Distributional Imbalances, Monetary Policy, and the U.S. Business Cycle

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Abstract

Cyclical changes in U.S. income and wealth inequality during 1954-2009 have limited influence on output cycles through persistent shifts in aggregate demand, explain about half of debt fluctuations but not its pre-Great-Recession pileup which is driven by credit relaxation based on an estimated with Bayesian mixed-frequency techniques DSGE model featuring ten sources of stochastic variation. Monetary policy effectiveness weakens with inequality. The more aggressive the stance against inflation, the faster the stabilization after inequality swings. A monetary policy response to inequality entails no gains for the inflation-output gap variability trade-off. Policy surprises trigger negligible pro-(counter-)cyclical income (wealth, consumption) inequality.

Keywords: Distributional Imbalances, Aggregate Demand, DSGE, Bayesian Estimation
JEL classification: E32, E52

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1 Introduction

Despite rising U.S. inequality, still little is known about its macroeconomic implications. The effects of inequality on long-term growth are rather mixed [Alesina and Rodrik, 1994; Persson and Tabellini, 1994; Alesina and Perotti, 1996; Banrejee and Duflo, 2003; Barro, 2000]. The origins of the soaring post-1980s U.S. household debt, though, are found on the coincidently rising top income share [Kumhof et al., 2015] and volatility of earnings [Iacoviello, 2008], urging the study of the financial markets and inequality nexus [Stiglitz 2014, 2015].

Nevertheless, the common element of the above studies is that they adopt a long-run perspective on the implications of inequality leaving unexplored their short- to medium-run effects. The present paper fills this void by examining the implications of changes in income and wealth inequality for output cycles, aggregate demand gyrations, debt swings, and monetary policy. In that way, it quantitatively evaluates a long-time-held view suggesting that distributional shifts do not influence the business cycle. It helps identify the response of aggregate demand to inequality. It sheds light on the portfolio adjustments of households in the face of fluctuations in inequality. It allows to address concerns about monetary policy effectiveness in the presence of inequality [Greenspan, 1998; Bullard, 2014; Bernanke, 2015; Coeuré, 2012; Mersch, 2014; Panetta, 2015; Draghi, 2016].

The present work, therefore, identifies the business cycle implications of inequality by studying the evolution of income and wealth inequality, household debt, and macroeconomic conditions jointly over a period of five decades (1954-2009) in U.S. through structural lenses. It introduces heterogeneous agents and distributional imbalances in a medium-scale model building on Christiano et al. (2005) and Smets and Wouters (2007), and estimates it. Agent heterogeneity is projected in two fixed groups – the top and the middle class – that sufficiently approximate reality where a disconnect between the top and the rest of the distribution is well-documented[1]. The imbalances pertain to two dimensions. First, the model features time-varying unequal distributions of income and wealth that differ from the equitable distribution of the representative agent (RA) model. Second, due to inequality, the effect of aggregate shocks can potentially differ from that implied by the same shocks in the RA model. The sources of imbalances involve an exogenous and an endogenous component.

The exogenous component pertains to three "distributional" shocks generating disper-

[1] As argued by Kumhof et al. (2015), the stable or slightly declining income mobility in the U.S. since the 1950s [Kopczuk et al., 2010] provides some support to the consideration of two agent groups.

sion in wages, wealth, and credit availability between the top and the middle class. Wage polarization shocks introduce time-varying incomplete wage insurance, and build on Walsh (2017) who introduces a similar, albeit deterministic, scheme[2]. In a similar spirit, Lansing and Markiewicz (2018) consider shocks in a labor aggregator reflecting changes in the skill premium. Wealth shocks, modeled as disturbances in preferences for wealth, are similar to those considered in [Fisher, 2015; Krishnamurthy and Vissing-Jorgensen, 2012; Iacoviello and Neri, 2010; Iacoviello, 2005]. The interaction of wealth shocks with heterogeneous preferences for wealth, however, leads to heterogeneous shock influence reflecting unequal investment opportunities and returns. The latter are documented by Fagereng et al. (2018) using tax records, while Lee (2012) models partial insurance of returns. Credit supply shocks are modeled as stochastic variations in the borrowing limit [Justiniano et al., 2015].

The endogenous component of imbalances stems from imperfect financial insurance and heterogeneous marginal propensities to consume (MPC). Intra-family loans provide partial insurance since the borrowing middle class (due to a lower discount factor than the top) can renege on its obligations as in Kiyotaki and Moore (1997) and Iacoviello (2005). Partial insurance renders distributional shocks relevant for equilibrium dynamics. It is worth pointing out that the middle class holds both liabilities and assets (firm ownership). Moreover, heterogeneous preferences over wealth, encapsulating Carroll (2000)'s argument that wealth confers social status, influence the MPC differentials caused by the borrowing constraint.

Through a full-information Bayesian approach, the model explains the U.S. top income and wealth deciles, household debt, and seven aggregate series *jointly* over a period of five decades. Both aggregate and distributional shocks are extracted within the model. Since the inequality series are in annual terms whereas all other data are available in a quarterly frequency, mixed frequency estimation is conducted. Debt is extracted as the common component of multiple debt series to strengthen identification. To deal with the large state space dimensionality, I borrow an efficient treatment of it from the econometrics literature and operationalize it in a DSGE and mixed-frequency context.

1.1 Findings.

Changes in income and wealth inequality have limited effect on output cycles. The combined effect of distributional shocks, which explains the majority[3] of the swings in income and

[2] See Alichi et al. (2016), Phillippon and Reshef (2012), and Heathcote et al. (2010) for empirical evidence.
[3] Aggregate shocks explain 39/10% of the swings in short/medium-run wealth inequality.

wealth inequality, accounts for about 10/6% of output cycles in the short/medium run: polarization, wealth, and credit shocks account for 3/2%, 4/2%, and 3/2% of those cycles, respectively. That influence does not change in size over time, is robust across a battery of checks, and operates through shifts in aggregate demand: the distributional shocks trigger persistent consumption responses across the population that do not net out entirely to zero.

The distributional shocks, however, explain a sizable part of the swings in household indebtedness: 75/52% in the short/medium run[4]. The finding of a connection of inequality and debt over the business cycle complements the longer-run connection between the two found in Kumhof et al. (2015) and Iacoviello (2008). Contrary to Kumhof et al. (2015), however, rising income inequality weakens the collateral channel and, hence, does not suffice to explain the debt pileup prior to the Great Recession. Neither does rising wealth inequality, because wealth shocks generate a negative correlation between wealth inequality and debt. The latter correlation, however, is positive after credit shocks. The heterogeneous dynamics induced by the triplet of distributional shocks, therefore, render credit relaxation a major force behind the debt pileup prior to the Great Recession in line with Mian and Sufi (2018), even though credit disturbances have limited effect on output as in Justiniano et al. (2015).

Moreover, contrary to the RA model where the persistence in consumption is mirrored in high habit formation that is often criticized for being at odds with the data, in the present paper that persistence is captured by changes in income and wealth inequality while the magnitude of the habit parameter falls from 0.77 in the RA model to 0.51. In contrast, preference heterogeneity amplifies the volatility of aggregate demand. Moreover, risk premium and investment shocks obtain a tad more elevated (ephemeral) influence on output (consumption) cycles compared to their influence in the RA model, suggesting that with distributional shocks demand shocks contribute less to the output–consumption correlation.

As for the transmission of distributional shocks, wage polarization shocks generate a positive output elasticity reflecting the pro-cyclicality of the top income decile in the data. They contract middle-class consumption, and lead to pro-cyclical responses in both income and wealth inequality. Since they drastically alter the distribution of assets and, thereby, the ability of middle class to post collaterals, the collateral channel worsens their effects. Put

[4]In modeling debt, I follow the mainstream approach of Iacoviello (2005). Debt is amortized within a quarter which according to Gelain et al. (2018b, 2018a) renders debt sensitive to aggregate shocks. The estimation may partially resolve the tension between the adopted modeling and the low-frequency observed debt dynamics in the likelihood construction by boosting the influence of distributional shocks on debt.

differently, access to credit is harder when inequality rises. Both wealth and credit shocks yield positive elasticities for output, the top income decile, debt, (via the debt payments) and middle-class assets. Although credit shocks lead to a positive correlation between wealth inequality and debt, wealth shocks lead to a negative correlation. The reason is that asset prices do not rise after credit shocks as much as they do after wealth shocks, and flatten the wealth distribution since the portfolio of the top always has two assets.

Turning to the inequality and monetary policy nexus, I find that in the presence of either high wealth or high income inequality, monetary policy is less effective in affecting the economy. Nevertheless, the systematic part of monetary policy transmission is not broken in the presence of inequality. An aggressive stance towards inflation stabilizes the economy even when the economy wide fluctuations emanate from distributional shocks because inflation and aggregate demand are pro-cyclical in response to these shocks. Nonetheless, reacting to either income, or wealth, or consumption inequality directly and not only through general equilibrium effects, brings small gains in the variability of the output gap that is linked to the variability of aggregate demand, in exchange of inflation volatility. In addition, the effect of erratic and unpredictable policy innovations on the path of income and wealth inequality, has been negligible throughout the sample. Expansionary innovations, in fact, raise income inequality because profits are unequally distributed, decrease wealth inequality because low lending costs help the middle class acquire assets, and decrease consumption inequality because the middle class has a higher MPC in response to such innovations.

The literature review follows below. Section 2 outlines the structural model. Section 3 elaborates on the estimation strategy. Section 4 presents the results. Section 5 concludes.

1.2 Related Literature.

In tackling inequality and debt, the present paper relates to Iacoviello (2008) and Kumhof et al. (2015). These papers feature exogenous production and, thereby, preclude a recurrent impact of changes in inequality on output. In contrast, in the present work, endogenous production enables the emergence of an aggregate demand channel. Kumhof et al. (2015) consider two agent groups too, namely the top and the rest, where the latter involves borrowers with no assets. The present work, however, considers middle-class households who hold both liabilities and assets, and allows for a broad view on household balance sheets.

This perspective on the portfolio of agents that allows to match income and wealth

inequality for both agent groups distinguishes this work from Cairó and Sim (2018) who endogenize production in the framework of Kumhof et al. (2015), and assume that workers only receive wages whereas shareholders own capital and the firms but do not supply labor. In addition, the middle-class assets along with the extraction of distributional shocks from the data within a structural setup contributes to the strand of the two-agent NK models featuring a fraction of agents excluded from financial markets, and abstracting from including information found in inequality series [Debortoli and Galí, 2018; Walsh, 2017; Eggertsson and Krugman, 2012; Lee, 2012; Curdia and Woodford, 2010; Iacoviello, 2005].

As argued by Christiano et al. (2018), a developing research strand involves Heterogeneous Agent New Keynesian (HANK) models along the lines of Kaplan et al. (2018). Studies in that strand feature idiosyncratic risk and investigate how inequality influences demand [Werning, 2015], as well as the various channels of monetary or fiscal policy transmission to inequality [Gornemann et al., 2014; Doepke et al., 2015; Sterk and Tenreyro, 2015; Kaplan and Violante, 2014; Auclert, 2015]. Similarly to those papers, I consider a small set of assets and a fraction of financially constrained agents. Contrary to them, I consider fixed rather than endogenously formed agent groups. Although this choice does not allow the study of precautionary savings, it helps with model tractability and is consistent with the observed changes in inequality and the disconnect between the top and the rest of the distribution.

Another distinguishing feature of the present work is that I include seven aggregate and three distributional shocks in total that exceed the number of shocks often considered in HANK models (two aggregate and one idiosyncratic)[5]. Moreover, contrary to HANK models involving either perfect competition or search frictions in labor markets, I consider staggered wage setting which is used in the workhorse monetary policy models. Furthermore, HANK models involve partial information approaches, namely moment matching and data treatment outside of the model. The present paper, though, adopts a full-information approach that allows to examine the joint historical evolution of U.S. inequality and macroeconomic series.

Delving into the interaction of monetary policy and inequality from a structural perspective complements a branch of the literature involving reduced-form models and examining whether various inequality series (i) are affected by policy and inflation [Lenza and Slacalek, 2018; Mumtaz and Theophilopoulou, 2017; Guerello, 2017; Coibion et al., 2016; Adam and Zhu, 2015; Casiraghi et al., 2016; Furceri et al., 2016; McKinsey Global Institute,

[5]This is true for Iacoviello (2008), Kumhof et al. (2015), and Cairó and Sim (2018) as well.

2013; Doepke and Schneider, 2006; Romer and Romer, 1998]; (ii) are associated with credit conditions [Coibion et al., 2014; Paul, 2017]; (iii) are cyclical [De Giorgi and Gambetti, 2017]. Worth pointing out is that extracting a latent factor from multiple debt measures strengthens identification and builds on the use of multiple observables in Boivin and Giannoni (2006) and multiple wages in Galí et al. (2012a, 2012b) and Justiniano et al. (2013).

The heterogeneity in preferences for wealth is aligned with that considered in Kumhof et al. (2015), Carroll et al. (2015), Tokuoka (2012), and Francis (2009). More generally, this formulation shares similarities with Sidrauski (1967) who introduces utility from money balances – an approach followed by Michaillat and Saez (2015) in order to study economic slack and by Zou (1998) who argues that it reflects Weber's spirit of capitalism[6]; with Kurz (1968) who examines non-linearities stemming from utility yielding capital in a growth model; and with Iacoviello (2005) who introduces utility from housing services.

2 Full-Fledged Model

The model builds on Christiano et al. (2005) and Smets and Wouters (2007), and shares similarities with Iacoviello and Neri (2010) and Justiniano et al. (2015). τ indexes the top family and μ indexes the middle-class family, populated by measures of n^{τ} and $n^{\mu} = 1 - n^{\tau}$ identical households, respectively. The two families differ in terms of their wealth preferences and discounting. Perfect insurance holds within families. Households participate in intra-family borrowing, and trade firms' ownership shares. Each household consists of a continuum of agents with different labor types. The differentiated labor is uniformly distributed, supplied along the intensive margin, priced in a staggered fashion by monopolistically competitive unions, aggregated and sold to monopolistically competitive intermediate good producers who rent capital from capital producers and choose prices in a staggered fashion.

2.0.1 Households. Household i, with $i \in \{\mu, \tau\}$, chooses a sequence of consumption, loans, and shares, $\{C_t^i, B_t^i, \Omega_t^i\}$, to maximize the present discounted value of future utility:

$$E_t \sum_{s=0}^{+\infty} (\beta^i)^s \left[ln\left(C_{t+s}^i - \eta C_{t+s-1}^i\right) - \theta \int_0^1 \frac{[L_{t+s}^i(j)]^{1+\chi}}{1+\chi} dj + \phi^i \upsilon_{t+s}^{\omega} ln\left(\Omega_{t+s}^i\right) \right] \tag{2.1}$$

Preferences are log-separable, and depend on consumption, on labor disutility across j labor types, and on the ownership of firms' shares (Ω_t^i) that confers social status. η

[6]Luo and Zou (2009), Zou (2015), and Bakshi and Chen. (1996) tread along that line.

mirrors external habit formation, χ is the inverse Frisch elasticity, and ϕ^i captures the strength of preferences over wealth (shares) which differs across families: $\phi^\mu \neq \phi^\tau$[7]. $\beta^\mu < \beta^\tau$ renders middle-class families more impatient than the top in a way analogous to that in Iacoviello (2005). υ_t^ω stands for the wealth shock affecting wealth preferences. The combination of that shock and heterogeneous ϕ^i creates wealth dispersion, and potentially captures unequal access to investment opportunities. $ln(\upsilon_t^\omega)$ follows an AR(1) process with parameters $\{\rho_\omega, \sigma_\omega\}$. The budget constraint for a middle-class household is given by

$$C_t^i + Q_t \left[\Omega_t^i - \left(1 - S_\omega(\Omega_t^i/\Omega_{t-1}^i)\right)\Omega_{t-1}^i\right] + T_t^i/P_t = Y_t^i \tag{2.2}$$

$$Y_t^i \equiv \int W_t^{i,h,r}(j) L_t^i(j) dj + F_t^\mu + [B_t^i/(e^{\upsilon_t^b} R_t P_t) - B_{t-1}^i/(P_{t-1}\Pi_t)] + \Omega_t^i V_t \tag{2.3}$$

The budget constraint of a top household is symmetric to the above. Y_t^i is the pre-tax income. υ_t^b is a risk premium shock following an AR(1) process with parameters $\{\rho_b, \sigma_b\}$. $S_\omega(\cdot)$, with $S_\omega(1) = S_\omega(1)' = 0$ and $S_\omega''(1) \equiv S_\omega > 0$, stands for portfolio adjustment costs. Q_t is the shares' price in terms of the final good. Π_t stands for price inflation. V_t denotes economy wide profits distributed to households according to Ω_t^i. T_t^i stands for nominal taxes. $W_t^{i,h,r}(j)$ is the real wage of labor type j in household i that would prevail in the absence of rigidities, and is equal to the marginal labor disutility expressed in consumption terms:

$$W_t^{i,h,r}(j) = \theta[L_t^i(j)]^\chi/\Xi_t^i = \theta L_t(j)^\chi/\Xi_t^i \tag{2.4}$$

where Ξ_t^i is the multiplier associated with the budget constraint. The second equality in (2.4) holds in equilibrium, and uses the fact that type-j labor is determined by the labor union's problem independently of the household identity.

Contrary to Smets and Wouters (2007) who consider an equal distribution of labor income ($W_t^r L_t$), but along the lines of Walsh (2017) and Lee (2012) who consider partial, albeit deterministic, income insurance, aggregate income is distributed to households via an imperfect wage insurance scheme. Household members supply labor, pool together wages across unions, but when the wage bill is allocated, they only receive a fraction of what would be allocated under perfect insurance. Thus, transfers F_t^i from the unions read as

$$F_t^\mu = s_t W_t^r L_t/n^\mu - \int W_t^{i,h,r}(j) L_t^i(j) dj \tag{2.5}$$

for the middle class and, symmetrically, as $F_t^\tau = (1-s_t) W_t^r L_t/n^\tau - \int W_t^{i,h,r}(j) L_t^i(j) dj$ for the

[7] Identifying heterogeneous η, θ, χ would require additional consumption and labor data. The homogeneity assumption, albeit stylized, ensures that steady state aggregates are the same as those in the RA model.

top. s_t stands for the time-varying wage share of the middle class; it is a *wage polarization* shock generating wage dispersion between the top and the middle class. For $s_t = n^{\mu}$, the scheme boils down to an equitable wage distribution. $\widehat{s}_t \equiv ln(s_t/\bar{s})$ follows an AR(1) process with associated parameters $\{\rho_s, \sigma_s\}$ and steady state $\bar{s}$.

Along the lines of Kiyotaki and Moore (1997) and Iacoviello (2005), middle-class borrowers can default, in which case lenders receive a fraction m_t, with steady state m, of the posted collateral. $ln(m_t)$ follows an AR(1) process with parameters $\{\rho_m, \sigma_m\}$. The firms' shares serve as collateral and have no impact on the production function as in Gelain et al. (2018b, 2018a). Thus, borrowing $B_t^i/(e^{\upsilon_t^b} R_t P_t)$ is up to a period-t limit determined by:

$$B_t^i/[e^{\upsilon_t^b} R_t P_t] \leq m_t E_t \left(Q_{t+1} \Omega_t^i \Pi_{t+1} / [e^{\upsilon_t^b} R_t] \right) \tag{2.6}$$

It is worth pointing out that the polarization shock in (2.5) enters in the budget constraint that becomes relevant for equilibrium dynamics because of the financial market imperfection. In contrast, under perfect insurance, shocks in polarization and the debt limit would play no role, while wealth shocks would lose interpretation. Thus, hurdles in perfect insurance play a catalytic role for distributional shocks to have an impact.

2.0.2 Capital. As in Chen et al. (2012), a representative capital producer invests I_t in raw capital, $\bar{K}_t$, subject to adjustment costs $S(I_t/I_{t-1})$. It chooses the utilization rate u_t that determines the effective capital, $K_t = u_t \bar{K}_{t-1}$, subject to utilization costs that are proportional to the last period's raw capital $(a(u_t)\bar{K}_{t-1})$. The rental rate of capital is denoted by R_t^k. The firm maximizes the present discounted value of future dividends,

$$E_t \sum_{s=0}^{\infty} [(\Xi_{t+s}^{avg} P_t)/(\Xi_t^{avg} P_{t+s})] \left[R_{t+s}^k K_{t+s} - P_{t+s} a(u_{t+s}) \bar{K}_{t+s-1} - P_{t+s} I_{t+s} - Z_{t+s} P_{t+s} \Phi_k \right] \tag{2.7}$$

subject to the law of capital accumulation: $\bar{K}_t = (1-\delta)\bar{K}_{t-1} + \upsilon_t^i \left(1 - S(I_t/I_{t-1})\right) I_t$. The steady state full utilization is associated with zero cost: $a(1) = 0$. As in Smets and Wouters (2007), the properties of the cost functions are defined so that $a(1)''/a(1)' = \psi/(1-\psi)$, $S(e^{\gamma}) = S(e^{\gamma})' = 0$, and $S(e^{\gamma})'' \equiv S > 0$. γ is the growth rate of aggregates along the balanced growth path, and $Z_t = e^{\gamma} Z_{t-1}$ reflects trend growth. δ is the depreciation rate. Fixed costs (Φ_k) ensure zero steady state dividends. υ_t^i is an investment disturbance; $ln(\upsilon_t^i)$ follows an AR(1) process with associated parameters $\{\rho_i, \sigma_i\}$. $\Xi_{t+1}^{avg}/\Xi_t^{avg}$ stands for the average discounting between $t+s$ and t, defined as: $(\beta^{\tau})^s [n^{\tau} \Xi_{t+s}^{\tau} + n^{\mu} \Xi_{t+s}^{\mu}]/[n^{\tau} \Xi_t^{\tau} + n^{\mu} \Xi_t^{\mu}]$[8].

