 2019 before the pandemic. Specifically, I adjust the shares for housing, equity and liquid assets relative to the mean for both positive and negative asset positions. Since the results in sections 5.2 and 5.3 confirm that the household consumption change is primarily from the MPC channel, I restrict myself to the CE data. I focus only on the general equilibrium consumption response. Since the share of redistribution in partial equilibrium is always higher, quantitatively significant results in general equilibrium is always the lower bound for corresponding estimates in partial equilibrium. Higher the share of redistribution in overall aggregate consumption response, greater is the underestimation relative to the benchmark without returns heterogeneity. Of course, I assume that the consumption expenditures are similar across the time periods under consideration.

I report the results for the one time unexpected decline in the real interest rate by 1% in Table 27 for both the years. Columns 2 and 3 maintain the assumptions of the benchmark results in how to measure household debt. Unless a mortgage is explicitly specified as ARM, it is not treated as such. Columns 4 and 5 assumes that all mortgages are ARMs. In times of monetary easing, ARMs would lead to greater consumption responses since the pass through towards overall transmission is higher from the automatically declining mortgage rate. Intuitively, the reverse is expected to be true for negative monetary policy surprise. The responses for 2007 and 2019 are broadly similar and display a roughly 17% & 16% increase. The main result for a substantial increase in the aggregate consumption in the presence of the additional channel of returns heterogeneity stays robust for different time periods under consideration. Restricting to quarterly frequency increases them by 26% & 24% respectively. As mentioned in section 5.5, the exposures from the real interest rate channel are stronger which drives up the increase in consumption. Interestingly, having only separate returns for housing would lead to corresponding 24% & 22% against -3% & 4% for equity at quarterly maturity. Housing becomes more important for consumption since the bulk of the distribution who won housing wealth typically also hold mortgages. It leads to a negative *URE* which is associated with a higher *MPC*. The findings support the aggressive quantitative easing by the Fed at the start of the pandemic. Though, its primary aim was to prevent financial panic, the support for equity & housing markets rationalizes an even faster

Table 27: Predicted aggregate consumption responses under expansionary shock for $\sigma = 0.5$ & $\gamma = -0.5$

In General Equilibrium	**All Mortgages**				**Only ARMs**			
	Benchmark		Quarterly		Benchmark		Quarterly	
	2007	2019	2007	2019	2007	2019	2007	2019
Auclert + House + Stock	1.52	1.50	2.38	2.23	1.76	1.75	4.07	3.48
Auclert + House	1.45	1.34	2.34	2.18	1.45	1.48	2.34	3.86
Auclert + Stock	1.30	1.52	1.82	1.88	1.69	1.73	2.66	2.70
Auclert	1.30	1.29	1.88	1.80	1.41	1.34	2.26	2.27

Note - Columns 2 and 3 refer to baseline calculations for all types of mortgages. Columns 4 and 5 assumes all mortgages are only adjustable rate. The baseline model (Row 4) differs only by the addition of the required returns heterogeneity. Rows 1 - 3 refer to the updated model with separate returns for the three assets, either present together or one at a time. The wealth distribution is approximated using SCF 2007 and 2019 by using average asset positions (positive & negative) for the entire distribution relative to the information provided in CE 2001. See notes in Table 3 for more details. The final general equilibrium estimate is comparable to column 3. The only sufficient statistic that varies with asset maturity assumption is $\widehat{\varepsilon_R}$. See Table 2 in Auclert (2019) for details regarding asset maturities.

recovery in consumption.

Similar results follow through for 2007 before the GFC. An expansionary policy during the housing bubble is of course not the policy recommendation. If households had relatively more housing wealth, they would experience bigger consumption gains in comparison with households who held more equity. The findings should be interpreted as the influence of a temporary decline in wealth gini on aggregate consumption with/without returns heterogeneity. What matters is not only the magnitude of overall gains but also who receives the larger share of these gains. The consumption responses are slightly higher in comparison to 2019 where the wealth gini increased. To check the robustness of this result, I focus on the importance of within class heterogeneity for housing on the aggregate consumption elasticity. Columns 5 - 8 report the analogous estimates if all mortgages are assumed to be ARMs. The benchmark maturity estimates for 2007 and 2019 increase to 25% & 30*-0.1cm. Restricting to quarterly frequency would lead to 80% & 53% corresponding increases. The numbers on isolating the returns to housing or equity are considerably lower. The numbers for an expansionary policy in 2007 show that ARMs allow stronger redistribution from housing relative to equity. Since the majority of the distribution who hold considerably more housing wealth have higher *MPCs*, the consumption response is progressively higher. The difference depends on the extent of the excess gains relative to equity despite overall lower returns on housing. The estimates are surprisingly powerful and motivate the need to consider the interaction of returns heterogeneity & wealth inequality for aggregate demand in the short run. As intuitively expected, fiscal and mortgage design policies should focus on reducing the costs associated with refinancing across the wealth distribution. Formally, this is akin to assuming all mortgages to be ARMs at short maturities. Priority would be expediting aid during times of need like at the onset of the pandemic for the more vulnerable sections who don't have enough liquid assets to avail the refinancing. The results show that the consumption recovery could be vastly improved.[27]

The same exercise is repeated for contractionary policy and the numbers are reported in Table 28. Keeping with the intuition explained before in section 5.3, consumption would have dropped 10% & 12% lesser for 2007 and 2019 with benchmark maturity. The corresponding numbers are 24% & 51% lesser for quarterly. Having only housing returns lead to 54% improvement in 2007 vs 41% for equity emphasizing the importance of housing before the GFC. Further assuming all mortgages are ARMs with quarterly maturity would have

[27]The findings support both empirical and structural results in the literature on refinancing frictions. See DeFusco and Mondragon (2020) and Chen et al. (2020) for more details respectively.

Table 28: Predicted aggregate consumption responses under contractionary shock for $\sigma = 0.5$ & $\gamma = -0.5$

In General Equilibrium	**All Mortgages**				**Only ARMs**			
	Benchmark		Quarterly		Benchmark		Quarterly	
	2007	2019	2007	2019	2007	2019	2007	2019
Auclert + House + Stock	1.18	1.13	1.43	0.88	0.86	0.87	0.79	1.18
Auclert + House	1.12	1.16	0.86	0.93	0.95	0.89	1.09	1.04
Auclert + Stock	1.13	0.98	1.11	0.95	0.85	0.85	1.06	1.06
Auclert	1.30	1.29	1.88	1.80	1.41	1.34	2.26	2.27

Note - Numbers are negative elasticities of aggregate consumption. See notes in Table 6 & Table 27 for more details.

improved aggregate consumption by 65% & 48*-0.1cm. As mentioned in section 5.5, the results for the asymmetric response are counter-intuitive when viewed in terms of a contractionary policy in 2007. Either way, the predicted results demonstrate that structural models need to take returns heterogeneity more seriously for calibrating the aggregate consumption response correctly.