[8] This definition simplifies a discount factor that would take into account the time-varying ownership of

2.0.3 Final Good. A perfectly competitive final good producer purchases and aggregates intermediate goods $Y_t(i)$, $\forall i \in [0,1]$, to output Y_t according to technology $Y_t = [\int_0^1 Y_t(i)^{(\lambda_{p,t}-1)/\lambda_{p,t}} di]^{\lambda_{p,t}/(\lambda_{p,t}-1)}$. $\lambda_{p,t}$ is the time varying elasticity of substitution across product varieties, with the gross markup, $\lambda_{p,t}/(\lambda_{p,t}-1)$, following an AR(1) process with parameters $\{\rho_p, \sigma_p\}$. The associated demand for good i and the aggregate price index are

$$Y_t(i) = [P_t(i)/P_t]^{-\lambda_{p,t}} Y_t \qquad \text{and} \qquad P_t = [\int P_t(i)^{1-\lambda_{p,t}} di]^{1/(1-\lambda_{p,t})} \tag{2.8}$$

2.0.4 Intermediate Good. Monopolistically competitive intermediate good producers, indexed by "i" and situated in the unit interval, hire labor $L_t(i)$ from a labor aggregator defined below, and capital $K_t(i)$ from the capital producing sector while taking as given factor prices (W_t, R_t^k), in order to produce output $Y_t(i)$ according to the production function:

$$Y_t(i) = e^{\widehat{z}_t} K_t(i)^{\alpha} \left(Z_t L_t(i)\right)^{1-\alpha} - Z_t \Phi_y \tag{2.9}$$

$\widehat{z}_t$ is the technology shock following an AR(1) process with associated parameters $\{\rho_z, \sigma_z\}$. Fixed production costs, Φ_y, guarantee zero steady state profits. Cost minimization yields the optimal capital-labor ratio, $K_t(i)/L_t(i) = [\alpha/(1-\alpha)](W_t/R_t^k)$, and marginal cost,

$$MC_t = (\alpha)^{-\alpha}(1-\alpha)^{-(1-\alpha)}(W_t)^{(1-\alpha)}(R_t^k)^{\alpha} Z_t^{-(1-\alpha)} e^{-\widehat{z}_t} \tag{2.10}$$

Each firm chooses price $P_t^{\circ}(i)$ with probability ζ_p. In periods in which the price cannot be optimally chosen, it is updated according to a convex combination of lagged and steady-state (gross) inflation based on the indexation parameter ι_p. Thus, the period-$(t+s)$ price of a firm that last chose its price in period t is given by $P_{t+s|t}(i) = P_t^{\circ}(i) X_{t,s}^p$, where $X_{t,s}^p \equiv \prod_{l=1}^{s} \Pi_{t+l-1}^{\iota_p} \Pi^{1-\iota_p}$ for $s > 0$ and $= 1$ for $s = 0$. The firm maximizes the present discounted value of current and expected future profits subject to output demand (2.8),

$$E_t \sum_{s=0}^{+\infty} (\zeta_p)^s \left[(\Xi_{t+s}^{avg} P_t)/(\Xi_t^{avg} P_{t+s})\right] \left[P_{t+s|t}(i) - MC_{t+s}\right] Y_{t+s|t}(i) \tag{2.11}$$

2.0.5 Labor Demand. Individuals of the same labor type j form a union that operates in a monopolistically competitive environment and sets wages in a staggered fashion. The unions sell differentiated labor to a labor agency that aggregates it according to technology $L_t = [\int L_t(j)^{(\lambda_{w,t}-1)/\lambda_{w,t}} dj]^{\lambda_{w,t}/(\lambda_{w,t}-1)}$. $\lambda_{w,t}$ is the time varying elasticity of substitution across labor varieties, with the gross markup, $\lambda_{w,t}/(\lambda_{w,t}-1)$, following an AR(1) process

firms and severely complicate the equations governing capital and investment and their associated steady state expressions – the chosen definition keeps them isomorphic to their representative agent analogues.

with parameters $\{\rho_w, \sigma_w\}$. The associated demand for type j and the aggregate wage are

$$L_t(j) = [W_t(j)/W_t]^{-\lambda_{w,t}} L_t \quad \text{and} \quad W_t = [\int W_t(j)^{1-\lambda_{w,t}} dj]^{1/(1-\lambda_{w,t})} \tag{2.12}$$

The type-j labor union, in turn, takes into account labor demand (2.12) and chooses wage $W_t^\circ(j)$ in a staggered way à la Calvo-Yun and Erceg et al. (2000), in order to maximize the present discounted value of expected future wages net of the economy wide average type-j labor disutility expressed in terms of the final good. Given equation (2.4) and the uniform distribution of labor types within each household, the latter is given by:

$$W_t^h(j) = n^\mu W_t^{\mu,h,r}(j) + n^\tau W_t^{\tau,h,r}(j) = \theta L_t(j)^\chi [n^\mu/\Xi_t^\mu + n^\tau/\Xi_t^\tau] \tag{2.13}$$

When wages are not reset, they are updated according to lagged and steady-state price inflation based on the indexation parameter ι_w: $W_{t+s|t}(j) = W_t^\circ(j) X_{t,s}^w$, where $X_{t,s}^w = \prod_{l=1}^s (e^\gamma \Pi_{t+l-1})^{\iota_w} (e^\gamma \Pi)^{1-\iota_w}$ for $s > 0$ and $= 1$ for $s = 0$. The objective function of a union is:

$$E_t \sum_{s=0}^{+\infty} (\zeta_w)^s \left[(\Xi_{t+s}^{avg} P_t)/(\Xi_t^{avg} P_{t+s})\right] \left[W_{t+s|t}(j) - W_{t+s}^h(j) P_{t+s}\right] L_{t+s}(j) \tag{2.14}$$

2.0.6 Policy. Monetary policy follows a Taylor rule with interest rate smoothing:

$$R_t/R = (R_{t-1}/R)^{\rho_r} [(\Pi_t/\Pi)^{\psi_\pi} (Y_t/Y_t^f)^{\psi_y} [(Y_t/Y_{t-1})/(Y_t^f/Y_{t-1}^f)]^{\psi_{\Delta y}}]^{1-\rho_r} e^{\upsilon_t^{mp}} \tag{2.15}$$

$\upsilon_t^{mp} \sim N(0, \sigma_{mp}^2)$ is a white noise disturbance. Y_t^f denotes output under flexible prices and wages and perfect insurance. Fiscal policy follows a balanced budget: $P_t G_t = T_t$, where $ln(G_t/Z_t G) = \rho_g ln(G_{t-1}/Z_{t-1} G) + \rho_{gz} \epsilon_t^z + \epsilon_t^g$, with $\epsilon_t^g \sim N(0, \sigma_g^2)$. To avoid additional complications, the tax burden is equally distributed across households: $T_t^i = T_t^\mu = T_t^\tau = T_t$[9].

2.0.7 Aggregation. Consumption is the weighted sum of family-specific consumption profiles: $C_t = n^\tau C_t^\tau + n^\mu C_t^\mu$. After using (2.9) and the capital-labor ratio, the aggregate production function reads as: $Y_t D_t = e^{\widehat{z}_t} K_t^\alpha (Z_t L_t)^{1-\alpha} - Z_t \Phi_y$, where $D_t = \int (P_t(i)/P_t)^{-\lambda_{p,t}} di$ is a measure of price dispersion. Market clearing dictates $n^\tau B_t^\tau = n^\mu B_t^\mu$ in the debt market, and $n^\tau \Omega_t^\tau + n^\mu \Omega_t^\mu = \Omega_t \equiv 1$ in the market for shares – the sum of shares is normalized to unity. Profits in the intermediate good sector are: $\Pi_t^{int} \equiv Y_t - W_t^r L_t - R_t^{k,r} K_t$. The dividends from capital production are given by $Div_t \equiv R_t^{k,r} K_t - a(u_t) \bar{K}_{t-1} - I_t - Z_t \Phi_k$. Thus, economy wide profits are: $V_t = \Pi_t^{int} + Div_t$. Combining the household (2.3) and government budget

[9] In the canonical model, the way in which government spending is financed, be it taxation or one-period bonds, is irrelevant in the log-linearized equilibrium. With heterogeneous households and financial frictions, this no longer is the case. Justiniano et al. (2015) consider some degree of heterogeneous taxation.

constraints, financial market clearing, and profits, yields the resource constraint

$$C_t + I_t + G_t + AC_t + \Phi_k Z_t = Y_t \tag{2.16}$$

featuring adjustment costs: $AC_t = a(u_t)\bar{K}_{t-1} + Q_t[n^{\mu}\Omega^{\mu}_{t-1}S_{\omega}(\Omega^{\mu}_t/\Omega^{\mu}_{t-1}) + n^{\tau}\Omega^{\tau}_{t-1}S_{\omega}(\Omega^{\tau}_t/\Omega^{\tau}_{t-1})]$.

2.0.8 Equilibrium. The stationary model, the steady state, and the log-linearized equilibrium are reported in Appendix A. The steady state of aggregate variables is the same as that of the representative agent economy. The interest rate is given by $R = \Pi e^{\gamma}/\beta^{\tau}$. Moreover, the steady state features heterogeneous consumption, debt, and shares, as well as a binding constraint (2.6) since $\beta^{\tau} > \beta^{\mu}$. I examine equilibria in which the constraint binds.

The model features 10 structural shocks. The 7 aggregate shocks are those considered in the representative agent model [Smets and Wouters, 2007]: risk premium, technology, wage and price markup, government spending, investment, and monetary policy shocks. To the above set, wage polarization, wealth, and credit supply shocks are added.

3 Estimation

I conduct mixed-frequency estimation over quarterly and annual data series starting in 1954Q3 and stoping in 2009Q4 to avoid getting further into the zero lower bound period. I discuss below the data, the measurement equations, the state space approach, and the priors.

3.1 Data And Observation Equations.

$t = \{1, 2, \ldots, n_q\} \mapsto \{1964Q1, \ldots, 2007Q4\}$ and $T = \{1, 2, \ldots, n_T\} \mapsto \{1964, \ldots, 2007\}$ denote the quarterly and annual time spans of the sample, respectively. Ten (o_q) quarterly series are used. Per capita real growth of output, consumption, and investment, along with labor hours, the Federal Funds Rate, the GDP deflator, and the growth rate of the compensation index are obtained from the sources described in Smets and Wouters (2007)[10].

Two quarterly measures of real per capita household debt, loaded with measurement error, aim to discipline the evolution of debt. Home mortgages (HM_t) and consumer credit debt (CC_t) are obtained from Fred. The loading in the second series is Ψ_b. The observation equations are reported below, where $dlnX_t \equiv 100(lnX_t - lnX_{t-1})$.

[10]The observation equations for that block of observables are similar to those in Smets and Wouters (2007), with the inclusion of measurement error, $\epsilon^j_t \sim N(0, \mu^2_j)$, for each generic j series being the difference.

$$\begin{bmatrix} dlnHM_t \\ dlnCC_t \end{bmatrix} = \begin{bmatrix} 100\gamma_{hm} \\ 100\gamma_{cc} \end{bmatrix} + \begin{bmatrix} 1 \\ \Psi_b \end{bmatrix} \left[\widehat{b}^{\mu}_{t} - \widehat{b}^{\mu}_{t-1} \right] + \begin{bmatrix} \epsilon^{hm}_t \\ \epsilon^{cc}_t \end{bmatrix}, \begin{bmatrix} \epsilon^{hm}_t \\ \epsilon^{cc}_t \end{bmatrix} \sim N \left(\begin{bmatrix} 0 \\ 0 \end{bmatrix}, \begin{bmatrix} \mu^2_{hm} & \\ & \mu^2_{cc} \end{bmatrix} \right) \tag{3.1}$$

The debt trends capture the fact that the sample growth rates of home mortgage and consumer credit debt (1% and 0.7%, respectively) are well above output growth (0.4%)[11].

Moreover, I introduce observables for the annual *top* 10% *income* and *wealth shares* obtained from the World Inequality Database and the work of Piketty and Saez (2003) and Saez and Zucman (2016). Table (1) gives inklings on correlations found in U.S. data. Income inequality is strongly pro-cyclical, whereas wealth inequality exhibits a small degree of counter-cyclicality. Both degrees of cyclicality are stronger in the post-84 period than in the pre-84 period. Furthermore, income inequality is positively correlated with the debt measures. Although wealth inequality is not correlated with debt on average, it is positively correlated with it in the years before 1984 but negatively correlated with it after 1984.

Table 1: Descriptive Statistics, Correlations

		TIS	TWS	Y	π	HM	CC
1954-2009	TIS	1.64	0.30	0.49	-0.16	0.34	0.32
	TWS	0.30	1.63	-0.07	-0.33	0.02	-0.07
1954-1983	TIS	1.50	0.32	0.43	-0.19	0.37	0.43
	TWS	0.32	1.90	-0.01	-0.27	0.21	0.08
1984-2009	TIS	1.69	0.15	0.68	0.37	0.23	0.19
	TWS	0.15	1.14	-0.22	-0.21	-0.56	-0.47

Notes: Growth rates, annual frequency. *Mnemonics:* TIS: Top 10% Income Share, TWS: Top 10% Wealth Share, Y: Real GDP per capita, π: inflation, HM: Real Home Mortgage Debt per capita, CC: Real Consumer Credit Debt per capita. *Data sources:* FRED Economic Data, World Inequality Database.

The model-implied pre-tax top income share that is consistent with the observed series (TIS_T) encompasses wages, profits (entrepreneurial income), and interest (capital income) over aggregate pre-tax income, and is pinned down by:

$$\begin{aligned} TIS_T &= \sum_{j=0}^{3} \left(n^{\tau} Y^{\tau}_{t-j} \right) / \sum_{j=0}^{3} \left(n^{\tau} Y^{\tau}_{t-j} + n^{\mu} Y^{\mu}_{t-j} \right) \\ &\approx \overline{tis} + \sum_{j=0}^{3} (\nu_j \cdot \widehat{tis}_{t-j}) + (\mathbf{1} \cdot \kappa_{tis} \cdot t) + \epsilon^{tis}_T \end{aligned} \tag{3.2}$$

[11] Earlier versions of the paper imposed the balanced growth path trend on the debt series that led to persistent and volatile measurement errors in (3.1).

$\widehat{tis}_t = \widehat{tis}_t^{ea} + \widehat{tis}_t^{b} + \widehat{tis}_t^{pr}$ is the cyclical part of the top income share. $\{\widehat{tis}_t^{ea}, \widehat{tis}_t^{b}, \widehat{tis}_t^{pr}\}$ drive its swings, stand for earnings, bond income, and profits, respectively, and are given in Table (2). The approximation (3.2) is obtained in equilibrium, after converting the ratio in terms of stationary variables and taking a Taylor expansion (Appx. D). The steady state top income share is given by $\overline{tis} = (1-s) + \overline{tis}_b$. $1-s$ is the top 10% wage share, and $\overline{tis}_b \equiv n^\tau b^\tau (R - e^\gamma \Pi)/(e^\gamma \Pi w^r L R)$ stands for bond income. Steady state profits are zero. The weight is given by $\nu_j \equiv e^{(3-j)\gamma}/[e^{3\gamma} + e^{2\gamma} + e^{1\gamma} + 1]$. Measurement error, $\epsilon_T^{tis} \sim N(0, \mu_{tis}^2)$, is included. $\kappa_{tis} \cdot t$ aims at capturing the non-stationary evolution of TIS_T after the mid-80s (the indicator function, $\mathbf{1}$, is non-zero during that period).

Table 2: Cyclical Swings, Top Income Share

earnings channel	$\widehat{tis}_t^{ea} = -\bar{s} \cdot \widehat{s}_t - (\widehat{w}_t^r + \widehat{L}_t)\ \overline{tis}_b$	(3.3)
bond income channel	$\widehat{tis}_t^{b} = (\widehat{b}_{t-1}^\tau - \widehat{\pi}_t)\ [n^\tau b^\tau/(e^\gamma \Pi w^r L)]$ $- (\widehat{b}_t^\tau - \widehat{r}_t - \widehat{v}_t^b)\ [n^\tau b^\tau/(w^r L R)]$	(3.4)
profits channel	$\widehat{tis}_t^{pr} = \widehat{\mathrm{v}}_t[(y/w^r L)\,(n^\tau \omega^\tau - \overline{tis})]$	(3.5)

According to (3.3–3.5), the top income share falls below its steady state if there is an increase in the wage share of the bottom ($\widehat{s}_t$), the average wage, employment, or inflation. In contrast, increases in the bottom borrowing and in profits ($\widehat{\mathrm{v}}_t$) boost capital income flowing to the top and, in turn, the top income share.

The model-implied top wealth share that is consistent with the observed series (TWS_T) is given by the sum of shares and assets over the value of all shares ($n^\tau \Omega_t^\tau Q_t + n^\mu \Omega_t^\mu Q_t = Q_t$) since family debt positions net out to zero:

$$\begin{aligned} TWS_T &= \sum_{j=0}^{3} n^\tau \left[Q_{t-j} \Omega_{t-j}^\tau + \frac{B_{t-j}^\tau / P_{t-j}}{e^{v_{t-j}^b} R_{t-j}} \right] / \sum_{j=0}^{3} Q_{t-j} \\ &\approx \overline{tws} + \sum_{j=0}^{3} (\nu_j \cdot \widehat{tws}_{t-j}^{tws}) + (\kappa_{tws} \cdot t) + \epsilon_T^{tws} \end{aligned} \tag{3.6}$$

$\widehat{tws}_t^{tws} = \widehat{tws}_t^{\omega} + \widehat{tws}_t^{b} + \widehat{tws}_t^{q}$ is the cyclical part of the top wealth share. $\{\widehat{tws}_t^{\omega}, \widehat{tws}_t^{b}, \widehat{tws}_t^{q}\}$ drive its fluctuations, stand for shares, bonds, and asset price gains/losses, respectively, and are given in Table (3). The approximation (3.6) is obtained after converting the ratio

in terms of stationary variables and taking a Taylor expansion. (Appx. D). The steady state top wealth share is given by $\overline{tws} = n^{\tau}\omega^{\tau} + \overline{tws}_b$. $n^{\tau}\omega^{\tau}$ is the top profit share, and $\overline{tws}_b \equiv n^{\tau}b^{\tau}/(Rq)$ is the top's outstanding assets to the value of shares in terms of the final good. Measurement error, $\epsilon_T^{tws} \sim N(0, \mu_{tws}^2)$, is included. $\kappa_{tws} \cdot t$ aims at capturing the fact that TWS_T exhibits a small positive sample growth rate.

Table 3: Cyclical Swings, Top Wealth Share

real assets (shares) channel	$\widehat{tws}_t^{\omega} = \widehat{\omega}_t^{\tau}\ (n^{\tau}\omega^{\tau})$	(3.7)
bonds channel	$\widehat{tws}_t^{b} = (\widehat{b}_t^{\tau} - \widehat{r}_t - \widehat{v}_t^{b})\ \overline{tws}_b$	(3.8)
asset price gains/losses channel	$\widehat{tws}_t^{q} = -\widehat{q}_t\ \overline{tws}_b$	(3.9)

According to (3.7–3.9), the top wealth share overshoots its steady state when the profit shares or the intra-household assets of the top increase. It undershoots it, however, when the interest rate, or the risk premium shock, or the asset price ($\widehat{q}_t$) increase since all those changes decrease the contribution of outstanding bonds to the top wealth share.

Few assumptions underlie equations (3.1, 3.2, 3.6). (3.1) implies that the observed debt pertains to the bottom 90% of the income distribution[12]. This mapping is supported by data from the Survey of Consumer Finance [Ravenna and Vincent, 2014], while including multiple debt indicators with measurement error helps extract their part that is relevant for the model. In addition, measurement error in both top shares (3.2 and 3.6) mitigates potential inconsistencies from assuming that the top of the income and wealth distributions coincide. Consistently with the model's foundations, there is no feedback from inequality to the growth rate along the balanced growth path that is determined by technology.

3.2 State Space And Likelihood.

I apply the state space approach of Chan and Jeliazkov (2009), along the lines of Charalampidis (2018), that leads to computational gains by exploiting the sparse and block-banded nature of precision matrices. I stack the measurement equations for aggregates series and (3.1) vertically to obtain:

$$\Upsilon_t = \Gamma_q + H_0\zeta_t + H_1\zeta_{t-1} + M_t \quad , \quad M_t \sim N(0, \Sigma_q) \tag{3.10}$$

[12] Kumhof et al. (2015) and Cairó and Sim (2018) map debt to the bottom 95%.

where Υ_t and Γ_q are $(o_q \times 1)$ vectors of quarterly observed series and intercepts, respectively. M_t collects the associated measurement errors. Σ_q is the diagonal covariance matrix. $\{H_0, H_1\}$ denote the $(o_q \times n_\zeta)$ selection matrices and include the slope coefficients. ζ_t is the period-t $(n_\zeta \times 1)$ state vector. Stacking (3.2) and (3.6) vertically yields:

$$\Upsilon_T = \Gamma_a + H_{30}\zeta_t + H_{31}\zeta_{t-1} + H_{32}\zeta_{t-2} + H_{33}\zeta_{t-3} + H_{34}\zeta_{t-4} + M_T \ , \ M_T \sim N(0, \Sigma_a) \quad (3.11)$$

where $\Upsilon_T \equiv [TIS_T, TWS_T]'$ and Γ_a are $(o_a \times 1)$ vectors $(o_a = 2)$ of annually observed series and intercepts, respectively. $M_T \equiv [\epsilon_T^{tis}, \epsilon_T^{tws}]'$ collects the measurement errors; Σ_a is the associated diagonal covariance matrix. $\{H_{30}, H_{31}, H_{32}, H_{33}, H_{34}\}$ denote the $(o_a \times n_\zeta)$ selection matrices that include the slope coefficients of (3.2) and (3.6).

Eq.(3.10) appears for four consecutive quarters until the end of a year when the inequality series are observed and linked to the model via (3.11). Stacking over time yields:

$$\begin{bmatrix} \Upsilon_{t=1} \\ \Upsilon_{t=2} \\ \Upsilon_{t=3} \\ \Upsilon_{t=4} \\ \Upsilon_{T=1} \\ \Upsilon_{t=5} \\ \Upsilon_{t=6} \\ \Upsilon_{t=7} \\ \Upsilon_{t=8} \\ \Upsilon_{T=2} \\ \vdots \end{bmatrix} = \begin{bmatrix} \Gamma_q \\ \Gamma_q \\ \Gamma_q \\ \Gamma_q \\ \Gamma_a \\ \Gamma_q \\ \Gamma_q \\ \Gamma_q \\ \Gamma_q \\ \Gamma_a \\ \vdots \end{bmatrix} + \begin{bmatrix} H_0 & \dots & \dots & \dots & \dots & \dots & \dots & \dots & \dots \\ H_1 & H_0 & \dots & \dots & \dots & \dots & \dots & \dots & \dots \\ \dots & H_1 & H_0 & \dots & \dots & \dots & \dots & \dots & \dots \\ \dots & \dots & H_1 & H_0 & \dots & \dots & \dots & \dots & \dots \\ H_{33} & H_{32} & H_{31} & H_{30} & \dots & \dots & \dots & \dots & \dots \\ \dots & \dots & \dots & H_1 & H_0 & \dots & \dots & \dots & \dots \\ \dots & \dots & \dots & \dots & H_1 & H_0 & \dots & \dots & \dots \\ \dots & \dots & \dots & \dots & \dots & H_1 & H_0 & \dots & \dots \\ \dots & \dots & \dots & \dots & \dots & \dots & H_1 & H_0 & \dots \\ \dots & \dots & \dots & H_{34} & H_{33} & H_{32} & H_{31} & H_{30} & \dots \\ \dots & \ddots & \ddots & \ddots & \ddots & \ddots & \ddots & \ddots & \ddots \end{bmatrix} \begin{bmatrix} \zeta_{t=1} \\ \zeta_{t=2} \\ \zeta_{t=3} \\ \zeta_{t=4} \\ \zeta_{t=5} \\ \zeta_{t=6} \\ \zeta_{t=7} \\ \zeta_{t=8} \\ \vdots \end{bmatrix} + \begin{bmatrix} M_{t=1} \\ M_{t=2} \\ M_{t=3} \\ M_{t=4} \\ M_{T=1} \\ M_{t=5} \\ M_{t=6} \\ M_{t=7} \\ M_{t=8} \\ M_{T=2} \\ \vdots \end{bmatrix} \quad (3.12)$$

The matrix representation of (3.12) is given by

$$\Upsilon = \Gamma + H\zeta + M \quad , \quad M \sim N\left(0_o, \Sigma_M \equiv I_{n_T} \otimes diag\left(diag[I_4 \otimes \Sigma_q]; diag[\Sigma_a]\right)\right) \quad (3.13)$$

where $o = [(4o_q + o_a)n_T] \times 1$. $\Upsilon \equiv [\Upsilon'_{t=1}, \Upsilon'_{t=2}, \Upsilon'_{t=3}, \Upsilon'_{t=4}, \Upsilon'_{T=1}, \dots]'$ is the observation vector. $\Gamma \equiv [\Gamma'_q, \Gamma'_q, \Gamma'_q, \Gamma'_q, \Gamma'_a, \dots]'$ is a vector of intercepts. $\zeta \equiv [\zeta'_1, \zeta'_2, \zeta'_3, \zeta'_4, \dots]'$ is the $(n_\zeta n_q) \times 1$ state vector. $M \equiv [M'_{t=1}, M'_{t=2}, M'_{t=3}, M'_{t=4}, M'_{T=1}, \dots]'$ collects the measurement errors. H is a sparse and block-banded matrix. According to (3.13), the likelihood of the data given the parameter vector Θ and the states ζ is $P(\Upsilon - \Gamma | \Theta, \zeta)$, where $(\Upsilon - \Gamma)|\Theta, \zeta \ \sim \ N(H\zeta, \Sigma_M)$.

The rational expectations solution of Sims (2002) to the system of log-linearized equilibrium conditions is given by

$$\zeta_t = \Phi_1(\Theta)\zeta_{t-1} + \Phi_2(\Theta)\epsilon_t \ , \quad \epsilon_t \sim N(0_{n_\epsilon}, I_{n_\epsilon}), \quad \forall t \geq 2 \quad (3.14)$$

$\{\Phi_1, \Phi_2\}$ are non-linear functions of the parameter vector Θ. ζ_1 is initialized with the steady state covariance D evaluated at the prior of Θ. Structural shocks are grouped in the $(n_\epsilon \times 1)$ vector ϵ_t, and are fewer than the observables ($n_\epsilon < o_q + o_a$). Defining the reduced-form errors, $\tilde{\epsilon}_t = \Phi_2 \epsilon_t$ for $t > 1$ and $\tilde{\epsilon}_1 = \epsilon_1$, and stacking (3.14) across time yields:

$$\begin{bmatrix} I_{n_\zeta} & \dots & \dots & \dots \\ -\Phi_1 & I_{n_\zeta} & \dots & \dots \\ \dots & \ddots & \ddots & \dots \\ \dots & \dots & -\Phi_1 & I_{n_\zeta} \end{bmatrix} \begin{bmatrix} \zeta_1 \\ \zeta_2 \\ \vdots \\ \zeta_T \end{bmatrix} = \begin{bmatrix} \tilde{\epsilon}_1 \\ \tilde{\epsilon}_2 \\ \vdots \\ \tilde{\epsilon}_T \end{bmatrix}, \quad \begin{bmatrix} \tilde{\epsilon}_1 \\ \tilde{\epsilon}_2 \\ \vdots \\ \tilde{\epsilon}_T \end{bmatrix} \sim N\left(0_{n_\zeta n_q}, \begin{bmatrix} D & \dots \\ \vdots & \Omega \otimes I_{T-1} \end{bmatrix}\right) \tag{3.15}$$

where $\Omega \equiv \Phi_2 \Phi_2'$. In matrix notation, the above equation reads as

$$Z\zeta = \tilde{\epsilon} \qquad , \qquad \tilde{\epsilon} \sim N(0_{n_\zeta n_q}, K_{\tilde{\epsilon}}^{-1}) \tag{3.16}$$

$\tilde{\epsilon} \equiv [\tilde{\epsilon}_1', \tilde{\epsilon}_2' \dots, \tilde{\epsilon}_T']'$ is the $(n_\zeta n_q) \times 1$ vector of errors, and $K_{\tilde{\epsilon}}$ is its sparse and block-banded precision. A change of variable transformation yields the prior state distribution, $P(\zeta|\Theta)$, with $\zeta|\Theta \sim N(\tilde{\zeta}, K^{-1})$ and $\tilde{\zeta} = 0_{n_\zeta n_q}$. The precision $K = Z' K_{\tilde{\epsilon}} Z$ is sparse and block-banded [Chan and Jeliazkov, 2009]. Bayes rule, $P(\zeta|\Upsilon, \Theta) \propto P(\Upsilon|\Theta, \zeta) P(\zeta|\Theta)$, yields the block-banded posterior precision: $P = K + H' \Sigma_M^{-1} H$. The posterior mean state vector $(\widehat{\zeta})$ is computed from (3.17) below based on the efficient simulation of Chan and Jeliazkov (2009).

$$P\widehat{\zeta} = K\tilde{\zeta} + H' \Sigma_M^{-1} (\Upsilon - \Gamma) \tag{3.17}$$

The integrated log-likelihood (given the parameters but marginally of the states) is evaluated at a high density point along the lines of Chib (1995) and, in particular, at the posterior mean of the hidden states: $\log P(\Upsilon|\Theta) = +logP(\Upsilon|\Theta, \widehat{\zeta}) + logP(\widehat{\zeta}|\Theta) - logP(\widehat{\zeta}|\Upsilon, \Theta)$.

3.3 Priors.

The Random Walk Metropolis-Hastings algorithm is used to simulate draws from the non-tractable posterior. The RA version is obtained for $n^\tau = 1$ and $\phi^\tau = 0$. The priors for the parameters appearing in both the present and the RA models are conventional[13] and reported in Table (4). Additionally, the fraction of top agents (n^τ) is 10% in accordance with the observed series. β^τ is set to 0.99, and β^μ is fixed at 0.985 as in Gelain et al. (2018b). The loan-to-value ratio (m) is fixed at 0.55 as in Iacoviello (2005). The top wage

[13] The std of all measurement errors is drawn from the Inverse Gamma centered at 0.15 (1 std) for the debt series and at 0.01 (0.001 std) for series matched to a single observable – these estimates are shown in the Appendix. δ and g are set to the values chosen in Smets and Wouters (2007).

share, $1-\bar{s}$, is calibrated at 0.32 – a value a tad below the sample average top income share (0.35) before the mid-80s since wages are less unequally distributed than overall income that includes capital income. The strength of preferences over wealth for the top (ϕ^{τ}) is sampled from Beta centered at 0.1 (0.03 standard deviation, "std") often considered in the literature. ϕ^{μ} is drawn from Beta too with a tad higher mean (0.15) that attenuates inequality in the distribution of shares which, when combined with the bonds-to-income ratio (influenced by m), yields a prior top wealth share of about 0.67 that is aligned with the data. The prior std for wage, wealth, and credit shocks is aligned with that of all other shocks; their prior persistence is a tad higher (0.7) though. Portfolio adjustment costs (S_{ω}) are small (0.1).

4 Findings

4.1 Parameter Estimates.

Table (4) displays the estimates in the RA and the present model. Zooming in on the parameters associated with the economy's aggregate dimension, habit (η) falls considerably from 0.77 in the RA model to 0.51. The inverse Frisch elasticity (χ) is a tad higher in the present model than in the RA model. Both price (ι_p) and wage (ι_w) indexation are a tad elevated compared to their RA estimates, whereas price (ζ_p) and wage (ζ_w) stickiness are a tad dampened down. Wage markup shocks become more volatile and persistent, and price markup shocks gain volatility but lose persistence. Risk premium shocks obtain a stronger low-frequency impact compared to the RA model (the persistence rises from 0.80 to 0.91, the volatility falls from 0.12 to 0.1). In the investment side, investment shocks obtain a more profound impact (ρ_i rises from 0.85 to 0.99, σ_i increases from 0.30 to 0.53), and along with the increased elasticity of utilization costs (ψ) compensate for the decrease in investment costs (S) from 6.74 in the RA model to 2.48. The inflation reaction coefficient (ψ_{π}) rises from 1.88 in the RA model to 2.17. Altogether, the small differences in the estimates across the two models suggest that parameters associated with the economy's aggregate dimension are mainly identified by aggregate data rather than by inequality and debt series.

As for the parameters associated with the distributional dimension of the model, the strength of preferences over wealth (ϕ^{μ}, ϕ^{τ}) is heterogeneous across households, 0.37 for the middle class and 0.15 for the top, and implies that the homogeneity often postulated in models might be restrictive[14]. Polarization, wealth, and credit shocks are all persistent.

[14]Justiniano et al. (2015) consider such heterogeneous parameters in their robustness checks.

Table 4: Posterior Distribution

	Prior	**Posterior** Mean [5-95%]			**Prior**	**Posterior**
		Rep. Agent	D. Imbalances			D. Imbalances
α	N(0.30, 0.05)	0.21 [0.19, 0.24]	0.25 [0.23, 0.27]	ϕ_μ	B(0.15, 0.03)	0.37 [0.32, 0.42]
η	B(0.70, 0.10)	0.77 [0.71, 0.82]	0.51 [0.46, 0.55]	ϕ_τ	B(0.10, 0.03)	0.15 [0.13, 0.17]
χ	N(2.00, 1.00)	4.14 [2.94, 5.39]	5.14 [4.01, 6.35]	ρ_s	B(0.70, 0.20)	0.99 [0.99, 0.99]
ψ	B(0.50, 0.10)	0.37 [0.24, 0.56]	0.59 [0.47, 0.72]	σ_s	IG(0.15, 1.00)	2.77 [2.16, 3.49]
S	N(4.00, 1.00)	6.74 [5.45, 8.01]	2.48 [1.92, 3.13]	ρ_ω	B(0.70, 0.20)	1.00 [0.99, 1.00]
ζ_w	B(0.60, 0.10)	0.90 [0.84, 0.95]	0.77 [0.73, 0.80]	σ_ω	IG(0.15, 1.00)	0.27 [0.21, 0.38]
ζ_p	B(0.60, 0.10)	0.91 [0.87, 0.94]	0.90 [0.87, 0.92]	ρ_m	B(0.70, 0.20)	0.99 [0.99, 1.00]
ι_p	B(0.50, 0.15)	0.07 [0.03, 0.12]	0.09 [0.04, 0.16]	σ_m	IG(0.15, 1.00)	1.55 [1.38, 1.72]
ι_w	B(0.50, 0.15)	0.75 [0.61, 0.87]	0.80 [0.67, 0.91]	Ψ_d	N(1.00, 0.50)	0.77 [0.63, 0.90]
ρ_r	B(0.75, 0.10)	0.90 [0.88, 0.92]	0.85 [0.83, 0.87]	μ_{hm}	IG(0.15, 1.00)	0.70 [0.49, 0.88]
ψ_π	N(1.70, 0.25)	1.88 [1.55, 2.22]	2.17 [1.89, 2.46]	μ_{cc}	IG(0.15, 1.00)	1.12 [0.99, 1.24]
ψ_y	N(0.12, 0.05)	0.20 [0.13, 0.26]	0.17 [0.12, 0.23]	γ_{hm}	N(1.00, 0.04)	1.01 [0.95, 1.07]
$\psi_{\Delta y}$	N(0.12, 0.05)	0.23 [0.14, 0.31]	0.33 [0.25, 0.41]	γ_{cc}	N(0.70, 0.04)	0.70 [0.64, 0.76]
ρ_b	B(0.60, 0.20)	0.80 [0.71, 0.88]	0.91 [0.88, 0.93]	κ_{tis}	N(0.32, 0.03)	0.30 [0.24, 0.35]
σ_b	IG(0.15, 1.00)	0.12 [0.09, 0.15]	0.10 [0.08, 0.12]	κ_{tws}	N(0.00, 0.03)	0.03 [-0.02, 0.07]
ρ_z	B(0.60, 0.20)	0.99 [0.98, 0.99]	0.96 [0.94, 0.97]		(,)	[,]
σ_z	IG(0.15, 1.00)	0.55 [0.51, 0.60]	0.57 [0.52, 0.61]		(,)	[,]
ρ_i	B(0.60, 0.20)	0.85 [0.75, 0.98]	0.99 [0.99, 1.00]		(,)	[,]
σ_i	IG(0.15, 1.00)	0.30 [0.25, 0.36]	0.53 [0.44, 0.64]		(,)	[,]
ρ_p	B(0.60, 0.20)	0.81 [0.74, 0.87]	0.71 [0.65, 0.78]		(,)	[,]
σ_p	IG(0.15, 1.00)	0.07 [0.05, 0.08]	0.10 [0.08, 0.11]		(,)	[,]
ρ_w	B(0.60, 0.20)	0.13 [0.05, 0.22]	0.25 [0.14, 0.38]		(,)	[,]
σ_w	IG(0.15, 1.00)	0.60 [0.54, 0.67]	0.63 [0.54, 0.72]		(,)	[,]
σ_{mp}	IG(0.15, 1.00)	0.24 [0.22, 0.26]	0.26 [0.23, 0.28]		(,)	[,]
ρ_g	B(0.60, 0.20)	0.97 [0.95, 0.99]	0.94 [0.91, 0.96]		(,)	[,]
σ_g	IG(0.15, 1.00)	0.46 [0.42, 0.50]	0.45 [0.41, 0.49]		(,)	[,]
ρ_{gz}	B(0.50, 0.20)	0.32 [0.26, 0.38]	0.34 [0.29, 0.40]		(,)	[,]
γ	N(0.40, 0.03)	0.39 [0.35, 0.43]	0.41 [0.38, 0.44]		(,)	[,]
π	N(0.80, 0.03)	0.83 [0.78, 0.87]	0.88 [0.83, 0.93]		(,)	[,]
υ_w	N(0.50, 0.03)	0.50 [0.45, 0.54]	0.50 [0.45, 0.55]		(,)	[,]
υ_p	N(0.30, 0.03)	0.34 [0.29, 0.38]	0.27 [0.22, 0.31]		(,)	[,]
$\bar{l}$	N(0.00, 0.10)	0.03 [-0.12, 0.20]	0.17 [0.03, 0.31]		(,)	[,]
$logL$		-1433	-2764			

Notes: "Rep. Agent " refers to the Smets and Wouters (2007) model estimated over the 1954Q3-2009Q4 period. "D. Imbalances" refers to the present paper's model.

Credit and wage shocks are more volatile than wealth shocks. The debt series are loaded with volatile measurement errors suggesting that the model picks a slow-evolving component from them. Home mortgage debt is favored over consumer credit debt ($\Psi_d = 0.77$). The trends in debt and the top shares are situated around their data averages. This set of parameters jointly with a subset of aggregate parameters yield tight posteriors for the steady state top income (37%) and wealth (68%) shares around their sample averages (38% and 67%). Inequality and debt data are, hence, informative for this set of parameters.

4.2 Economy Wide Implications of Inequality.

4.2.1 Economy Wide Effect. I quantify the autonomous effect of distributional shocks on the U.S. business cycle in Table (5) which displays the forecast error variance decomposition two/ten years ahead. The combined effect of wage, wealth, and credit shocks explains less than 10% of output fluctuations at any horizon. More precisely, wage polarization shocks have a small impact (3/2%) on output cycles. Wealth shocks explain 4/2% of output cycles. That influence is aligned with the findings of Iacoviello and Neri (2010), according to which a similar shock affecting preferences over housing exerts about the same influence on output. Credit supply shocks, too, exert limited influence (3/2%) on output cycles. The latter influence is consistent with the findings of Justiniano et al. (2015). The small influence of the above triplet of shocks is confirmed in the cases of inflation and of the interest rate.

Despite its aforementioned limited influence, the above triplet of shocks has a profound impact on household indebtedness. It explains 75% and 52% of household debt swings at short and long horizons, respectively. Polarization shocks account for 8% of long-run debt swings. The influence of wealth shocks on debt (44/27%) is about 1.5 times higher than the influence of credit supply shocks on debt (30/17%) at any horizon. The sizable influence of the above shocks on household debt empirically corroborates the dynamics described in Kumhof et al. (2015) and Stiglitz (2014), according to which households outside of the top leverage their portfolios in response to swings in inequality.

It is worthwhile to elaborate on the labeling of polarization, wealth, and credit shocks as "*distributional*" shocks. Polarization shocks account for the entire cyclical fluctuations of income inequality and have a sizable impact on wealth (13/61%) and consumption inequality as well (91/95% and 69/85% of the cycles in the consumption of the top and the middle class, respectively). Wealth shocks, too, have a sizable influence on the fluctuations of wealth inequality (40/9%). Credit supply shocks have a moderate impact on middle-class' indebtedness and the top wealth share (8%/20%). The changes in polarization, wealth, and credit shocks, therefore, capture cyclical swings in income and wealth inequality as well as in debt. Their economy wide effect, therefore, reflects the effect of changes in inequality.

Although demand and supply side shocks are labeled as "*aggregate*" shocks following convention, they may in fact have distributional consequences because their transmission is filtered through MPC heterogeneity and imperfect insurance. According to Table (5), income

Table 5: Business Cycles and Distributional Shocks

	variable							
shock	$\widehat{y}_t$	$\widehat{\pi}_t$	$\widehat{r}_t$	$\widehat{b}_t^{\tau}$	$\widehat{tis}_t$	$\widehat{tws}_t$	$\widehat{c}_t^{\tau}$	$\widehat{c}_t^{\mu}$
wage polariz.	3/2	0/1	2/5	1/8	99/100	13/61	91/95	69/85
wealth pref.	4/2	1/1	5/5	44/27	0/0	40/9	2/1	3/1
credit supply	3/2	0/1	3/3	30/17	0/0	8/20	1/0	2/0
distributional	10/6	1/3	11/13	75/52	100/100	61/90	93/96	74/86
technology	32/28	1/2	0/0	15/7	0/0	16/3	0/1	6/3
price markup	10/5	68/60	16/8	2/1	0/0	6/1	0/0	1/0
wage markup	2/2	8/8	1/1	5/1	0/0	6/1	0/0	1/0
supply side	44/35	77/70	18/9	22/9	0/0	28/5	1/1	9/4
risk premium	28/14	12/13	49/46	1/2	0/0	5/2	0/0	9/3
investment	5/39	7/12	6/24	1/35	0/0	2/1	6/3	1/6
gov. spending	1/1	0/0	0/0	0/1	0/0	0/1	0/0	2/1
mon. policy	13/6	2/2	16/8	1/1	0/0	4/2	0/0	5/1
demand side	46/59	22/27	72/78	3/39	0/0	11/5	6/3	17/11

Notes: Forecast Error Variance Decomposition 8/40 quarters ahead, computed at the posterior mean. *Mnemonics:* $\{\widehat{y}_t, \widehat{\pi}_t, \widehat{r}_t, \widehat{b}_t^{\tau}, \widehat{tis}_t, \widehat{tws}_t, \widehat{c}_t^{\tau}, \widehat{c}_t^{\mu}\}$ stand for output, inflation, the interest rate, lending/borrowing, top income share, top wealth share, top and middle-class consumption (% deviation from steady state).

inequality is mainly explained by polarization shocks. In contrast, supply and demand side shocks galvanize 28/5% and 11/5% of the short/medium-run fluctuations of wealth inequality, respectively. The short-run effect of supply shocks is mainly attributed to technology shocks through their impact on the debt overhang, whereas the long-run effect is distributed across all supply shocks. All demand side shocks but government spending shocks have about a co-equal influence on the swings of wealth inequality.

4.2.2 Diffusion. Figure (1) displays the effect of wage polarization shocks on the economy and on the top income and wealth deciles. In response to wage polarization, top consumption rises whereas middle-class consumption falls. The two changes do net out to zero, and result in a gradual economy wide consumption increase – an aggregate demand stimulus – that eventually raises production, employment, and wages. Polarization shocks, therefore, operate through an *aggregate demand channel*. The latter hinges on the heterogeneous consumption responses across the population, reflecting the heterogeneity in marginal propensities to consume. The workings of a demand channel are corroborated by the fact that the output and consumption increases are about coequal on impact. The positive output elasticity mirrors the observed pro-cyclicality of the top income share (0.49 in Table 1). In addition, polarization shocks generate pro-cyclical, albeit small in magnitude, inflation and interest

rate responses. Therefore, the adjustment is stronger in quantities than in prices.

The effect of polarization on the evolution of inequality and debt is highly persistent, and mirrors the low-frequency shifts in the observed debt and inequality series. Wage polarization leads to pro-cyclical responses in both income and wealth inequality. More specifically, it results in a higher share of earnings flowing to the top (tis^{ea}). The top families leverage their income to increase consumption (c^{τ}) and raise their shares (tws^{ω}). Interest payments from bond holdings (tis^{b}) boost income inequality (tis) further. Due to the increased demand for ownership shares, their price goes up and negatively feedbacks to the top wealth share (tws^{q}) since part of the assets of the top is in terms of bonds. It is worth pointing out that the collateral channel amplifies the effect of these shocks: although middle-class households borrow after the shock, the combination of a fixed supply of shares and of an increasing fraction of them going to the top (tws^{ω} rises) leaves middle-class households with less collaterals to post. As a result, the middle class borrows (tws^{b} falls) and consumes less. Thus, access to credit is harder when income inequality rises.

Figure (2) displays the effect of wealth and credit shocks. The effects of changes in the desire for wealth accumulation and in the borrowing capacity of the middle class are similar. Both shocks trigger positive output and aggregate demand elasticities, fueled by the consumption expansion of the middle class since the consumption of top households exhibits a small drop, that confirm the presence of an aggregate demand channel. Inflation, the interest rate, and the real wage exhibit a small pro-cyclical response.

Both credit and wealth shocks quickly elevate income inequality (tis^{b} falls in the first period because lending rises on impact but payments start in the second period). Over time, the economic expansion leads to profits for the top (tis^{pr}) that shape the increase in income inequality (tis) since the response of the earnings channel (tis^{ea}) is negligible. Both shocks lead to an expansion in the bonds held by the top (tws^{b}): middle-class families borrow in order to increase their ownership shares (tws^{ω} decreases). The high demand for shares raises their price which, in turn, negatively affects the top wealth share (tws^{q}). It is worth pointing out that despite the fact that both wealth and credit shocks lead to changes of the same sign, the former shocks drive down wealth inequality, generating a negative correlation between debt and wealth inequality, whereas the latter raise it, causing a positive correlation. This difference happens because credit shocks do not generate an increase in the asset price (reflected in tws^{q}) as large as that observed after wealth shocks.

Figure 1: Economy Wide Implications of Wage Polarization Shocks

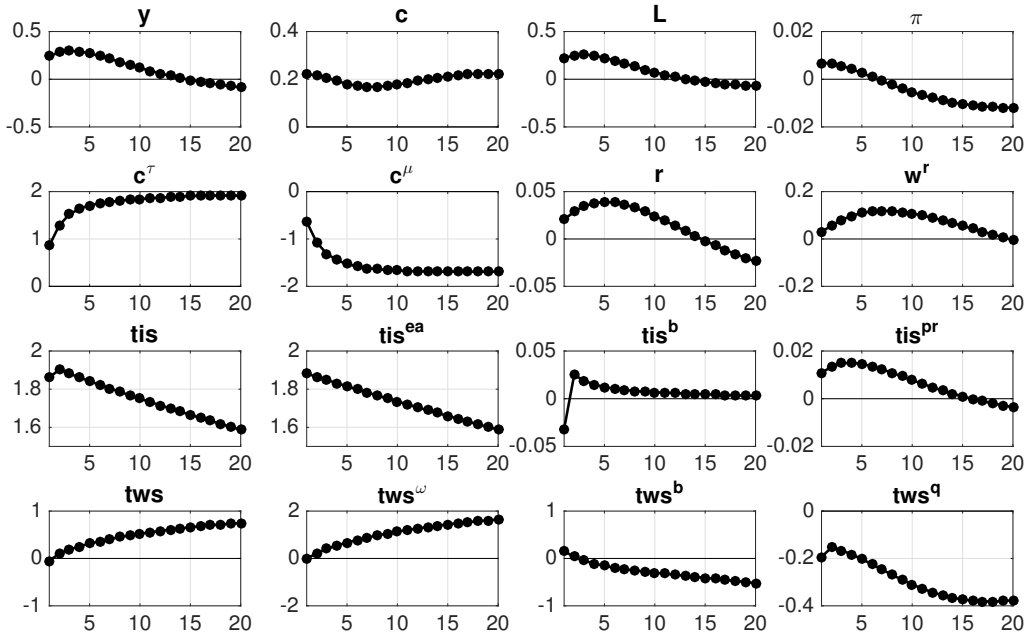
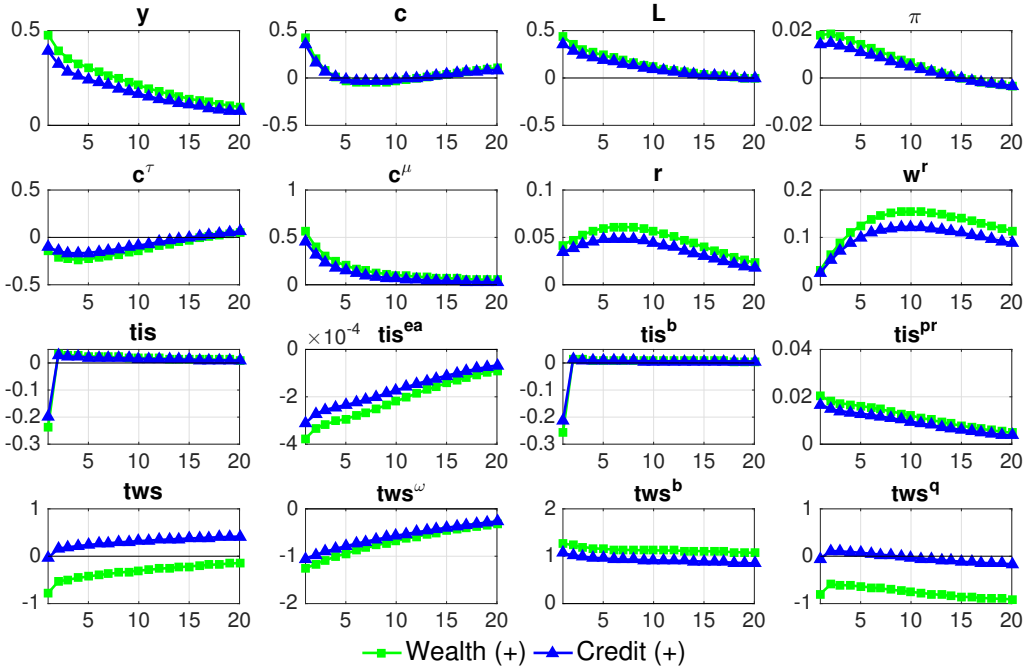


Figure 2: Economy Wide Implications of Wealth and Credit Shocks



Notes: impulse response functions, % deviation from steady state. 3rd row:: top income share (tis): earnings (tis^{ea}), bond income (tis^{b}), and profits (tis^{pr}) channels, with $tis = tis^{ea} + tis^{b} + tis^{pr}$. 4th row:: top wealth share (tws): shares (tws^{ω}), bonds (tws^{b}), and asset price (tws^{q}) channels, with $tws = tws^{\omega} + tws^{b} + tws^{q}$.

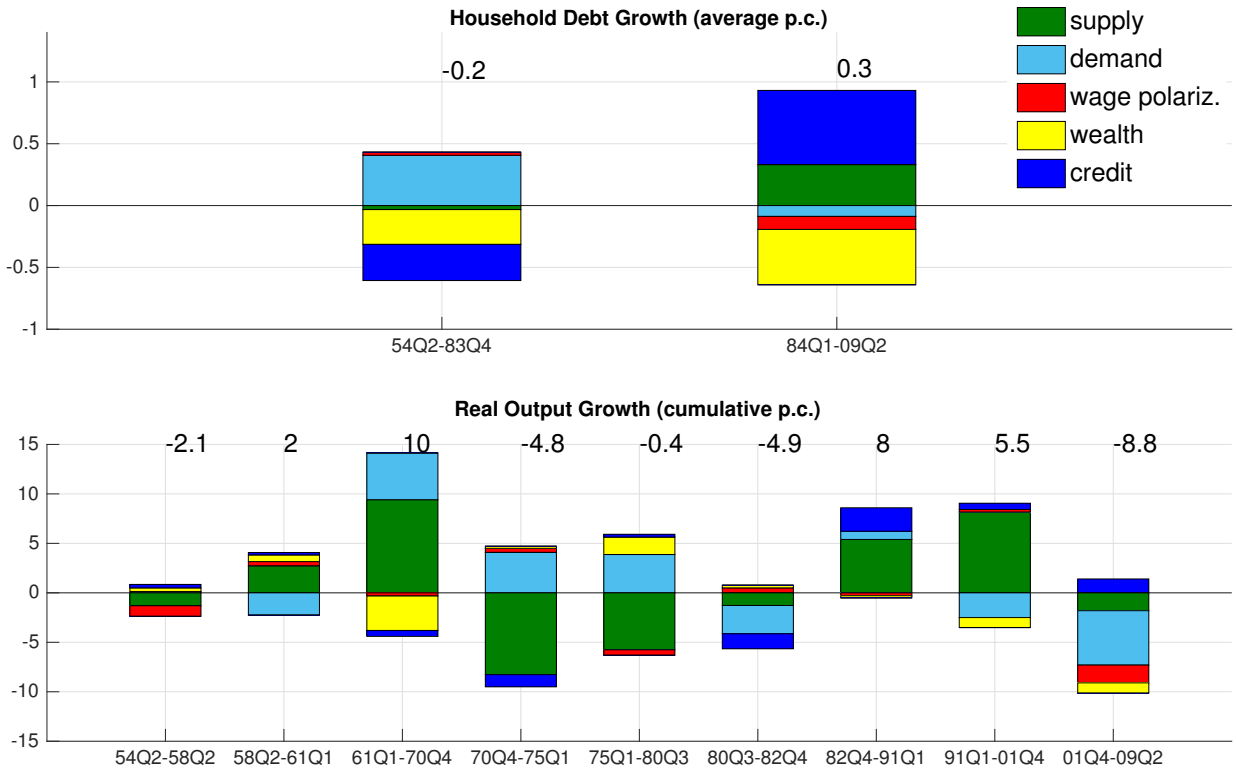
4.2.3 Debt Pileup and Output Cycles. Although the findings of Table (5) suggest that distributional shocks explain about 50-70% of household debt fluctuations, they remain silent about the influence of those shocks during the debt buildup of the decades prior to the Great Recession. Fig.(3) tackles this question. The top panel displays the structural forces behind debt growth during 1954-1982 and 1983-2009. It demonstrates a debt buildup over the business cycle: debt growth is larger during the 1983-2009 period (0.3) than during the 1954-1982 period (-0.2). The contribution of credit shocks to the debt buildup is sizable; it accounts for about half of debt growth. This evidence, hence, casts support on Mian and Sufi (2018) and citations therein, who argue that the U.S. credit expansion was one of the main factors behind the debt buildup, but goes goes against Justiniano et al. (2015) who find that a taste shock for housing (modeled as the present wealth shock) accounts for the observed leveraging. What is it though that drives the latter difference?

The present distributional shocks are differently identified through the cross-equation restrictions and aim to capture cyclical changes in income and wealth inequality. Thus, two factors explain the above difference: (i) the weakening of the collateral channel due to rising income inequality, and (ii) the negative correlation of wealth inequality and debt in response to wealth shocks. The cyclical rise of income inequality after the 1980s (see Appx.) is reflected in wage polarization shocks. The latter trigger an increase in the ownership of shares of top households as shown in Fig.(1). As a result, middle-class families have fewer shares available to use as collateral and, thus, borrow less. Rising income inequality, hence, cannot trigger an increase in borrowing. A downward influence on debt accumulation is also triggered by wealth shocks after the 1980s. Negative wealth shocks explain a large part of the cyclical rise in wealth inequality during that period (see Appx.), and trigger a decrease in household debt according to the negative correlation shown in Fig.(2). Therefore, against both polarization and wealth shocks pushing towards a reduction in borrowing, credit supply shocks obtain an influential role in explaining the observed increase in debt.

The bottom panel of Fig.(3) corroborates that distributional shocks have limited impact on output cycles. Wealth shocks are more influential during the cycles before the 1980s than after that period. Polarization shocks exert a small influence throughout time. Credit relaxation consistently boosts output growth during the cycles from 1982 to 2009. Interestingly, despite the impact of credit shocks on debt found above that differs from the evidence of Justiniano et al. (2015), the small influence of credit shocks on output cycles is compatible

with Justiniano et al. (2015) according to whom such shocks do not suffice to account for the severity of the Great Recession and have limited economic influence.

Figure 3: Debt Pileup and Output Cycles



Notes: Historical decomposition. *Top Panel:* Quarterly average real per capita debt growth shown on top of each column. *Bottom Panel:* cumulative real per capita output growth shown on top of each column. Demand shocks: risk premium, investment, monetary, and government spending. Supply shocks: technology, price and wage markup.

4.2.4 Imbalances. This section disentangles the influence of exogenous distributional imbalances (distributional shocks) from the influence of mechanisms (heterogeneous ϕ's and imperfect insurance) that endogenously generate distributional imbalances. Table (6) reports the properties of aggregate demand across various alternative scenarios pertaining to imbalances. Removing the impact of distributional shocks while keeping in the model the mechanisms of endogenous imbalances, results in an aggregate demand that is more volatile than (0.85 vs 0.74), less persistent than (-0.07 vs 0.26), and considerably different from (0.19) the observed demand. Therefore, a sizable part of the persistent evolution of aggregate demand and, thereby, of the economy hinges on distributional shocks reflecting changes in inequality and debt. Put differently, a large part of the economy's persistence is attributed

to the low-frequency dynamics of inequality and debt. This result is mirrored in the lower habit (η) that is obtained in the present model compared to the RA model (0.51 vs 0.77).

Removing distributional shocks and assuming homogeneous preferences over wealth across households results in an aggregate demand that remains more volatile than (0.81 vs 0.74) and largely deviates from (0.31) the observed series. Nevertheless, this series is less volatile than the series with heterogeneous ϕ's (0.81 vs 0.85). The heterogeneity in wealth preferences, therefore, amplifies consumption heterogeneity and demand volatility.

As a final step, I impose perfect insurance. The model collapses to the RA specification and, therein (i.e. with the RA parameter estimates), I consider the propagation of aggregate shocks extracted from the present model. The fact that the volatility of the resulting aggregate demand is not dampened down implies that the estimated standard deviation of disturbances in the RA model is about the same with that in the present model. Nevertheless, the resulting series is far more persistent (0.59) than the observed and counterfactual series above. The RA model, therefore, yields higher endogenous persistence reflected in the deep parameter of habit than the present model does (see Appx. for a graphical depiction).

Table 6: Measuring Endogenous and Exogenous Distributional Imbalances

	Mean	**Volatility**	**Persistence**	**Deviation**
Aggregate Demand				
Observed (minus measur. error)	0.48	0.74	0.26	0.00
No Exogenous Imbalances	0.49	0.85	-0.07	0.19
No Exog. Imbalances & $\phi^{\mu} = \phi^{\tau}$	0.49	0.81	-0.09	0.31
No Exog. & Endog. Imbalances	0.47	0.85	0.59	0.31
Inflation				
Observed (minus measur. error)	0.85	0.58	0.86	0.00
No Exogenous Imbalances	0.84	0.58	0.86	0.00
No Exog. Imbalances & $\phi^{\mu} = \phi^{\tau}$	0.83	0.58	0.86	0.00
No Exog. & Endog. Imbalances	0.80	0.71	0.91	0.05

Notes: Observed and simulated series. Quarterly % changes in aggregate demand (consumption) and inflation. "Deviation" refers to the quarterly average squared deviation from the observed series.

The bottom part of Table (6) shows that both distributional shocks and heterogeneous ϕ's have limited *direct* effects on the volatility and persistence of inflation: after removing them following the steps described above, inflation remains close to the data. The reason behind this result is that the inclusion of inequality and debt entails an *indirect* implication for inflation, namely the attenuation of general equilibrium effects to it mirrored in high

price indexation (0.09 vs 0.07) and volatility of price markup shocks (0.10 vs 0.07), as well as in a low persistence of the latter shocks (0.71 vs 0.81); see Table (4). This attenuation is reflected on the resulting inflation series deviating from the observed (0.05) when the volatile aggregate shocks of the present model are fed to the RA model that does not dampen them.

4.2.5 The Nature of Aggregate Shocks. Is the transmission of aggregate shocks to economy wide variables in the model with distributional imbalances (DI) different from that implied by the RA model due to keeping track of additional facets of the U.S. economy? Table (7) reports the five-year cumulative effect of aggregate shocks in the DI and RA models. Matching inequality and debt alters aspects of these shocks. Compared to the RA model, technology and price markup shocks in the DI model obtain a tad less influential role in the fluctuations of all variables. In contrast, wage markup shocks are more prominent in explaining output and consumption in the DI model than in the RA model. Risk premium and investment shocks exert a pronounced effect on the economy when inequality is considered. Interestingly, along with the habit reduction, the influence of risk premium shocks on consumption declines in the DI model compared to the RA model. The influence of government spending shocks is more temporary in the DI than in the RA economy[15].

Table 7: Total Effect of Aggregate Shocks across Model Specifications

	y_t		π_t		r_t		c_t	
	RA	DI	RA	DI	RA	DI	RA	DI
technology	16.9	15.7	-0.7	-0.2	-0.7	0.1	12.9	9.6
price markup	-6.5	-6.0	1.2	0.7	1.0	0.7	-4.3	-3.4
wage markup	-3.0	-4.3	0.9	0.5	0.8	0.3	-3.9	-4.0
premium	8.1	10.5	0.0	0.7	1.4	2.9	8.8	6.1
investment	8.6	10.7	-0.2	0.7	0.4	1.6	0.8	-5.3
spending	2.7	0.5	0.1	-0.0	0.2	0.0	-5.9	-4.1
policy	6.1	6.4	0.1	0.2	-1.1	-0.2	5.8	3.8

Notes: Cumulative % deviation from steady state after twenty quarters. RA: Representative Agent model. DI: Distributional Imbalances model.

It is worth mentioning that in the Appendix I show, and explain why, (i) all demand shocks (risk premium, investment, government spending) generate pro-cyclical income inequality; (ii) risk premium shocks contrary to investment and government spending shocks spur counter-cyclical wealth inequality; (iii) price markup shocks generate pro-cyclical re-

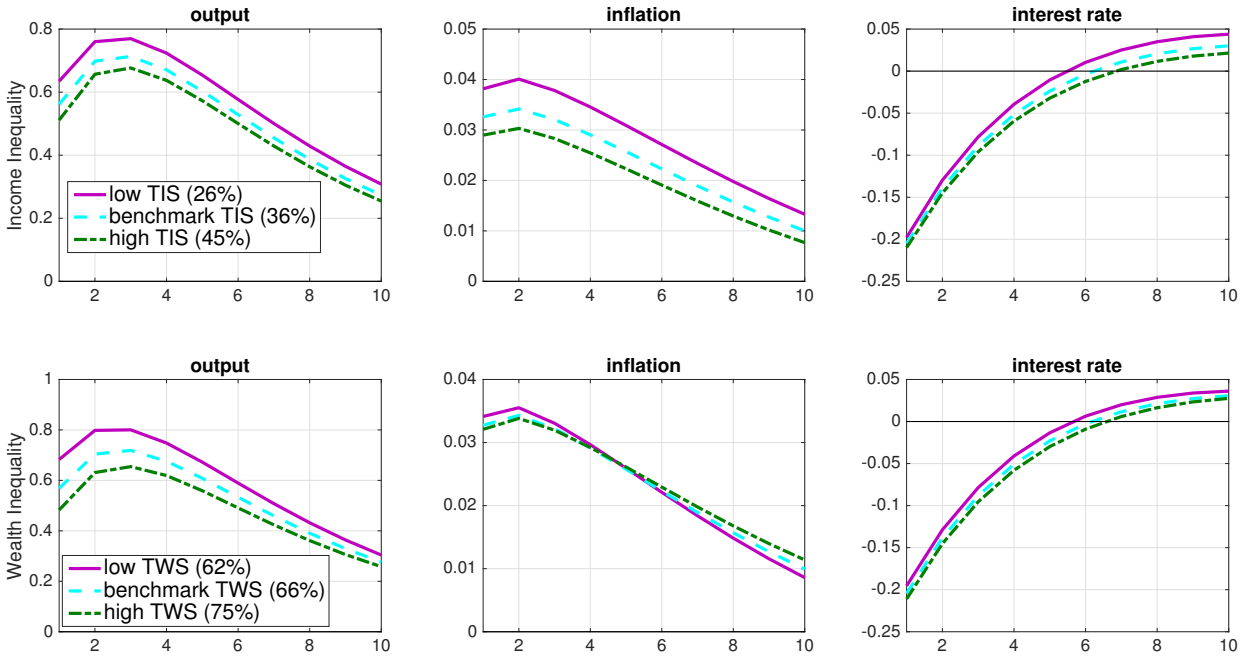
[15]In the Appx., I compare the FEVD and IRFs across the DI and RA specifications, and show that including the top deciles and debt in the estimation has minor implications for the path of the output gap.

sponses in both income and wealth inequality; (iv) wage markup and technology shocks generate pro-cyclical income inequality and counter-cyclical wealth inequality.

4.3 Monetary Policy and Inequality.

4.3.1 Policy Effectiveness. In considering the locus of monetary policy and inequality, I first delve into whether the influence of monetary policy on the business cycle weakens in the presence of inequality. Fig.(4) shows that the higher the degree of either income or wealth inequality, the lower the effect of an expansionary monetary policy change on the response of output. The effect of the policy expansion on inflation is similar to that of output in the case of higher income inequality, but is attenuated compared to that of output in the case of higher wealth inequality. Thus, the findings of Fig.(4) suggest that the control of monetary policy over output and inflation weakens in regimes of high income and wealth inequality.

Figure 4: Monetary Policy Effectiveness and Inequality

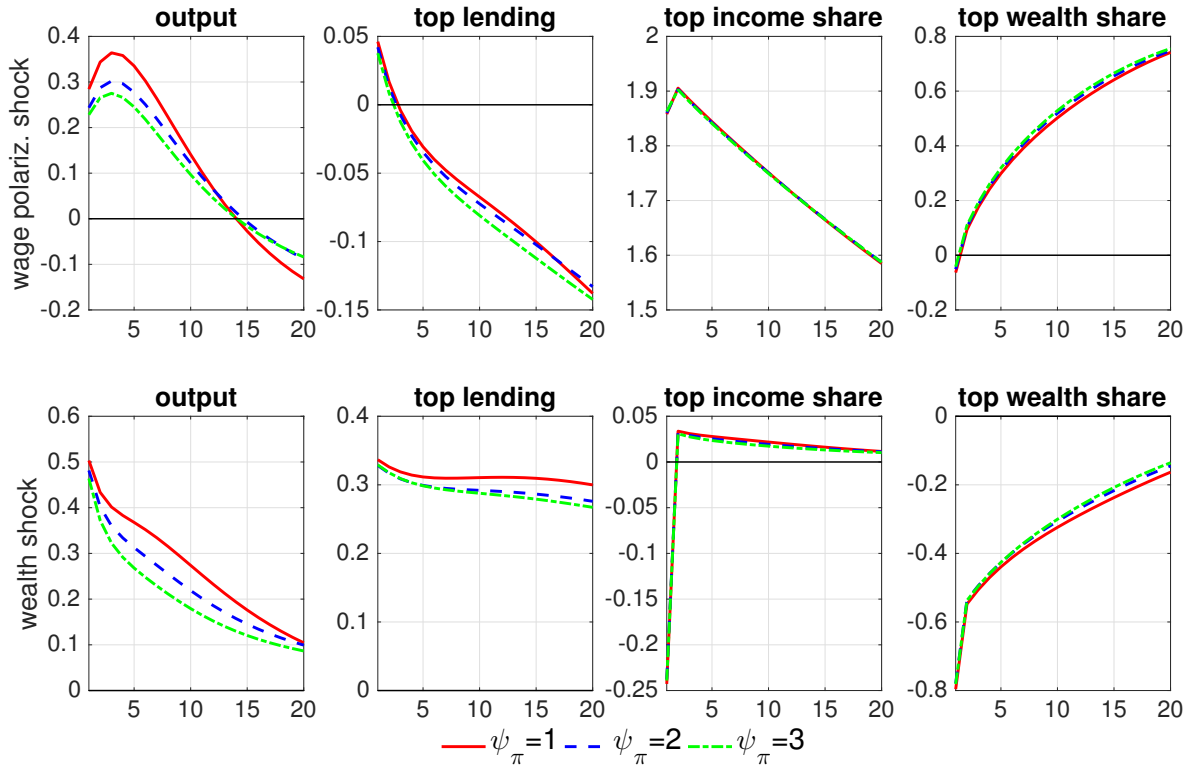


Notes: Transmission of monetary policy innovations across different inequality regimes: regimes of lower than and higher than benchmark (steady-state-implied) degree of income and wealth inequality. Income and wealth inequality pertain to the top income (TIS) and top wealth (TWS) shares, respectively.

4.3.2 Policy Stance. What is, though, the role of the monetary policy stance against inflation in the transmission of swings in inequality? According to Fig.(5), the policy regime towards inflation (ψ_π) influences the amplitude of the output elasticity to wage polarization

and wealth shocks: the more non-accommodative the policy, the smaller the output elasticity. The reason behind this result is that distributional shocks generate pro-cyclical changes in aggregate demand and, thereby, in inflation. As a result, monetary policy faces no trade-off in stabilizing the economy by monitoring aggregates, rather than household-specific variables, when the fluctuations emanate from changes in inequality.

Figure 5: Monetary Policy Stance and the Transmission of Distributional Imbalances



Notes: Transmission of polarization and wealth shocks across different policy regimes towards inflation.

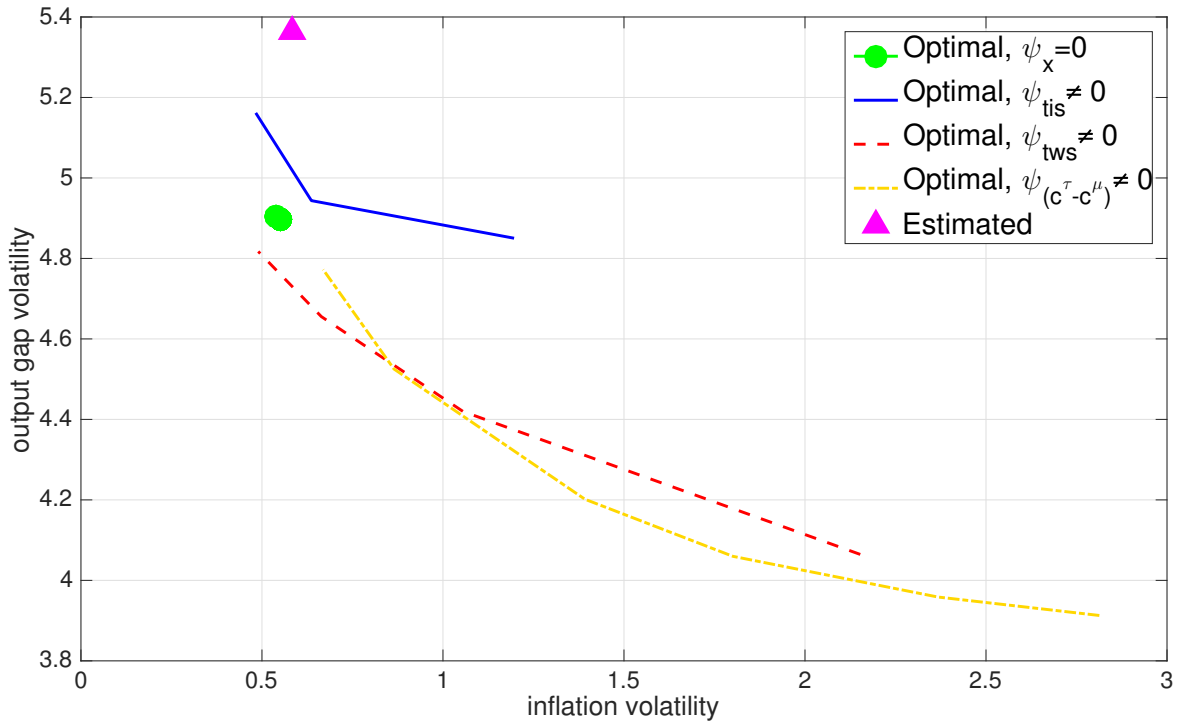
More specifically, as described in Fig.(1), polarization shocks weaken the collateral channel and force the middle class to bring down its debt obligations, while inflation and output, driven by the consumption of the top, increase. Therefore, the stronger the policy reaction to inflation, the higher the interest rate rise and, thereby, the heavier the debt burden on the middle class and, in turn, the reduction in its debt obligations. Furthermore, in response to wealth shocks, output, inflation, and debt rise. A non-accommodative policy curtails the debt expansion through a sharp raise of the policy rate. Interestingly, the various degrees of the systematic policy reaction to inflation have limited impact on the trajectory of income and wealth inequality in response to wealth and polarization shocks.

4.3.3 Should Monetary Policy React To Inequality? Assuming that the volatilities of inflation and of the output gap are the only objectives of monetary policy, it is important to quantify how their trade-off depends on an interest rate policy that responds to distributional imbalances not only indirectly, through general equilibrium effects, but also directly. This section addresses this issue by considering policy rules in the form of (in log-linear terms):

$$\widehat{r}_t = \rho_r \widehat{r}_{t-1} + (1-\rho_r)\left[\psi_\pi \widehat{\pi}_t + \psi_y(\widehat{y}_t - \widehat{y}_t^f) + \psi_{\Delta y}\Delta(\widehat{y}_t - \widehat{y}_t^f) + \psi_j \widehat{x}_t^j\right] + \epsilon_t^{mp} \tag{4.1}$$

where $\widehat{x}_t^j$ is replaced, in turn, with the top income decile ($\widehat{tis}_t$), the top wealth decile ($\widehat{tis}_t$), and the top–middle-class consumption differential ($n^\tau \widehat{c}_t^\tau - n^\mu \widehat{c}_t^\mu$). The associated reaction coefficients are given by $\psi_j \in \{\psi_{tis}, \psi_{tws}, \psi_{(c^\tau - c^\mu)}\}$. I set all parameters at their posterior mean and, in the spirit of Levin et al. (1999) and Iacoviello (2005), search for the $\{\psi_\pi, \psi_j\}$ values that minimize a welfare loss function of inflation and output gap variabilities, $\lambda \text{Var}(\widehat{\pi}_t) + (1-\lambda)\text{Var}(\widehat{y}_t - \widehat{y}_t^f)$, across different relative weights on inflation stabilization.

Figure 6: Policy Frontier



Notes: Inflation – output gap trade-off across monetary policy rules.

As displayed in Fig.(6), the alternative rules achieve negligible to no gains in terms of the inflation–output gap variability trade-off. More specifically, in the case of a policy

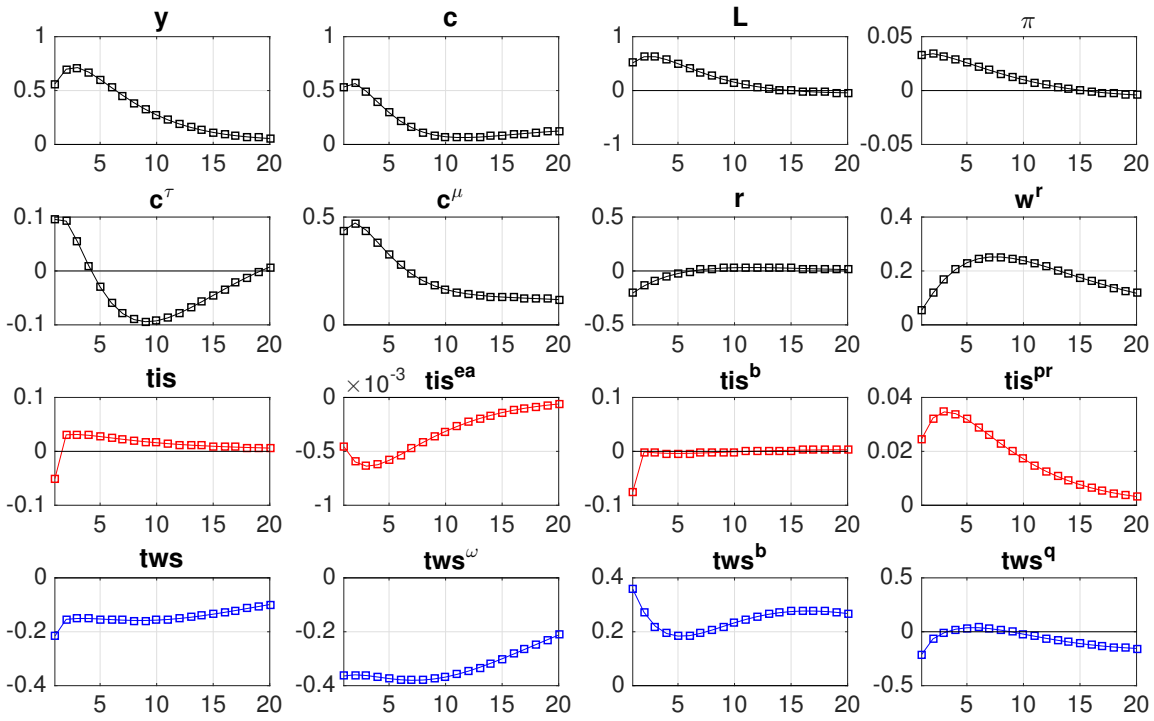
response to income inequality, the locus of the trade-off shifts in a region of slightly higher inflation and output gap volatilities compared to that emanating from the "optimal rule" featuring an optimal inflation response and no response to inequality[16]. In the case of a policy response to either the consumption differential or the top wealth share, the locus of the inflation–output gap variability trade-off shifts south-east, and monetary policy achieves moderate gains in terms of the output gap variability (due to the increased sensitivity of policy to inequality and, thereby, to aggregate demand) that are unattainable by the optimal rule, but faces a much higher inflation volatility than that of the optimal rule. For a loss function placing weight almost exclusively on output gap variability, a policy response to wealth inequality yields negligible gains of about 2-3% in terms of the output gap volatility compared to the optimal policy for a level of inflation volatility around 0.5%.

As the welfare weight on inflation volatility goes from zero to one, ψ_{tis} rises from -0.12 to -0.03, ψ_{tws} rises from -0.45 to -0.03, and $\psi_{(c^{\mu}-c^{\tau})}$ rises from -0.36 to -0.03. Hence, all the coefficients are considerably different from zero when the welfare criterion places more weight on output gap than on inflation volatility since the variables attached to those coefficients heavily depend on distributional shocks inducing persistent shifts in aggregate demand and, thereby, in the output gap. Conversely, a welfare function favoring inflation over output gap stabilization places negligible weight on changes in inequality.

4.3.4 From Erratic Policies To Inequality. I now shed light on the propagation of unpredictable changes in the policy instrument to inequality. Fig.(7) pins down the effect of an unexpected expansionary interest rate change. The latter stimulates the consumption of middle-class households more than that of the top. Thus, consumption inequality declines. Aggregate demand shifts outwards and production adjusts to it. Low lending costs favor middle-class borrowing (tws^b) which leads to interest payments to the top (tis^b). The latter along with the unequally disturbed profits (tis^{pr}) stemming from the economic expansion lead to a positive (pro-cyclical) elasticity of income inequality. In contrast, the elasticity of wealth inequality is negative (counter-cyclical) because the middle class uses the borrowed funds to raise its asset holdings (tws^{ω} falls). The latter along with the asset price rise (tws^q falls) that accompanies low interest rates, spur downward pressures to wealth inequality that dominate top's increased bond assets.

[16]The curve involves an optimal ψ_{π} conditionally on the posterior distribution of all model parameters, and is situated below the point indicated by the estimated policy rule over the historical data.

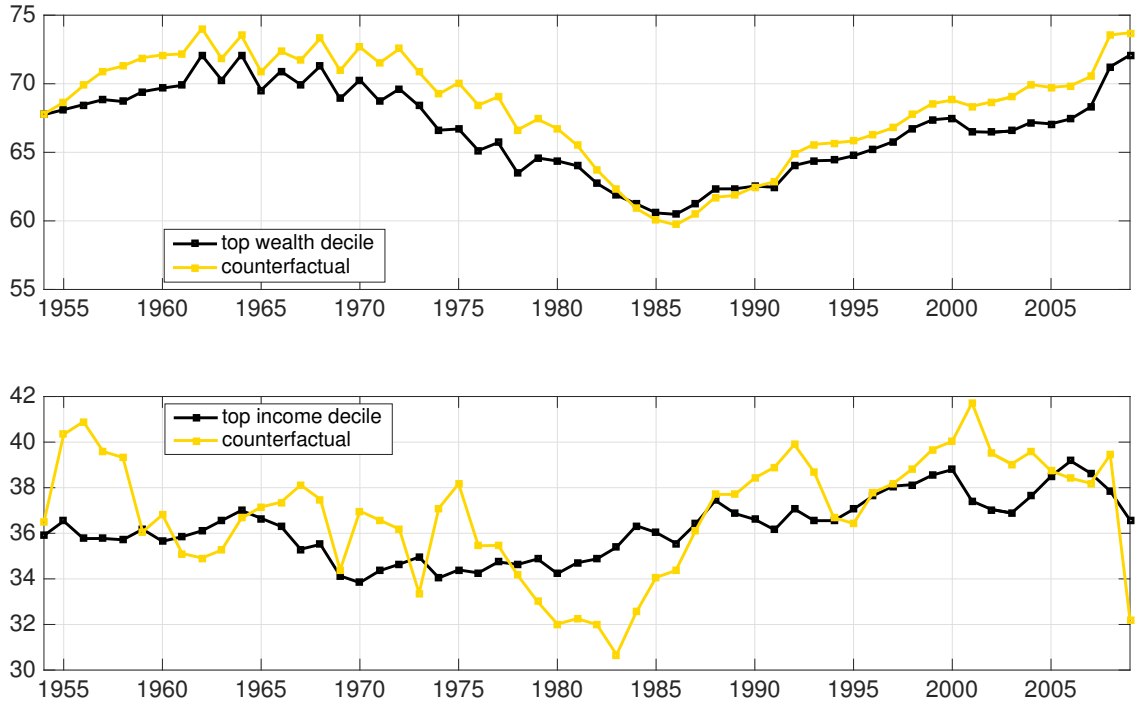
Figure 7: Monetary Policy Disturbances



Notes: impulse response functions (posterior mean). All variables in % deviation from steady state. 1st and 2nd row: aggregate variables. 3rd row:: top income share (tis): earnings (tis^{ea}), bond income (tis^{b}), and profits (tis^{pr}) channels, with $tis = tis^{ea} + tis^{b} + tis^{pr}$. 4th row:: top wealth share (tws): shares (tws^{ω}), bonds (tws^{b}), and asset price gains/losses (tws^{q}) channels, with $tws = tws^{\omega} + tws^{b} + tws^{q}$.

What has been the effect of policy surprises (i.e. interest rate changes not explained by fundamentals) on inequality across the 1954-2009 period though? Fig.(8) quantifies this effect by displaying how the U.S. income and wealth inequality would have looked like, had monetary policy been characterized by zero surprises during that period. According to the findings, there are some differences of small magnitude (about 1-3% points) between the observed and the counterfactual series. In terms of wealth inequality, between 1955 and 1981 as well as between 2000 and 2009 the initially formed differences between the actual and the counterfactual series persist and remain rather constant. From the mid-80s and up to about 2000, the counterfactual series converges to the actual one from above implying that the counterfactual policy is more expansionary than the actual policy. In terms of income inequality, the picture is a tad different: in the absence of policy surprises, the counterfactual income inequality becomes more noisy and volatile than the actual series. This evidence demonstrates a sensitivity of the top income share to the policy rate.

Figure 8: Monetary Policy Surprises and Inequality Swings



Notes: Counterfactual top 10% income and wealth shares for zero monetary policy surprises.

4.4 Robustness Checks.

4.4.1 Loan-To-Value Ratio. The analysis so far has not made clear how the transmission of distributional shocks depends on the degree of financial market imperfections captured by the loan-to-value ratio (m); the higher the m, the lower the imperfections[17]. The analysis relegated to the Appendix unveils two messages. First, the elasticities of output to wage and wealth shocks are of the same sign but of different magnitude depending on m. The fact that values of m, as low as 0.1, generate positive output elasticity to the wealth shock illustrates that this shock differs from the taste shock over housing considered in Iacoviello (2005), since the output elasticity to the latter shock changes sign for low m. Second, low financial market imperfections amplify the aggregate demand channel and, thereby, the effect of polarization and wealth shocks on output.

4.4.2 Identification. To further understand the influence of inequality data compared to that of aggregate data on the estimates for the parameters associated with the distributional

[17]In terms of steady state effects, a higher m raises debt, as well as the top income and wealth shares.

dimension of the model, I repeat the estimation without including the top deciles in the observation vector as well as polarization and wealth shocks in the stochastic structure. The results suggest that income and wealth inequality series are in fact informative. The estimation yields top income and wealth deciles (651% and 73%, respectively, at the steady state) that are at odds with U.S. data. Compared to the benchmark run, ϕ^{τ} rises from 0.15 to 0.35 and ϕ^{μ} rises from 0.37 to 0.52. Credit supply shocks become less volatile and their influence on debt rises from 30/17% in the benchmark model to 40/35% in the estimation without inequality data, whereas their influence on output remains unchanged. The loading of consumer credit debt (Ψ_d) rises from (0.77) to (0.87).

4.4.3 Credit and Wealth Shocks. Table (5) shows that wealth and credit shocks each account for a sizable part of debt fluctuations. Are these two shocks, however, somehow connected? Several results suggest some degree of connection. First, the two innovations have a negative correlation of -0.29 despite their modeling as *iid* processes[18]. Second, a negative connection between the two shocks is observed in the historical decompositions of Fig.(3). Third, as discussed in the above section, re-estimating the model by excluding top shares from the observation set as well as polarization and wealth shocks from the stochastic structure raises the influence of credit shocks on debt. Altogether, these results suggest that disentangling wealth from credit shocks is important in understanding changes in the economy. Including shifts in wealth inequality in the estimation helps in that direction by disciplining the path of variables appearing in the observation equation for wealth (3.6).

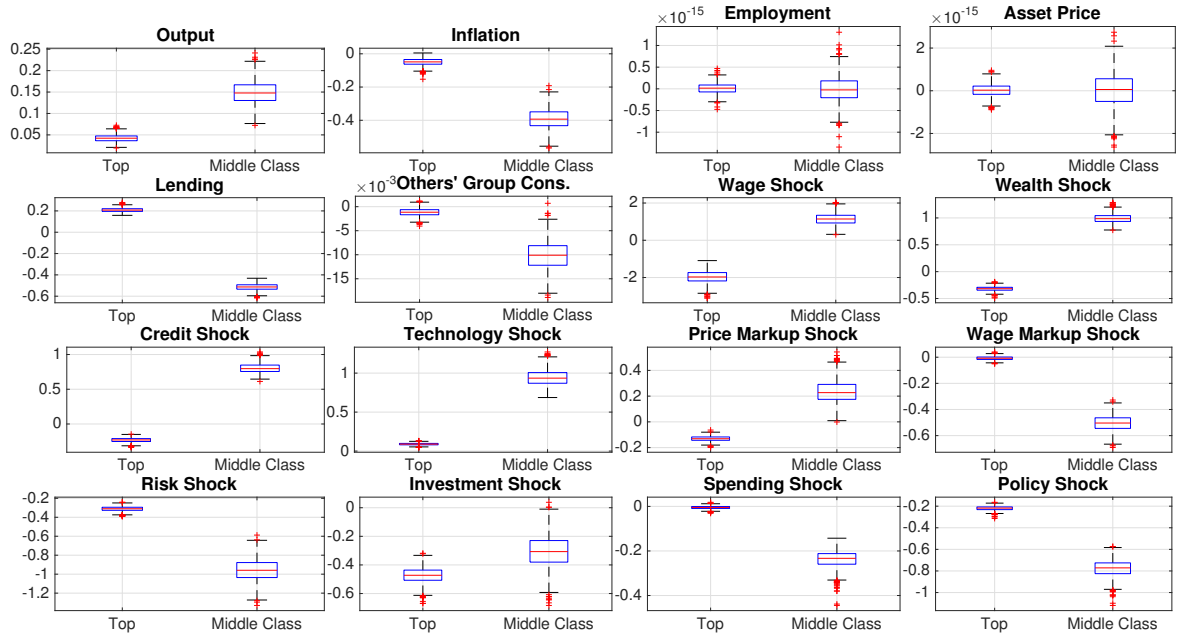
4.4.4 Prior. The postulated prior specification is not dogmatic. At the prior, distributional shocks account for 0%, 2%, 67%, and 1% of the short-term cycles in output, debt, income inequality, and wealth inequality, respectively (see Appx.). That effect is considerably smaller than the estimated one (10%, 75%, 100%, and 61%, respectively; Table 5).

4.4.5 Marginal Propensity To Consume. This section quantifies the model-implied MPC heterogeneity across top and middle-class households. Fig.(9) displays the posterior distribution of MPC out of several variables and all sources of stochastic variation. Sev-

[18] In contrast, the correlation between wealth and risk premium shocks is negligible (0.01), which does not validate the connection between risk premium and taste shocks for assets shown in Fisher (2015). It is worth mentioning that consistently with the literature showing that the top income share is connected to the top tax rate [Piketty et al., 2014; Piketty and Saez, 2013], I find a 0.28 correlation between polarization and government spending shocks.

eral insights emerge. First, middle-class households are more prone to consume out of an increase in output than top households are. Additionally, middle-class households reduce their consumption in response to debt more strongly than top households increase theirs (panel 1,1). Furthermore, the evidence suggests negligible reaction of a group's consumption to the other group's consumption (panel 2,2). In addition, the consumption responses to a wage shock are of the opposite sign across the population and orders of magnitude larger than the MPC observed for other shocks and variables (panel 2,3). Moreover, according to panels (2,4) and (3,1), in response to wealth and credit shocks, the MPC has the opposite sign across the population and is more than ten times higher for the middle class than for the top. Interestingly, panels (1,3) and (1,4) suggest a weak feedback from employment and asset prices to consumption choices for both groups. Lastly, it is worth mentioning that for homogeneous wealth preferences ($\phi^{\tau} = \phi^{\mu}$), the MPC heterogeneity is attenuated (Appx.).

Figure 9: Marginal Propensity To Consume Differentials



Notes: Posterior distribution of consumption responses across variables and sources of stochastic variation.

4.4.6 Portfolio Costs. The elasticity of portfolio costs (S_w) is kept to a low value (0.1) – small costs is the conventional view in the literature; see Iacoviello (2005) for example. Considering high values for S_w while conditioning on the posterior parameter distribution leads to a monotonic increase in the influence of wealth shocks: rising S_w from 0.1 to 1

increases the influence of wealth shocks on output from 2% to 89%. Such an unrealistic increase suggests that the posterior distribution of S_w depends on that of the other parameters. Unreported results suggest that when S_w is estimated, it obtains moderate values around 2, dampens down the influence of wealths shocks to some extent because part of the debt persistence is now captured by the sluggishness induced by high portfolio costs, and boosts the general equilibrium effects of aggregate shocks on debt. Nevertheless, no sizable changes are observed in the parameters and the overall influence of distributional shocks.

5 Concluding Remarks

The present paper adds to the literature on the macroeconomic ramifications of inequality by examining the historical fluctuations of inequality, debt, and aggregate series jointly over five decades through the lens of a proposed and estimated structural model. The takeaway message suggests that swings in inequality have limited effect on business cycles, but influence household debt gyrations to a large extent. The monetary policy transmission is not heavily impaired in this framework because the effect of changes in inequality on output cycles operate through persistent changes in aggregate demand. This paper sets the stage for further explorations across several dimensions. For example, delving into the swings of inequality in environments where debt plays a more crucial role for economic stability than that considered in this paper, or where there are multiple debt instruments with different characteristics available, may reveal a richer macroeconomic influence of inequality swings.

References

Adam, K. and Zhu, J. "Price level changes and the redistribution of nominal wealth across the euro area", September 2015. ECB, Working Paper Series.

Alesina, A. and Perotti, R. "Income Distribution, Political Stability and Investment". *European Economic Review*, 40 (6), 1203–1228, 1996.

Alesina, A. and Rodrik, D. "Distributive Politics and Economic Growth". *Quarterly Journal of Economics*, 109 (2), 465–490, 1994.

Alichi, A., Kantenga, K., and Solé, J. "Income Polarization in the United States", June 2016. IMF Working Paper.

Auclert, A. "Monetary Policy and the Redistribution Channel", 2015. PhD Job Market Paper.

Bakshi, G. and Chen., Z. "The Spirit of Capitalism and Stock-Market Prices". *American Economic Review*, 86 (1), 133–157, 1996.

Banrejee, A. and Duflo, E. "Inequality and Growth: What Can the Data Say?" *Journal of Economic Growth*, 8, 267–299, 2003.

Barro, R. "Inequality and Growth in a Panel of Countries". *Journal of Economic Growth*, 5 (1), 5–32, 2000.

Bernanke, B. "Monetary policy and inequality", June 2015. Brookings Institution, blog.

Boivin, J. and Giannoni, M. "DSGE MODELS IN A DATA-RICH ENVIRONMENT", December 2006. NBER Working Paper No. 332.

Bullard, J. "Income Inequality and Monetary Policy: A Framework with Answers to Three Questions", June 2014. C. Peter McColough Series on International Economics Council of Foreign Relations, New York, N.Y.

Cairó, I. and Sim, J. "Income Inequality, Financial Crises, and Monetary Policy", 2018. Finance and Economics Discussion Series 2018-048. Washington: Board of Governors of the Federal Reserve System.

Carroll, C. D. "Why Do the Rich Save So Much?" In J. B. Slemrod, ed., "Does Atlas Shrug? The Economic Consequences of Taxing the Rich.", Cambridge, MA:Harvard University Press, 2000.

Carroll, C. D., Slacalek, J., Tokuoka, K., and White, M. N. "The Distribution of Wealth and the Marginal Propensity to Consume", March 2015. Working Paper 1655, European Central Bank.

Casiraghi, M., Gaiotti, E., Rodano, L., and Secchi, A. "A "reverse Robin Hood"? The distributional implications of non-standard monetary policy for Italian households", July 2016. Banca D'Italia, Working Paper Series.

Chan, J. C. C. and Jeliazkov, I. "Efficient Simulation and Integrated Likelihood Estimation in State Space Models". *International Journal of Mathematical Modelling and Numerical Optimisation*, 1, 101–120, 2009.

Charalampidis, N. "On Unemployment And Wage Cycles: Euro Area 1999–2016", 2018. Working Paper.

Chen, H., Cùrdia, V., and Ferrero, A. "The Macroeconomic Effects of Large-Scale Asset Purchase Programmes". *The Economic Journal*, 122, F289–F315, November 2012.

Chib, S. "Marginal Likelihood from the Gibbs Output". *ournal of the American Statistical Association*, 90, 1313–1321, 1995.

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

Christiano, L., Eichenbaum, M., and Tranbandt, M. "On DSGE Models". *Journal of Economic Perspectives*, 32 (3), 113–140, 2018.

Coeuré, B. "What can monetary policu do about inequality?", October 2012. Speach, International Day for the Eradication of Poverty, Intergroup "Extreme Poverty and Human Rughts, Fourth World Committee" event, European Parliament.

Coibion, O., Gorodnichenko, Y., Kudlyak, M., and Modragon, J. "Does Greater Inequality Lead to More Household Borrowing? New Evidence from Household Data", January 2014. Working Paper.

Coibion, O., Gorodnichenko, Y., Kueng, L., and Silvia, J. "Innocent Bystanders? Monetary Policy and Inequality". *Journal of Monetary Economics*, 88 (C), 70–89, 2016.

Curdia, V. and Woodford, M. "Credit Spreads and Monetary Policy". *Journal of Money, Credit and Banking*, 42 (s1), 3–35, September 2010.

De Giorgi, G. and Gambetti, L. "Business cycle fluctuations and the distribution of consumption". *Review of Economic Dynamics*, 23, 19–41, 2017.

Debortoli, D. and Galí, J. "Monetary Policy with Heterogeneous Agents: Insights from TANK models", 2018. Working Paper.

Doepke, M. and Schneider, M. "Inflation and the Redistribution of Nominal Wealth". *Journal of Political Economy*, 114 (6), 1069–1097, 2006.

Doepke, M., Schneider, M., and Selezneva, V. "Distributional Effects of Monetary Policy", 2015. Working Paper.

Draghi, M. "Stability, equity and monetary policy", October 2016. 2nd DIW Europe Lecture, German Insttute for Economic Reseach (DIW).

Eggertsson, G. and Krugman, P. "Debt, Deleveraging, and the Liquidity Trap: A Fisher-

Minsky-Koo approach". *Quarterly Journal of Economics*, 127 (3), 1469–1513, 2012.

Erceg, C., Henderson, D., and Levin, A. "Optimal Monetary Policy with Staggered Wage and Price Contracts". *Journal of Monetary Economics*, 46 (2), 281–314, 2000.

Fagereng, A., Guiso, L., Malacrino, D., and Pistaferri, L. "Heterogeneity and Persistence in Returns to Wealth", July 2018. IMF Working Paper WP/18/171.

Fisher, J. "On the Structural Interpretation of the Smets-Wouters "Risk Premium" Shock". *Journal of Money, Credit and Banking*, 47 (2-3), 511–516, 2015.

Francis, J. "Wealth and the capitalist spirit". *Journal of Macroeconomics*, 31, 394–408, 2009.

Furceri, D., Loungani, P., and Zdzienicka, A. "The Effects of Monetary Policy Shocks on Inequality", December 2016. IMF Working Paper.

Galí, J., Smets, F., and Wouters, R. "Slow Recoveries: A Structural Interpretation". *Journal of Money, Credit and Banking*, 44 (2), 9–30, December 2012a.

Galí, J., Smets, F., and Wouters, R. "Unemployment in an estimated New Keynesian model". In D. Acemoglou and M. Woodford, eds., "NBER Macroeconomics Annual 2011", vol. 26, pp. 329–30. University of Chicago Press, 2012b.

Gelain, P., Lansing, K., and Natvik, G. "Explaining the Boom-Bust Cycle in the U.S. Housing Market: A Reverse Engineering Approach". *Journal of Money, Credit, and Banking*, 50, 1751–1782, 2018a.

Gelain, P., Lansing, K., and Natvik, G. "Leaning Against the Credit Cycle". *Journal of the European Economic Association*, 16, 1350–1393, 2018b.

Gornemann, N., Kuester, K., and Nakajima, M. "Doves for the Rich, Hawks for the Poor? Distributional Consequences of Monetary Policy", March 2014. Working Paper.

Greenspan, A. "Income Inequality: Issues and Policy Options", August 1998. Remarks by Chairman Alan Greenspan at a symposium sponsored by the Federal Reserve Bank of Kansas.

Guerello, C. "Conventional and Unconventional Monetary Policy vs. Household Income Distribution: An Empirical Analysis for the Euro Area". *Journal of International Money and Finance*, 85, 187–214, 2017.

Heathcote, J., Perri, F., and Violante, G. "Unequal We Stand: An Empirical Analysis of Economic Inequality in the United States, 1967-2006". *Review of Economic Dynamics*, 13 (1), 15–51, 2010.

Iacoviello, M. "House Prices, Borrowing Constraints, and Monetary Policy in the Business Cycle". *American Economic Review*, 95 (3), 739–764, June 2005.

Iacoviello, M. "Household Debt and Income Inequality, 1963-2003". *Journal of Money, Credit and Banking*, 40 (5), 929–965, 2008.

Iacoviello, M. and Neri, S. "Housing Market Spillovers: Evidence from an Estimated DSGE Model". *American Economic Journal: Macroeconomics*, 2 (2), 125–164, 2010.

Justiniano, A., Primiceri, G., and Tambalotti, A. "Is There a Trade-Off Between Inflation and Output Stabilization?" *American Economic Journal: Macroeconomics*, 5 (2), 1–31, 2013.

Justiniano, A., Primiceri, G., and Tambalotti, A. "Household leveraging and deleveraging". *Review of Economic Dynamics*, 18 (1), 3–20, 2015.

Kaplan, G., Moll, B., and Violante, G. "Monetary Policy according to HANK". *American Economic Review*, 108 (3), 697–743, 2018.

Kaplan, G. and Violante, G. "A Model of the Consumption Response to Fiscal Stimulus Payments". *Econometrica*, 82 (4), 1199–1239, July 2014.

Kiyotaki, N. and Moore, J. "Credit Cycles". *Journal of Political Economy*, 105 (2), 211–248, 1997.

Kopczuk, W., Saez, E., and Song, J. "Earnings Inequality and Mobility in the United States: Evidence from Social Security Data since 1937." *Quarterly Journal of Economics*, 125 (1), 91–128, 2010.

Krishnamurthy, A. and Vissing-Jorgensen, A. "The Aggregate Demand for Treasury Debt".

Journal of Political Economy, 120 (2), 233–267, 2012.

Kumhof, M., Ranciere, R., and Winant, P. "Inequality, Leverage, and Crises". *American Economic Review*, 105 (3), 1217–45, 2015.

Kurz, M. "Optimal Economic Growth and Wealth Effects". *International Economic Review*, 9 (3), 348–357, 1968.

Lansing, K. and Markiewicz, A. "Top Incomes, Rising Inequality, and Welfare". *Economic Journal*, 128, 262–297, 2018.

Lee, J. "Aggregate Implications of Heterogeneous Households in a Sticky-Price Model". *Journal of Money, Credit and Banking*, 44 (1), 1–22, February 2012.

Lenza, M. and Slacalek, J. "How Does Monetary Policy Affect Income and Wealth Inequality? Evidence from Quantitative Easing in the Euro Area", October 2018. Working Paper.

Levin, A., Wieland, V., and Williams, J. "Robustness of Simple Monetary Policy Rules under Model Uncertainty". In J. Taylor, ed., "Monetary policy rules", pp. 263–299. University of Chicago Press, 1999.

Luo, Y. and Zou, H. "The Spirit of Capitalism, Precautionary Savings, and Consumption". *Journal of Money, Credit and Banking*, 41, 543–554, 2009.

McKinsey Global Institute. "Q.E. and ultra-low interest rates: Distributional effects and risks". Tech. rep., McKinsey Global Institute, November 2013.

Mersch, Y. "Monetary policy and inequality", October 2014. Keynote speech, Corporate Credit Conference, Zurich 2014.

Mian, A. and Sufi, A. "Finance and Business Cycles: The Credit-Driven Household Demand Channel". *Journal of Economic Perspectives*, 32 (3), 31–58, 2018.

Michaillat, P. and Saez, E. "An Economical Business-Cycle Model", April 2015. NBER Working Paper 19777.

Mumtaz, H. and Theophilopoulou, A. "The Impact of Monetary Policy on Inequality in the UK. An Empirical Analysis". *European Economic Review*, 98, 410–423, 2017.

Panetta, F. "The Distributional Consequences of Monetary Policy", November 2015. Remarks.

Paul, P. "Historical Patterns of Inequality and Productivity around Financial Crises", September 2017. Federeal Reserve Bank of San Francisco.

Persson, T. and Tabellini, G. "Is Inequality Harmful for Growth?" *American Economic Review*, pp. 600–621, 1994.

Phillippon, T. and Reshef, A. "Wages and Human Capital in the U.S. Finance Industry: 1909-2006". *Quarterly Journal of Economics*, 127 (4), 1551–1609, 2012.

Piketty, T. and Saez, E. "Income Inequality in the United States, 1913-1998". *Quarterly Journal of Economics*, 118 (1), 1–39, 2003.

Piketty, T. and Saez, E. "Optimal Labor Income Taxation". In "Handbook of Public Economics", vol. 5. Elsevier B.V., 2013.

Piketty, T., Saez, E., and Stantcheva, S. "Optimal Taxation of Top Labor Incomes: A Tale of Three Elasticities". *American Economic Journal: Economic Policy*, 6 (1), 230–271, 2014.

Ravenna, F. and Vincent, N. "A Note on Inequality and Debt in a Model with Heterogeneous Agents". *Economics Letters*, 123 (2), 2014.

Romer, C. and Romer, D. "Monetary Policy and the Well-Being of the Poor", August 1998. Federal Reserve Bank of Kansas City's 1998 Symposium.

Saez, E. and Zucman, G. "Wealth Inequality in the United States since 1913: Evidence from Capitalized Income Tax Data". *Quarterly Journal of Economics*, 131 (2), 519–578, 2016.

Sidrauski, M. "Rational Choice and Patterns of Growth in a Monetary Economy". *American Economic Review*, 57 (2), 534–544, 1967.

Sims, C. A. "Solving Linear Rational Expectations Models". *Computational Economics*, 20 (1-2), 1–20, 2002.

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

Sterk, V. and Tenreyro, S. "The Transmission of Monetary Policy through Redistributions and Durable Purchases", May 2015. Working Paper.

Stiglitz, J. "New Theoretical Perspectives on the Distribution of Income and Wealth among Individuals", 2014. Working Paper.

Stiglitz, J. "Fed Policy, Inequality, and Equality of Oppotunity", April 2015. Remarks Prepared for Delivary at The Ninth Biennial Federal Resereve System Community Development Research Conference.

Tokuoka, K. "Is wealth accumulation a luxury good?" *Economics Letters*, 115, 523–527, 2012.

Walsh, C. "Workers, Capitalists, Wage Flexibility and Welfare", July 2017. Working Paper.

Werning, I. "Incomplete Markets and Aggregate Demand", September 2015. Working Paper.

Zou, H. "The Spirit Of Capitalism And Rational Bubbles". *Macroeconomic Dynamics*, 1-26 2015.

Zou, H.-F. "The Spirit of Capitalism, Social Status, Money, and Accumulation". *Journal of Economics*, 68, 219–233, 1998.

Appendices

(not for printed publication; for online reference only)

A Model

A.1 Nonlinear.

This section collects the nonlinear non-stationary equilibrium equations.

A.1.1 Households. The first order equilibrium conditions for μ family read as follows:

$$\Xi_t^\mu = 1/\left[C_t^\mu - \eta C_{t-1}^\mu\right] \tag{A.1}$$

$$\Xi_t^\mu = E_t \beta^\mu \Xi_{t+1}^\mu e^{\upsilon_t^b} R_t/\Pi_{t+1} + \Lambda_t^\mu \tag{A.2}$$

$$\begin{aligned}\Xi_t^\mu Q_t \left[1 + S'_\omega\left(\frac{\Omega_t^\mu}{\Omega_{t-1}^\mu}\right)\right] = \beta^\mu E_t \Xi_{t+1}^\mu Q_{t+1}\left[1 - S_\omega\left(\frac{\Omega_{t+1}^\mu}{\Omega_t^\mu}\right) + \frac{\Omega_{t+1}^\mu}{\Omega_t^\mu} S'_\omega\left(\frac{\Omega_{t+1}^\mu}{\Omega_t^\mu}\right)\right] \\ + \frac{\phi^\mu \upsilon_t^\omega}{\Omega_t^\mu} + \Xi_t^\mu V_t + \Lambda_t^\mu m_t E_t\left(\frac{Q_{t+1}\Pi_{t+1}}{e^{\upsilon_t^b} R_t}\right)\end{aligned} \tag{A.3}$$

$\{\Xi_t^\mu, \Lambda_t^\mu\}$ are the multipliers associated with the budget constraints. (A.1) pins down the multiplier, (A.2) describes the inter-temporal consumption substitution, and (A.3) governs the inter-temporal wealth accumulation. The marginal rate of substitution between j-type labor and consumption is:

$$W_t^{i,h,r}(j) = \theta(L_t^i(j))^\chi/\Xi_t^i = \theta(L_t(j))^\chi/\Xi_t^\mu \tag{A.4}$$

The first order equilibrium conditions for τ family read as follows:

$$\Xi_t^\tau = 1/\left[C_t^\tau - \eta C_{t-1}^\tau\right] \tag{A.5}$$

$$\Xi_t^\tau = E_t \beta^\tau \Xi_{t+1}^\tau e^{\upsilon_t^b} R_t/\Pi_{t+1} \tag{A.6}$$

$$\begin{aligned}\Xi_t^\tau Q_t \left[1 + S'_\omega\left(\frac{\Omega_t^\tau}{\Omega_{t-1}^\tau}\right)\right] = \beta^\tau E_t \Xi_{t+1}^\tau Q_{t+1}\left[1 - S_\omega\left(\frac{\Omega_{t+1}^\tau}{\Omega_t^\tau}\right) + \frac{\Omega_{t+1}^\tau}{\Omega_t^\tau} S'_\omega\left(\frac{\Omega_{t+1}^\tau}{\Omega_t^\tau}\right)\right] \\ + \frac{\phi^\tau \upsilon_t^\omega}{\Omega_t^\tau} + \Xi_t^\tau V_t\end{aligned} \tag{A.7}$$

where $\{\Xi_t^\tau\}$ is the multiplier associated with the budget constraint. The marginal rate of substitution between labor and consumption for labor type "j" of family i is given by:

$$W_t^{i,h,r}(j) = \theta(L_t^i(j))^\chi/\Xi_t^i = \theta(L_t(j))^\chi/\Xi_t^\tau \tag{A.8}$$

A.1.2 Capital Production. The optimization problem of the capital producing firm (2.7) pins down the equilibrium rental rate of capital:

$$R_t^{k,r} \equiv R_t^k / P_t = a'(u_t) \tag{A.9}$$

The price of capital, Q_t^k, is determined by

$$Q_t^k / P_t = E_t(\Xi_{t+1}^{avg} / \Xi_t^{avg}) \left[(R_{t+1}^k / P_{t+1}) u_{t+1} - a(u_{t+1}) + (1-\delta) Q_{t+1}^k / P_{t+1} \right] \tag{A.10}$$

Investment dynamics are pinned down by

$$1 = \frac{Q_t^k}{P_t} \upsilon_t^i \left[1 - S\left(\frac{I_t}{I_{t-1}}\right) - \frac{I_t}{I_{t-1}} S'\left(\frac{I_t}{I_{t-1}}\right) \right] + E_t \frac{\Xi_{t+1}^{avg}}{\Xi_t^{avg}} \frac{Q_{t+1}^k}{P_{t+1}} \upsilon_{t+1}^i \left(\frac{I_{t+1}}{I_t}\right)^2 S'\left(\frac{I_{t+1}}{I_t}\right) \tag{A.11}$$

A.1.3 Intermediate Good Firms. Maximization of (2.11) yields the optimal price for an optimizing firm as the weighted average of current and future marginal costs:

$$E_t \sum_{s=0}^{+\infty} (\zeta_p)^s \left[\frac{\Xi_{t+s}^{avg} P_t}{\Xi_t^{avg} P_{t+s}} \right] Y_{t+s|t}(i) (\lambda_{p,t+s} - 1) \left[P_t^\circ(i) X_{t,s}^p - \frac{\lambda_{p,t+s}}{\lambda_{p,t+s} - 1} MC_{t+s} \right] = 0 \tag{A.12}$$

Taking into account the infrequent price adjustment and that all optimizing firms choose the same price P_t°, the evolution of the aggregate price index (2.8) is described by

$$P_t = \left[(1-\zeta_p)(P_t^\circ)^{1-\lambda_{p,t}} + \zeta_p \left(\Pi_{t-1}^{\iota_p} \Pi^{1-\iota_p} P_{t-1} \right)^{1-\lambda_{p,t}} \right]^{1/(1-\lambda_{p,t})} \tag{A.13}$$

A.1.4 Labor Unions. Maximization of (2.14) yields the optimal wage, W_t°, chosen by all re-optimizing unions:

$$E_t \sum_{s=0}^{+\infty} (\zeta_w)^s \left[\frac{\Xi_{t+s}^{avg} P_t}{\Xi_t^{avg} P_{t+s}} \right] L_{t+s}(j) (\lambda_{w,t+s} - 1) \left[W_t^\circ X_{t,s}^w - \frac{\lambda_{w,t+s}}{\lambda_{w,t+s} - 1} W_{t+s}^h(j) P_{t+s} \right] = 0 \tag{A.14}$$

The aggregate wage is given by:

$$W_t = \left[(1-\zeta_w)(W_t^\circ)^{1-\lambda_{w,t}} + \zeta_w \left(e^\gamma \Pi_{t-1}^{\iota_w} \Pi^{1-\iota_w} W_{t-1} \right)^{1-\lambda_{w,t}} \right]^{1/(1-\lambda_{w,t})} \tag{A.15}$$

A.2 Stationary Model.

Trend growth is given by $Z_t = Z_{t-1} e^\gamma$. I render the model stationary before estimating it. Small letters denote stationary real variables, e.g. $c_t^j = C_t^j / Z_t$, $b_t^j = B_t^j / (P_t Z_t)$ for $j \in \{\mu, \tau\}$, $y_t = Y_t / Z_t$, $k_t = K_t / Z_t$, $v_t = V_t / Z_t$, $div_t = Div_t / Z_t$, $\pi_t^{int} = \Pi_t^{int} / Z_t$. The multipliers read as: $\xi_t^j = \Xi_t^j Z_t$ for $j \in \{\mu, \tau\}$, and $\lambda_t^\mu = \Lambda_t^\mu Z_t$. The real price of equity is $q_t = Q_t / Z_t$; the real rental rate of capital is $r_t^{k,r} = R_t^k / P_t$. The real capital price is: $q_t^k = Q_t^k / P_t$. The equity shares are stationary by construction and re-expressed with small letters: $\omega_t^j \equiv \Omega_t^j / 1$.

A.2.1 Households. The first order conditions (A.1-A.3) for the middle class become:

$$\xi_t^\mu = 1/\left[c_t^\mu - \eta c_{t-1}^\mu/(e^\gamma)\right] \tag{A.16}$$

$$\xi_t^\mu = E_t \beta^\mu \xi_{t+1}^\mu \frac{1}{e^\gamma}\frac{e^{\upsilon_t^b} R_t}{\Pi_{t+1}} + \lambda_t^\mu \tag{A.17}$$

$$\xi_t^\mu q_t \left[1 + S'_\omega\left(\frac{\omega_t^\mu}{\omega_{t-1}^\mu}\right)\right] = \beta^\mu E_t \xi_{t+1}^\mu q_{t+1}\left[1 - S_\omega\left(\frac{\omega_{t+1}^\mu}{\omega_t^\mu}\right) + \frac{\omega_{t+1}^\mu}{\omega_t^\mu} S'_\omega\left(\frac{\omega_{t+1}^\mu}{\omega_t^\mu}\right)\right] + \\ + \frac{\phi^\mu \upsilon_t^\omega}{\omega_t^\mu} + \xi_t^\mu v_t + \lambda_t^\mu e^\gamma m_t E_t\left(\frac{q_{t+1}\Pi_{t+1}}{e^{\upsilon_t^b} R_t}\right) \tag{A.18}$$

while those for the top (A.5–A.7) read as:

$$\xi_t^\tau = 1/\left[c_t^\tau - \eta c_{t-1}^\tau/(e^\gamma)\right] \tag{A.19}$$

$$\xi_t^\tau = E_t \beta^\tau \xi_{t+1}^\tau \frac{1}{e^\gamma}\frac{e^{\upsilon_t^b} R_t}{\Pi_{t+1}} \tag{A.20}$$

$$\xi_t^\tau q_t \left[1 + S'_\omega\left(\frac{\omega_t^\tau}{\omega_{t-1}^\tau}\right)\right] = \beta^\tau E_t \xi_{t+1}^\tau q_{t+1}\left[1 - S_\omega\left(\frac{\omega_{t+1}^\tau}{\omega_t^\tau}\right) + \frac{\omega_{t+1}^\tau}{\omega_t^\tau} S'_\omega\left(\frac{\omega_{t+1}^\tau}{\omega_t^\tau}\right)\right] + \\ + \frac{\phi^\tau \upsilon_t^\omega}{\omega_t^\tau} + \xi_t^\tau v_t \tag{A.21}$$

The budget constraints (2.3) and (2.6) for the bottom become:

$$c_t^\mu - \frac{b_t^\mu}{e^{\upsilon_t^b} R_t} + q_t\left[\omega_t^\mu - \left(1 - S_\omega\left(\omega_t^\mu/\omega_{t-1}^\mu\right)\right)\omega_{t-1}^\mu\right] + t_t^\mu = \frac{S_t w_t^r L_t}{n^\mu} - \frac{b_{t-1}^\mu}{e^\gamma \Pi_t} + \omega_t^\mu v_t \tag{A.22}$$

and

$$b_t^\mu/[e^{\upsilon_t^b} R_t] \leq m_t E_t\left(q_{t+1}\omega_t^\mu \Pi_{t+1} e^\gamma/[e^{\upsilon_t^b} R_t]\right) \tag{A.23}$$

A.2.2 Capital Producers. The effective capital and the rental rate read as

$$k_t = u_t \bar{k}_{t-1}\frac{1}{e^\gamma} \quad \textit{and} \quad R_t^{k,r} = a'(u_t) \tag{A.24}$$

Period-t (real) dividends (2.7) are given by

$$div_t \equiv R_t^{k,r} k_t - a(u_t)\bar{k}_{t-1}\frac{1}{e^\gamma} - i_t - \Phi_k \tag{A.25}$$

The law of capital accumulation (**??**) becomes:

$$\bar{k}_t = (1-\delta)\bar{k}_{t-1}\frac{1}{e^\gamma} + \upsilon_t^i\left(1 - S\left(\frac{i_t}{i_{t-1}}e^\gamma\right)\right) i_t \tag{A.26}$$

The dynamics of the price of capital (A.10) are pinned down by the following condition:

$$q_t^k = E_t\left(\frac{\xi_{t+1}^{avg}}{\xi_t^{avg}}\frac{1}{e^\gamma}\right)\left[R_{t+1}^{r,k} u_{t+1} - a(u_{t+1}) + (1-\delta) q_{t+1}^k\right] \tag{A.27}$$

Investment dynamics are governed by

$$1 = q_t^k \upsilon_t^i \left[1 - S\left(\frac{i_t}{i_{t-1}}e^{\gamma}\right) - \frac{i_t}{i_{t-1}}e^{\gamma} S'\left(\frac{i_t}{i_{t-1}}e^{\gamma}\right)\right] + E_t \frac{\xi_{t+1}^{avg}}{\xi_t^{avg} e^{\gamma}} q_{t+1}^k \upsilon_{t+1}^i \left(\frac{i_{t+1}}{i_t}e^{\gamma}\right)^2 S'\left(\frac{i_{t+1}}{i_t}e^{\gamma}\right) \tag{A.28}$$

A.2.3 Average Stochastic Discount Factor. The stationary factor reads as

$$\xi_{t+s}^{avg}/\xi_t^{avg} \equiv (\beta^{\tau})^s [n^{\tau}\xi_{t+s}^{\tau} + n^{\mu}\xi_{t+s}^{\mu}]/[n^{\tau}\xi_t^{\tau} + n^{\mu}\xi_t^{\mu}] \tag{A.29}$$

A.2.4 Intermediate Good. The production function (2.9) reads as:

$$y_t(i) = e^{\widehat{z}_t} k_t^{\alpha}(i) L_t(i)^{1-\alpha} - \Phi_y \tag{A.30}$$

The capital-labor ratio reads as

$$k_t(i)/L_t(i) = [\alpha/(1-\alpha)](W_t/P_t Z_t)/(R_t^k/P_t) = [\alpha/(1-\alpha)](w_t^r/R_t^{k,r}) \tag{A.31}$$

and the (real) marginal cost (2.10) as:

$$mc_t^r \equiv MC_t/P_t = (\alpha)^{-\alpha}(1-\alpha)^{-(1-\alpha)}(w_t^r)^{(1-\alpha)}(R_t^{k,r})^{\alpha} e^{-\widehat{z}_t} \tag{A.32}$$

Aggregate (real) profits in the intermediate good sector are:

$$\pi_t^{int} \equiv \Pi_t^{int}/Z_t = y_t - w_t^r L_t - R_t^{k,r} k_t \tag{A.33}$$

The optimal price for optimizing firms (A.12) is determined by

$$E_t \sum_{s=0}^{+\infty} (\zeta_p)^s \left[\xi_{t+s}^{avg}/\xi_t^{avg}\right] \left(X_{t,s}^p/P_{t+s}\right)^{-\lambda_{p,t+s}} y_{t+s} \frac{1}{\upsilon_{t+s}^p} \left[\frac{P_t^{\circ,r} X_{t,s}^p}{\prod_{l=1}^s \Pi_{t+l}} - (1+\upsilon_{t+s}^p) mc_{t+s}^r\right] = 0 \tag{A.34}$$

where $P_t^{\circ,r} \equiv P_t^{\circ}/P_t$ and the time-varying price markup is redefined as $(1+\upsilon_t^p) \equiv \lambda_t^p/(\lambda_t^p - 1)$, that is, $\lambda_t^p = 1 + 1/\upsilon_t^p$. The evolution of the aggregate price index (A.13) is described by

$$1 = (1-\zeta_p)(P_t^{\circ,r})^{1-\lambda_t^p} + \zeta_p \left(\Pi_{t-1}^{\iota_p} \Pi^{1-\iota_p}/\Pi_t\right)^{1-\lambda_t^p} \tag{A.35}$$

A.2.5 Labor Demand. Labor demand for type "j" workers and the aggregate wage (2.12) are given by:

$$L_t(j) = \left(\frac{w_t(j)}{w_t}\right)^{-\lambda_t^w} L_t \quad \textit{and} \quad w_t = \left(\int w_t(j)^{1-\lambda_t^w} dj\right)^{1/(1-\lambda_t^w)} \tag{A.36}$$

The labor disutility (2.13) expressed in terms of the final good is given by

$$w_t^h(j) = W_t^h(j)/Z_t = \theta(L_t(j))^{\chi}[n^{\mu}/\xi_t^{\mu} + n^{\tau}/\xi_t^{\tau}] \tag{A.37}$$

The first order condition determining the (real) optimal wage (A.14) $w_t^{\circ} = w_t^{\circ}(j)$ is given by

$$E_t \sum_{s=0}^{+\infty} (\zeta_w)^s \left[\xi_{t+s}^{avg}/\xi_t^{avg}\right] \frac{1}{\upsilon_{t+s}^w} \left[\frac{w_t^{\circ,r} X_{t,s}^w}{e^{\sum_{l=1}^s(\gamma)} \prod_{l=1}^s \Pi_{t+l}} - (1+\upsilon_{t+s}^w) w_{t+s}^h(j) \right] L_{t+s}(j) = 0 \quad \text{(A.38)}$$

The gross time-varying wage markup is redefined as $(1+\upsilon_t^w) \equiv \lambda_t^w/(\lambda_t^w - 1)$. The (real) aggregate wage reads as:

$$w_t^r = \left[(1-\zeta_w)(w_t^{\circ,r})^{1-\lambda_{w,t}} + \zeta_w \left(e^\gamma \Pi_{t-1}^{\iota_w} \Pi^{1-\iota_w} w_{t-1}^r / [e^\gamma \Pi_t] \right)^{1-\lambda_{w,t}} \right]^{1/(1-\lambda_{w,t})} \quad \text{(A.39)}$$

A.2.6 Policy. The following equation describes the policy rule (2.15) in the stationary model

$$\frac{R_t}{R} = \left(\frac{R_{t-1}}{R}\right)^{\rho_r} \left[\left(\frac{\Pi_t}{\Pi}\right)^{\psi_\pi} \left(\frac{y_t}{y_t^f}\right)^{\psi_y} \left(\frac{y_t/y_{t-1}}{y_t^f/y_{t-1}^f} \right)^{\psi_{\Delta y}} \right]^{1-\rho_r} e^{\upsilon_{mp,t}} \quad \text{(A.40)}$$

A.2.7 Aggregation. Aggregate consumption is the weighted sum of type-specific consumption profiles: $c_t = n^\tau c_t^\tau + n^\mu c_t^\mu$. The labor and capital aggregates are given by $L_t = \int_0^1 L_t(i)di$ and $k_t = \int_0^1 k_t(i)di$, respectively. Market clearing in the debt market dictates $n^\tau b_t^\tau = n^\mu b_t^\mu$, and in the equity market: $n^\tau \omega_t^\tau + n^\mu \omega_t^\mu = \omega_t \equiv 1$, where the sum of all equity shares is normalized to unity. Aggregate output is given by $D_t y_t = e^{\widehat{z}_t} k_t^\alpha L_t^{1-\alpha} - \Phi_y$. Aggregate profits in the intermediate good sector are $\{\pi_t^{int} \equiv y_t - w_t^r L_t - R_t^{k,r} k_t\}$. The period-t dividends of the fund managing capital production are given by $\{div_t \equiv R_t^{k,r} k_t - a(u_t)\bar{k}_{t-1}/e^\gamma - i_t - \Phi_k\}$. Thus, economy wide profits are: $\upsilon_t = \pi_t^{int} + div_t$. The resource constraint (2.16) becomes:

$$y_t = c_t + i_t + g_t + ac_t + \Phi_k \quad \text{(A.41)}$$

$$ac_t = a(u_t)\bar{k}_{t-1}e^{-\gamma} + q_t \left[n^\mu \omega_{t-1}^\mu S_\omega \left(\omega_t^\mu/\omega_{t-1}^\mu\right) + n^\tau \omega_{t-1}^\tau S_\omega \left(\omega_t^\tau/\omega_{t-1}^\tau\right) \right] \quad \text{(A.42)}$$

A.3 Steady State

A.3.1 Economy wide variables. Examining the solution of the steady state reveals that the steady state of economy wide aggregates coincides with that derived from the representative agent model. The following normalizations are considered: $u = 1$, $a(1) = 0$, $S(e^\gamma) = S'(e^\gamma) = 0$, $S''(e^\gamma) \equiv S''$, $\delta = 0.025$, $g/y = 0.18$. The (net) markups υ_p and υ_w are estimated in this paper. The real marginal cost is given by eq.(A.34): $mc^r = 1/(1+\upsilon_p)$, with eq.(A.35) implying $P^{\circ,r} = P^\circ/P = 1$. The price of capital in (A.28) becomes $q^k = 1$, and the real rental rate of capital in (A.27) and (A.24) reads as: $R^{k,r} = (e^\gamma/\beta) - (1-\delta) = a'(1)$. The effective and raw capital are connected through eq.(A.24): $k = \bar{k}/e^\gamma$. The latter combined with the capital accumulation equation (A.26) yields the investment-to-output

ratio: $i/y = (k/y)(e^{\gamma} - (1-\delta))$. Fixed costs in capital production (A.25) are set in order to yield zero steady state dividends: $\Phi_k/y = R^{k,r}k/y - i/y$. Eq.(A.32) pins down the steady state real wage: $w^r = [mc^r(\alpha)^{\alpha}(1-\alpha)^{(1-\alpha)}(R^{k,r})^{-\alpha}]^{1/(1-\alpha)}$. The capital-to-labor ratio is given by (A.31): $k/L = [\alpha/(1-\alpha)](w^r/R^{k,r})$. After using the steady state analogues of equations (A.30, A.31, A.32), the aggregate profits in the intermediate good sector (A.33) become: $\Pi_t^f = y - w^r L - R^{k,r}k = [(w^r L)/(1-\alpha)][(1/mc^r) - 1] - \Phi_y$. The fixed cost term is, then, set in order to yield zero profits. The labor-to-output ratio is then given using (A.30): $L/y = (1 + \Phi_y/y)/(k/L)^{\alpha}$. The resource constraint (A.41) pins down the aggregate consumption-to-output ratio: $c/y = 1 - (g/y) - (i/y) - (\Phi_k/y)$. The government budget constraint is described by $g = t = t^{\mu} = t^{\tau}$.

The discounting between two consecutive periods is: $\xi_{+1}^{avg}/\xi^{avg} = \beta^{\tau}$ according to (A.29). The latter coincides with the discounting of the representative agent specification given the particular definition of the average discount factor. The risk-free rate is given by the Euler equation for the top (A.20):

$$R = \Pi e^{\gamma}/\beta^{\tau} \tag{A.43}$$

It coincides with the risk-free rate in the representative agent model given that the discount factor of the top (β^{τ}) is equal to the single discount factor of the representative agent model (both are fixed at 0.9995). The inverted multipliers (A.16, A.19) read as: $1/\xi^{\mu} = [1-\eta/e^{\gamma}]c^{\mu}$ and $1/\xi^{\tau} = [1-\eta/e^{\gamma}]c^{\tau}$. Equations (A.38) and (A.39) link the real wage with the marginal disutility of work expressed in terms of the final good and with the optimal wage: $w^r = w^{\circ,r} = (1+\upsilon_w)w^h$. Plugging the expressions for the multipliers in the labor disutility (A.37) implies $w^h = \theta L^{\chi}[n^{\mu}/\xi^{\mu} + n^{\tau}/\xi^{\tau}] = \theta L^{\chi}[1-\eta/e^{\gamma}][n^{\mu}c^{\mu} + n^{\tau}c^{\tau}] = \theta L^{\chi}[1-\eta/e^{\gamma}]c$. The latter condition coincides with the analogous condition of the representative agent model and allows to pin down the level of L and that of all the real variables from thereon.

A.3.2 Family-specific variables. The Euler equation for the middle class (A.17) combined with the risk free rate (A.43) yields:

$$\lambda^{\mu} = (\beta^{\tau} - \beta^{\mu})\xi^{\mu}/\beta^{\tau} \tag{A.44}$$

which is positive for $\beta^{\tau} > \beta^{\mu}$, implying that the middle class borrows from the top at the steady state. After using (A.17), the Euler equations (A.21) and (A.18) yield the share holdings across agents:

$$\omega^{\tau} q = \left[\frac{\phi^{\tau}(1-\eta/e^{\gamma})}{1-\beta^{\tau}}\right] c^{\tau} \quad \text{and} \quad \omega^{\mu} q = \left[\frac{\phi^{\mu}(1-\eta/e^{\gamma})}{1-\beta^{\mu}-(\beta^{\tau}-\beta^{\mu})m}\right] c^{\mu} \tag{A.45}$$

The last two equations suggest that the top-to-middle-clss wealth ratio ($\omega^{\tau} q/\omega^{\mu} q$) depends on three factors: i) the ratio of the strength of wealth consideration in the utility function of the top and the middle class (ϕ^{τ}/ϕ^{μ}); ii) the consumption ratio c^{τ}/c^{μ}; and iii) the difference in the magnitudes between β^{τ} and β^{μ}. The debt limit (m) also influences the top-to-middle-class ratio of ownership shares. The constraint (A.23) pins down the intra-household debt at the steady state:

$$b^{\mu} = m\Pi e^{\gamma} \omega^{\mu} q \tag{A.46}$$

Then, the market clearing condition pins down b^{τ}: $n^{\tau} b^{\tau} = n^{\mu} b^{\mu}$. The budget constraint (A.22) for an agent in the middle class reads as:

$$c^{\mu} + b^{\mu}\left[\frac{1}{\Pi e^{\gamma}} - \frac{1}{R}\right] = s w^{r} L/n^{\mu} - g \tag{A.47}$$

Plugging (A.45) in (A.46), and the result in (A.47) yields a solution for the consumption of the middle class (c^{μ}) as a function of aggregate variables already pinned down and of parameters. Then, the consumption of the top (c^{τ}) can be pinned down either from the definition of aggregate consumption ($c = n^{\tau} c^{\tau} + n^{\mu} c^{\mu}$) or the steady state expression of the budget constraint of the top. Equipped with $\{c^{\mu}, c^{\tau}\}$, I work backwards and find $\{\xi^{\mu}, \xi^{\tau}\}$ from (A.16, A.19), $\{\omega^{\mu} q, \omega^{\tau} q\}$ from (A.45), and λ^{μ} from (A.44). Given the equity levels, the intra-household debt (b^{μ}) is determined by (A.46), and the equity price (q) is found from the equity market clearing condition: $n^{\tau}\omega^{\tau} q + n^{\mu}\omega^{\mu} q = 1 \times q$. Working backwards again, one pins down $\{\omega^{\mu}, \omega^{\tau}\}$.

A.4 Log-linearized Equilibrium.

This section provides the equilibrium conditions that are log-linearized around the above steady state of deterministic growth. The log-deviation of a generic stationary variable (x_t) from its steady state (x) is denoted as $\widehat{x}_t \equiv ln(x_t/x)$. Additionally, $\widehat{r}_t^{k,r} \equiv ln(R_t^{k,r}/R^{k,r})$, $\widehat{\pi}_t \equiv ln(\Pi_t/\Pi)$, and $\widehat{r}_t \equiv ln(R_t/R)$. Since the intermediate good (π_t^{int}) and aggregate (v_t) profits, as well as the dividends (div_t), have a zero steady state value, I define their log-linearized analogues as a ratio to final output, i.e. $\widehat{v}_t = v_t/y = \widehat{\pi}_t^{int} + \widehat{div}_t = \pi_t^{int}/y + div_t/y$.

A.4.1 Households. The first order conditions for the middle class (A.16-A.18) yield

$$-(1-\eta/e^{\gamma})\widehat{\xi}_t^{\mu}=\widehat{c}_t^{\mu}-(\eta/e^{\gamma})\widehat{c}_{t-1}^{\mu} \tag{A.48}$$

$$\widehat{\xi}_t^{\mu}=\left(\frac{\beta^{\mu}R}{\Pi e^{\gamma}}\right)E_t\left(\widehat{\xi}_{t+1}^{\mu}+\widehat{v}_t^{b}+\widehat{r}_t-\widehat{\pi}_{t+1}\right)+\left(1-\frac{\beta^{\mu}R}{\Pi e^{\gamma}}\right)\widehat{\lambda}_t^{\mu} \tag{A.49}$$

$$\begin{aligned}\widehat{\omega}_t^{\mu}\left[1+\beta^{\mu}+\frac{\phi^{\mu}}{\omega^{\mu}q\xi^{\mu}S_{\omega}''}\right]+\left(\frac{1}{S_{\omega}''}\right)(\widehat{\xi}_t^{\mu}+\widehat{q}_t)&=\widehat{\omega}_{t-1}^{\mu}+\beta^{\mu}E_t\widehat{\omega}_{t+1}^{\mu}+(\beta^{\mu}/S_{\omega}'')E_t\widehat{\xi}_{t+1}^{\mu}+\\&+\left[\frac{\beta^{\mu}}{S_{\omega}''}+\frac{\lambda^{\mu}}{\xi^{\mu}}\frac{e^{\gamma}m\Pi}{S_{\omega}''R}\right]E_t\widehat{q}_{t+1}+\left(\frac{\phi^{\mu}}{\omega^{\mu}q\xi^{\mu}S_{\omega}''}\right)\widehat{v}_t^{\omega}+\left(\frac{y}{S_{\omega}''q}\right)\widehat{v}_t\\&+\left[\frac{\lambda^{\mu}}{\xi^{\mu}}\frac{e^{\gamma}m\Pi}{S_{\omega}''R}\right]E_t\left(\widehat{\lambda}_t^{\mu}+\widehat{m}_t+\widehat{\pi}_{t+1}-\widehat{r}_t-\widehat{v}_t^{b}\right)\end{aligned} \tag{A.50}$$

where $\widehat{v}_t^{b}\equiv ln(v_t^{b})$ and $\widehat{v}_t^{\omega}\equiv ln(v_t^{\omega})$.

The conditions for the top (A.19-A.21) imply

$$-(1-\eta/e^{\gamma})\widehat{\xi}_t^{\tau}=\widehat{c}_t^{\tau}-(\eta/e^{\gamma})\widehat{c}_{t-1}^{\tau} \tag{A.51}$$

$$\widehat{\xi}_t^{\tau}=E_t\left(\widehat{\xi}_{t+1}^{\tau}+\widehat{v}_t^{b}+\widehat{r}_t-\widehat{\pi}_{t+1}\right) \tag{A.52}$$

$$\begin{aligned}\widehat{\omega}_t^{\tau}\left[1+\beta^{\tau}+\frac{\phi^{\tau}}{\omega^{\tau}q\xi^{\tau}S_{\omega}''}\right]+\left(\frac{1}{S_{\omega}''}\right)(\widehat{\xi}_t^{\tau}+\widehat{q}_t)&=\widehat{\omega}_{t-1}^{\tau}+\beta^{\tau}E_t\widehat{\omega}_{t+1}^{\tau}+(\beta^{\tau}/S_{\omega}'')E_t\widehat{\xi}_{t+1}^{\tau}+\\&+\left[\frac{\beta^{\tau}}{S_{\omega}''}\right]E_t\widehat{q}_{t+1}+\left(\frac{\phi^{\tau}}{\omega^{\tau}q\xi^{\tau}S_{\omega}''}\right)\widehat{v}_t^{\omega}+\left(\frac{y}{S_{\omega}''q}\right)\widehat{v}_t\end{aligned} \tag{A.53}$$

The two budget constraints for the bottom (A.23, A.22) read as:

$$\widehat{b}_t^{\mu}=\widehat{m}_t+E_t\widehat{q}_{t+1}+\widehat{\omega}_t^{\mu}+E_t\widehat{\pi}_{t+1} \tag{A.54}$$

$$\begin{aligned}c^{\mu}\widehat{c}_t^{\mu}-(b^{\mu}/R)(\widehat{b}_t^{\mu}-\widehat{r}_t-\widehat{v}_t^{b})+(\omega^{\mu}q)(\widehat{\omega}_t^{\mu}-\widehat{\omega}_{t-1}^{\mu})&=(sw^{r}L/n^{\mu})(\widehat{w}_t^{r}+\widehat{L}_t)+(sw^{r}L/n^{\mu})\widehat{s}_t\\&-(b^{\mu}/[\Pi e^{\gamma}])(\widehat{b}_{t-1}^{\mu}-\widehat{\pi}_t)+(\omega^{\mu}y)\widehat{v}_t-g\widehat{g}_t\end{aligned} \tag{A.55}$$

where (A.55) uses the government budget constraint: $t=t^{\mu}=t^{\tau}=g$ and $\widehat{t}_t=\widehat{t}_t^{\mu}=\widehat{t}_t^{\tau}=\widehat{g}_t$. The deviation of the income share from its steady state value is defined as: $\widehat{s}_t\equiv ln(s_t/s)$.

A.4.2 Capital Production. The effective capital and the rental rate (A.24) read as

$$\widehat{k}_t=\widehat{u}_t+\widehat{\bar{k}}_{t-1}\quad\quad and\quad\quad \widehat{r}_t^{k,r}=[\psi/(1-\psi)]\widehat{u}_t \tag{A.56}$$

Period-t (real) dividends (A.25) are given by

$$\widehat{div}_t\equiv(R^{k,r}k/y)\left[\widehat{r}_t^{k,r}+\widehat{k}_t-\widehat{u}_t-\left(\frac{e^{\gamma}-1+\delta}{e^{\gamma}/\beta^{\tau}-1+\delta}\right)\widehat{i}_t\right] \tag{A.57}$$

The law of capital accumulation (A.26) becomes:

$$\widehat{\bar{k}}_t=[(1-\delta)/e^{\gamma}](\widehat{\bar{k}}_{t-1})+[1-(1-\delta)/e^{\gamma}](\widehat{v}_t^{i}+\widehat{i}_t) \tag{A.58}$$

where $\widehat{\upsilon}_t^i \equiv ln(\upsilon_t^i)$. The dynamics of the price of capital (A.27) are pinned down by:

$$\widehat{q}_t^k = E_t\left(\widehat{\xi}_{t+1}^{avg} - \widehat{\xi}_t^{avg}\right) + \left(\frac{R^{k,r}}{R^{k,r}+1-\delta}\right) E_t\widehat{r}_{t+1}^{r,k} + \left(\frac{1-\delta}{R^{k,r}+1-\delta}\right) E_t\widehat{q}_{t+1}^k \tag{A.59}$$

Investment dynamics (A.28) are governed by

$$\widehat{i}_t = \left(\frac{1}{1+\beta^\tau}\right)(\widehat{i}_{t-1}) + \left(\frac{\beta^\tau}{1+\beta^\tau}\right)(E_t\widehat{i}_{t+1}) + \left[\left(\frac{1}{1+\beta^\tau}\right)\left(\frac{1}{e^{2\gamma}S''}\right)\right](\widehat{q}_t^k + \widehat{\upsilon}_t^i) \tag{A.60}$$

A.4.3 Discounting. The average discounting (A.29) between two consecutive periods reads as

$$\widehat{\xi}_{t+1}^{avg} - \widehat{\xi}_t^{avg} = \left(\frac{n^\tau\xi^\tau}{n^\tau\xi^\tau + n^\mu\xi^\mu}\right)(\widehat{\xi}_{t+1}^{\tau} - \widehat{\xi}_t^{\tau}) + \left(\frac{n^\mu\xi^\mu}{n^\tau\xi^\tau + n^\mu\xi^\mu}\right)(\widehat{\xi}_{t+1}^{\mu} - \widehat{\xi}_t^{\mu}) \tag{A.61}$$

A.4.4 Intermediate Good. Log-linearizing the aggregate production function yields

$$\widehat{y}_t = (1+\Phi_y/y)[\alpha\widehat{k}_t + (1-\alpha)\widehat{L}_t + \widehat{z}_t] \tag{A.62}$$

The linearized equation for the capital-labor ratio(A.31) reads as

$$\widehat{k}_t = \widehat{w}_t^r - \widehat{r}_t^{k,r} + \widehat{L}_t \tag{A.63}$$

and the (real) marginal cost (A.32) as

$$\widehat{mc}_t^r = (1-\alpha)\widehat{w}_t^r + \alpha\widehat{r}_t^{k,r} - \widehat{z}_t \tag{A.64}$$

The linearized aggregate (real) profits (A.33) in the intermediate good sector are:

$$\widehat{\pi}_t^{int} \equiv \pi_t^{int}/y = \widehat{y}_t - \left(\frac{w^r L}{y}\right)(\widehat{w}_t^r + \widehat{L}_t) - \left(\frac{R^{k,r}k}{y}\right)(\widehat{r}_t^{k,r} + \widehat{k}_t) \tag{A.65}$$

Linearizing and combining equations (A.34) and (A.35) yields the Phillips curve:

$$\widehat{\pi}_t = \left(\frac{\beta^\tau}{1+\iota_p\beta^\tau}\right)E_t\widehat{\pi}_{t+1} + \left(\frac{1}{1+\iota_p\beta^\tau}\right)\widehat{\pi}_{t-1} + \left[\frac{(1-\zeta_p)(1-\zeta_p\beta^\tau)}{\zeta_p(1+\iota_p\beta^\tau)}\right]\left(\widehat{mc}_t^r + \left(\frac{\upsilon_p}{1+\upsilon_p}\right)\widehat{\upsilon}_t^p\right) \tag{A.66}$$

A.4.5 Labor Demand. Linearizing the labor demand and the wage aggregator in (A.36), the labor disutility (2.13), and the aggregate wage dynamics (A.39) and, then, plugging all those equations in the linearized condition for the optimal wage (A.38) yields:

$$\begin{aligned}\widehat{w}_t^r - \widehat{w}_{t-1}^r + \widehat{\pi}_t - \iota_w\widehat{\pi}_{t-1} &= \beta^\tau\left[E_t\widehat{w}_{t+1}^r - \widehat{w}_t^r + E_t\widehat{\pi}_{t+1} - \iota_w\widehat{\pi}_t\right] + \\ &+ \left[\frac{(1-\zeta_w)(1-\zeta_w\beta^\tau)}{\zeta_w(1+\chi\epsilon_w)}\right]\left(\chi\widehat{L}_t - \left(\frac{(n^\mu\xi^\tau)\widehat{\xi}_t^\mu + (n^\tau\xi^\mu)\widehat{\xi}_t^\tau}{n^\mu\xi^\tau + n^\tau\xi^\mu}\right) - \widehat{w}_t^r + \left(\frac{\upsilon_w}{1+\upsilon_w}\right)\widehat{\upsilon}_t^w\right)\end{aligned} \tag{A.67}$$

The latter is similar to the analogous condition of the representative agent model (B.11) with the difference been detected in the average discount factor of the right-hand-side expression.

A.4.6 Policy. The linearized policy rule is derived from (A.40):

$$\widehat{r}_t = \rho_r \widehat{r}_{t-1} + (1-\rho_r)\left[\psi_\pi \widehat{\pi}_t + \psi_y(\widehat{y}_t - \widehat{y}_t^f) + \psi_{\Delta y}\Delta(\widehat{y}_t - \widehat{y}_t^f)\right] + \epsilon_t^{mp} \tag{A.68}$$

where Δ stands for the first-difference operator.

A.4.7 Aggregation & Market Clearing. Equity and bonds market clearing imply:

$$(n^\tau \omega^\tau)\widehat{\omega}_t^\tau + (n^\mu \omega^\mu)\widehat{\omega}_t^\mu = 0 \tag{A.69}$$

$$\widehat{b}_t^\tau = \widehat{b}_t^\mu \tag{A.70}$$

Aggregate consumption is the weighted sum of family-specific consumptions:

$$\widehat{c}_t = [n^\mu c^\mu / c]\widehat{c}_t^\mu + [n^\tau c^\tau / c]\widehat{c}_t^\tau \tag{A.71}$$

The log-linearized resource constraint (A.41) reads as:

$$(c/y)\widehat{c}_t + (i/y)\widehat{i}_t + (g/y)\widehat{g}_t + (R^{k,r}k/y)\widehat{u}_t = \widehat{y}_t \tag{A.72}$$

Finally, the aggregate period-t profits distributed back to households are given by

$$\widehat{v}_t = \widehat{\pi}_t^{int} + \widehat{div}_t \tag{A.73}$$

A.4.8 Equilibrium Definition. The eight equations (A.48)–(A.53), (A.54), and (A.55) of the household side determine a solution for eight variables: $\{\widehat{\xi}_t^\mu, \widehat{\xi}_t^\tau, \widehat{\lambda}_t^\mu, \widehat{c}_t^\mu, \widehat{c}_t^\tau, \widehat{b}_t^\mu, \widehat{\omega}_t^\mu, \widehat{\omega}_t^\tau\}$. The bond holdings of the top $\{\widehat{b}_t^\tau\}$ are, then, pinned down by the bonds market clearing condition (A.70). The price of equity $\{\widehat{q}_t\}$ is pinned down by the equity market clearing condition (A.69). Aggregate consumption $\{\widehat{c}_t\}$ is given by (A.71). The six equations (A.56)–(A.60) in the capital production side determine a solution for the following six variables: $\{\widehat{\bar{k}}, \widehat{k}_t, \widehat{r}_t^{k,r}, \widehat{q}_t^k, \widehat{i}_t, \widehat{div}_t\}$. Equation (A.61) yields the average discount factor $\{\widehat{\xi}_t^{avg}\}$. The five equations (A.62)–(A.66) pin down the following five variables: $\{\widehat{y}_t, \widehat{L}_t, \widehat{\pi}_t^{int}, \widehat{\pi}_t, \widehat{mc}_t^r\}$. Equation (A.67) determines the real wage $\{\widehat{w}_t^r\}$. The nominal interest rate $\{\widehat{r}_t\}$ is found by (A.68). A solution for the utilization rate $\{\widehat{u}_t\}$ stems from the resource constraint (A.72). Aggregate profits $\{\widehat{v}_t\}$ are given by (A.73).

A.4.9 Dimensionality Reduction. To reduce the state dimensionality, $\{\xi_t^\tau, \xi_t^\mu, \widehat{\xi}_t^{avg}\}$ are substituted out of the system using equations (A.48, A.51, A.61). Similarly, the bonds and equity market clearing conditions (A.70, A.69) are used to eliminate $\{\widehat{b}_t^\mu\}$ and $\{\widehat{\omega}_t^\mu\}$. $\{\widehat{k}_t\}$ is eliminated using (A.24). $\{\widehat{mc}_t^r\}$ is substituted out using (A.64). $\{\widehat{\pi}_t^{int}, \widehat{div}_t, \widehat{v}_t\}$ are eliminated using (A.65, A.57, A.73).

A.4.10 Shocks. All the shock processes are collected in Table (A.1). Aggregate shocks (risk premium, investment, price and wage markup) are scaled exactly in the same way as in the canonical model described in Appendix B in order to preserve comparability across the two specifications. It is worth pointing out that scaling the risk premium requires making an additional adjustment at the observation equation for the top wealth share (**??**). Some distributional shocks are also scaled. In particular, income shocks ($\widehat{s}_t$) entering in the budget constraint (A.55) are scaled to enter with a coefficient of one; they are then properly adjusted in the observation equation for the top income share. Wealth shocks ($\widehat{\upsilon}_t^{\omega}$) are scaled to enter with a unitary coefficient in (A.53) and with a properly adjusted coefficient in (A.49). The shock to the debt limit ($\widehat{m}_t$) is not scaled.

Table A.1: Shock Processes

Demand Side		
1. Risk Premium	$\widehat{\upsilon}_t^b = \rho_b \widehat{\upsilon}_{t-1}^b + \epsilon_t^b$	$\epsilon_t^b \sim N(0, \sigma_b^2)$
2. Investment Adjustment Cost	$\widehat{\upsilon}_t^i = \rho_i \widehat{\upsilon}_{t-1}^i + \epsilon_t^i$	$\epsilon_t^i \sim N(0, \sigma_i^2)$
3. Government Spending	$\widehat{g}_t = \rho_g \widehat{g}_{t-1} + \epsilon_t^g + \rho_{gz}\epsilon_t^z$	$\epsilon_t^g \sim N(0, \sigma_g^2)$
4. Monetary Policy Innovation		$\epsilon_t^{mp} \sim N(0, \sigma_{mp}^2)$
Supply Side		
5. Technology	$\widehat{z}_t = \rho_z \widehat{z}_{t-1} + \epsilon_t^z$	$\epsilon_t^z \sim N(0, \sigma_z^2)$
6. Price Markup	$\widehat{\upsilon}_t^p = \rho_p \widehat{\upsilon}_{t-1}^p + \epsilon_t^p$	$\epsilon_t^p \sim N(0, \sigma_p^2)$
7. Wage Markup	$\widehat{\upsilon}_t^w = \rho_w \widehat{\upsilon}_{t-1}^w + \epsilon_t^w$	$\epsilon_t^w \sim N(0, \sigma_w^2)$
Distributional		
8. Income Shock	$\widehat{s}_t = \rho_s \widehat{s}_{t-1} + \epsilon_t^s$	$\epsilon_t^s \sim N(0, \sigma_s^2)$
9. Wealth Shock	$\widehat{\upsilon}_t^{\omega} = \rho_{\omega} \widehat{\upsilon}_{t-1}^{\omega} + \epsilon_t^{\omega}$	$\epsilon_t^{\omega} \sim N(0, \sigma_{\omega}^2)$
10. Credit Shock	$\widehat{m}_t = \rho_m \widehat{m}_{t-1} + \epsilon_t^m$	$\epsilon_t^m \sim N(0, \sigma_m^2)$

B Representative Agent Model

The representative agent specification of the present paper is essentially the Smets and Wouters (2007) model with the addition of measurement errors in the estimation, and the estimation of steady state price and wage markups. Contrary to Smets and Wouters (2007), I consider AR(1) instead of ARMA(1,1) processes for the price and wage markup shocks. The representative agent model is derived from the distributional model for $n^{\tau} = 1$ and $\phi^{\tau} = 0$. The steady state economy wide aggregates coincide across the two models. The

complete set of log-linearized equations is reported below.

Inter-Temporal Consumption

$$\widehat{c}_t = \left(\frac{1}{1+\eta/e^{\gamma}}\right)\left[E_t\widehat{c}_{t+1} + (\eta/e^{\gamma})(\widehat{c}_{t-1}) - (1-\eta/e^{\gamma})\left(\widehat{r}_t - E_t\widehat{\pi}_{t+1} - \upsilon_t^b\right)\right] \tag{B.1}$$

Capital Accumulation

$$\widehat{\bar{k}}_t = \left(\frac{1-\delta}{e^{\gamma}}\right)(\widehat{\bar{k}}_{t-1}) + \left(1 - \frac{1-\delta}{e^{\gamma}}\right)\left(\widehat{i}_t + \upsilon_t^i\right) \tag{B.2}$$

Capital Price

$$\widehat{q}_t^k = -\left(\widehat{r}_t - E_t\widehat{\pi}_{t+1} + \upsilon_t^b\right) + \left(\frac{R^{k,r}}{R^{k,r}+1-\delta}\right)E_t\widehat{r}_{t+1}^{k,r} + \left(\frac{1-\delta}{R^{k,r}+1-\delta}\right)E_t\widehat{q}_{t+1}^k \tag{B.3}$$

Investment Dynamics

$$\widehat{i}_t = \left(\frac{\beta}{1+\beta}\right)(E_t\widehat{i}_{t+1}) + \left(\frac{1}{1+\beta}\right)(\widehat{i}_{t-1}) + \left[\left(\frac{1}{1+\beta}\right)\left(\frac{1}{e^{2\gamma}S''}\right)\right]\left(\widehat{q}_t^k + \upsilon_t^i\right) \tag{B.4}$$

Capital Rental Rate

$$\widehat{r}_t^{k,r} = (\psi/(1-\psi))\,\widehat{u}_t \tag{B.5}$$

Effective Capital

$$\widehat{k}_t = \widehat{u}_t + \widehat{\bar{k}}_{t-1} \tag{B.6}$$

Capital Demand

$$\widehat{k}_t = \widehat{w}_t^r - \widehat{r}_t^{k,r} + \widehat{L}_t \tag{B.7}$$

Production Function

$$\widehat{y}_t = (1+\Phi_y/y)\left(\alpha\widehat{k}_t + (1-\alpha)\widehat{L}_t + \widehat{z}_t\right) \tag{B.8}$$

Marginal Cost

$$\widehat{mc}_t^r = (1-\alpha)\widehat{w}_t^r + \alpha\widehat{r}_t^{k,r} - \widehat{z}_t \tag{B.9}$$

Inflation

$$\widehat{\pi}_t = \left(\frac{\beta}{1+\iota_p\beta}\right)E_t\widehat{\pi}_{t+1} + \left(\frac{1}{1+\iota_p\beta}\right)\widehat{\pi}_{t-1} + \left[\frac{(1-\zeta_p)(1-\zeta_p\beta)}{\zeta_p(1+\iota_p\beta)}\right]\left(\widehat{mc}_t^r + \left(\frac{\upsilon_p}{1+\upsilon_p}\right)\widehat{\upsilon}_t^p\right) \tag{B.10}$$

Wage Dynamics

$$\widehat{w}_t^r - \widehat{w}_{t-1}^r + \widehat{\pi}_t - \iota_w\widehat{\pi}_{t-1} = \beta\left[E_t\widehat{w}_{t+1}^r - \widehat{w}_t^r + E_t\widehat{\pi}_{t+1} - \iota_w\widehat{\pi}_t\right] +$$
$$+\left[\frac{(1-\zeta_w)(1-\zeta_w\beta)}{\zeta_w(1+\chi\epsilon_w)}\right]\left(\chi\widehat{L}_t + \left(\frac{1}{1-\eta/e^{\gamma}}\right)(\widehat{c}_t - (\eta/e^{\gamma})(\widehat{c}_{t-1})) - \widehat{w}_t^r + \left(\frac{\upsilon_w}{1+\upsilon_w}\right)\widehat{\upsilon}_t^w\right) \tag{B.11}$$

Market Clearing

$$(c/y)\widehat{c}_t + (i/y)\widehat{i}_t + (g/y)\widehat{g}_t + \left(R^{k,r}k/y\right)\widehat{u}_t = \widehat{y}_t \tag{B.12}$$

Monetary Policy

$$\widehat{r}_t = \rho_r \widehat{r}_{t-1} + (1-\rho_r)\left[\psi_\pi \widehat{\pi}_t + \psi_y(\widehat{y}_t - \widehat{y}_t^f) + \psi_{\Delta y}\Delta(\widehat{y}_t - \widehat{y}_t^f)\right] + \epsilon_t^{mp} \tag{B.13}$$

B.1 Shocks.

A few shocks are scaled to enter with a coefficient of one; the risk premium shock is scaled in eq.(B.1) and adjusted accordingly in eq.(B.3); the investment adjustment cost is scaled in eq.(B.4) and adjusted accordingly in eq.(B.2); the price and wage markup shocks are scaled in equations (B.10) and (B.11), respectively; the government spending shock is scaled in eq.(B.12). These adjustments improve the converge of the sampler, introduce correlated priors, and illustrate the impact of the disturbances' prior standard deviation.

C Flexible Price And Wage Equilibrium

The flexible price and wage equilibrium is the same in both the benchmark and the representative agent models. It is derived from the above set of equations for flexible prices and wages. The variables associated with that equilibrium are denoted with the superscript "f".

D Observation Equations For Inequality Measures

In this section, I derive the observation equations (3.2) and (3.6) for the top income and wealth shares. The annual top income share (TIS_T) is given by:

$$\frac{\sum_{j=0}^{3} n^{\tau}\left[\frac{(1-s_{t-j})W^{r}_{t-j}L_{t-j}}{n^{\tau}}+\Omega^{\tau}_{t-j}V_{t-j}+\frac{B^{\tau}_{t-j-1}}{P_{t-j-1}\Pi_{t-j}}-\frac{B^{\tau}_{t-j}}{e^{\upsilon^{b}_{t-j}}R_{t-j}P_{t-j}}\right]}{\sum_{j=0}^{3}\left[W^{r}_{t-j}L_{t-j}+V_{t-j}\right]}= \tag{D.1}$$

$$\frac{\sum_{j=0}^{3} n^{\tau}\left[\frac{Z_{t-j}(1-s_{t-j})W^{r}_{t-j}L_{t-j}}{n^{\tau}Z_{t-j}}+Z_{t-j}\Omega^{\tau}_{t-j}\frac{V_{t-j}}{Z_{t-j}}+Z_{t-j}\frac{B^{\tau}_{t-j-1}}{Z_{t-j}P_{t-j-1}\Pi_{t-j}}-Z_{t-j}\frac{B^{\tau}_{t-j}}{e^{\upsilon^{b}_{t-j}}R_{t-j}P_{t-j}Z_{t-j}}\right]}{\sum_{j=0}^{3}\left[Z_{t-j}\frac{W^{r}_{t-j}L_{t-j}}{Z_{t-j}}+Z_{t-j}\frac{V_{t-j}}{Z_{t-j}}\right]}= \tag{D.2}$$

$$\frac{\sum_{j=0}^{3} n^{\tau}Z_{t-j}\left[\frac{(1-s_{t-j})w^{r}_{t-j}L_{t-j}}{n^{\tau}}+\omega^{\tau}_{t-j}v_{t-j}+\frac{b^{\tau}_{t-j-1}}{e^{\gamma+\widehat{z}_{t-j}}\Pi_{t-j}}-\frac{b^{\tau}_{t-j}}{e^{\upsilon^{b}_{t-j}}R_{t-j}}\right]}{\sum_{j=0}^{3}Z_{t-j}\left[w^{r}_{t-j}L_{t-j}+v_{t-j}\right]}= \tag{D.3}$$

$$\frac{\sum_{j=0}^{3} n^{\tau}Z_{t-j}\left[\frac{(1-se^{\widehat{s}_{t-j}})w^{r}Le^{\widehat{w}^{r}_{t-j}+\widehat{L}_{t-j}}}{n^{\tau}}+\omega^{\tau}ye^{\widehat{\omega}^{\tau}_{t-j}}\widehat{v}_{t-j}+\frac{b^{\tau}}{e^{\gamma}\Pi}e^{\widehat{b}^{\tau}_{t-j-1}-\widehat{z}_{t-j}-\widehat{\Pi}_{t-j}}-\frac{b^{\tau}}{R}e^{\widehat{b}^{\tau}_{t-j}-\widehat{v}^{b}_{t-j}-\widehat{r}_{t-j}}\right]}{\sum_{j=0}^{3}Z_{t-j}\left[w^{r}Le^{\widehat{w}^{r}_{t-j}+\widehat{L}_{t-j}}+y\widehat{v}_{t-j}\right]}= \tag{D.4}$$

$$=\ldots\,(\text{first order expansion around the steady state}) \tag{D.5}$$

$$\approx(1-s)+\left(\frac{n^{\tau}b^{\tau}}{e^{\gamma}\Pi w^{r}L}-\frac{n^{\tau}b^{\tau}}{Rw^{r}L}\right)+ \tag{D.6}$$

$$+\sum_{j=0}^{3}\nu_{j}\begin{bmatrix}-s\widehat{s}_{t-j}+\left(\frac{n^{\tau}b^{\tau}}{e^{\gamma}\Pi w^{r}L}\right)\left(\widehat{b}^{\tau}_{t-j-1}-\widehat{\pi}_{t-j}-\widehat{w}^{r}_{t-j}-\widehat{L}_{t-j}\right)+\\ -\left(\frac{n^{\tau}b^{\tau}}{Rw^{r}L}\right)\left(\widehat{b}^{\tau}_{t-j}-\widehat{r}_{t-j}-\widehat{v}^{b}_{t-j}-\widehat{w}^{r}_{t-j}-\widehat{L}_{t-j}\right)+\\ +\widehat{v}_{t-j}\left(\frac{y}{w^{r}L}\right)\left(n^{\tau}\omega^{\tau}-(1-s)-\left(\frac{n^{\tau}b^{\tau}}{e^{\gamma}\Pi w^{r}L}\right)\right)\end{bmatrix} \tag{D.7}$$

$$=\overline{tis}+\sum_{j=0}^{3}\nu_{j}\begin{bmatrix}-s\widehat{s}_{t-j}-\overline{tis}_{b}\left(\widehat{w}^{r}_{t-j}+\widehat{L}_{t-j}\right)\\ +\left(\frac{n^{\tau}b^{\tau}}{e^{\gamma}\Pi w^{r}L}\right)\left(\widehat{b}^{\tau}_{t-j-1}-\widehat{\pi}_{t-j}\right)\\ +\left(\frac{n^{\tau}b^{\tau}}{Rw^{r}L}\right)\left(\widehat{b}^{\tau}_{t-j}-\widehat{r}_{t-j}-\widehat{v}^{b}_{t-j}\right)\\ +\widehat{v}_{t-j}\left(\frac{y}{w^{r}L}\right)\left(n^{\tau}\omega^{\tau}-\overline{tis}\right)\end{bmatrix} \tag{D.8}$$

where the weights are given by: $\nu_j \equiv e^{(3-j)\gamma}/[e^{3\gamma}+e^{2\gamma}+e^{1\gamma}+1]$, and $\overline{tis} \equiv (1-s)+\left(\frac{n^{\tau}b^{\tau}}{e^{\gamma}\Pi w^{r}L}-\frac{n^{\tau}b^{\tau}}{Rw^{r}L}\right)=(1-s)+\overline{tis}_{b}$, and $\overline{tis}_{b}\equiv\left(\frac{n^{\tau}b^{\tau}(R-e^{\gamma}\Pi)}{e^{\gamma}\Pi Rw^{r}L}\right)$.

The annual wealth share (3.6) of the top includes the equity shares and the outstanding household debt measured at the end of each period, where in the denominator the assets of the top cancel out with liabilities of the middle class ($n^{\tau}B_t^{\tau} = n^{\mu}B_t^{\mu}$) and the total ownership shares in the economy are equal to one ($n^{\tau}\Omega_t^{\tau} + n^{\mu}\Omega_t^{\mu} = 1$):

$$\frac{\sum_{j=0}^{3} n^{\tau}\left[Q_{t-j}\Omega_{t-j}^{\tau} + \frac{B_{t-j}^{\tau}}{e^{v_{t-j}^{b}} R_{t-j}P_{t-j}}\right]}{\sum_{j=0}^{3}\left[Q_{t-j}\right]} = \tag{D.9}$$

$$\frac{\sum_{j=0}^{3} n^{\tau} Z_{t-j}\left[\frac{Q_{t-j}}{Z_{t-j}}\Omega_{t-j}^{\tau} + \frac{B_{t-j}^{\tau}/Z_{t-j}}{e^{v_{t-j}^{b}} R_{t-j}P_{t-j}}\right]}{\sum_{j=0}^{3} Z_{t-j}\left[\frac{Q_{t-j}}{Z_{t-j}}\right]} = \tag{D.10}$$

$$\frac{\sum_{j=0}^{3} n^{\tau} Z_{t-j}\left[q_{t-j}\omega_{t-j}^{\tau} + \frac{b_{t-j}^{\tau}}{e^{v_{t-j}^{b}} R_{t-j}}\right]}{\sum_{j=0}^{3} Z_{t-j}\left[q_{t-j}\right]} = \tag{D.11}$$

$$\frac{\sum_{j=0}^{3} n^{\tau} Z_{t-j}\left[q\omega^{\tau} e^{\widehat{q}_{t-j}}\widehat{\omega}_{t-j}^{\tau} + (b^{\tau}/R)e^{\widehat{b}_{t-j}^{\tau} - \widehat{v}_{t-j}^{b} - \widehat{r}_{t-j}}\right]}{\sum_{j=0}^{3} Z_{t-j}\left[q e^{\widehat{q}_{t-j}}\right]} = \tag{D.12}$$

$$= \ldots \text{(first order expansion around the steady state)} \tag{D.13}$$

$$\approx \left(n^{\tau}\omega^{\tau} + \frac{n^{\tau}b^{\tau}}{Rq}\right) + \sum_{j=0}^{3}\nu_j\left[(n^{\tau}\omega^{\tau})\widehat{\omega}_{t-j}^{\tau} + \left(\frac{n^{\tau}b^{\tau}}{Rq}\right)\left(\widehat{b}_{t-j}^{\tau} - \widehat{r}_{t-j} - \widehat{v}_{t-j}^{b} - \widehat{q}_{t-j}\right)\right] \tag{D.14}$$

$$= \overline{tws} + \sum_{j=0}^{3}\nu_j\left[(n^{\tau}\omega^{\tau})\widehat{\omega}_{t-j}^{\tau} + \overline{tws}_b\left(\widehat{b}_{t-j}^{\tau} - \widehat{r}_{t-j} - \widehat{v}_{t-j}^{b} - \widehat{q}_{t-j}\right)\right] \tag{D.15}$$

where $\overline{tws} \equiv \left(n^{\tau}\omega^{\tau} + \frac{n^{\tau}b^{\tau}}{Rq}\right) = n^{\tau}\omega^{\tau} + \overline{tws}_b$, and $\overline{tws}_b \equiv \left(\frac{n^{\tau}b^{\tau}}{Rq}\right)$.

E Data Overview

In Tables (E.1) and (E.2), I report the first and second moments in the inequality, debt and the main aggregate series (in an annual frequency to ease the exposition). Table (E.1) suggests that both the top income and wealth deciles exhibit a positive growth rate over the sample. The growth rate for the top wealth decile (0.16) is smaller than that of the top income decile (0.40). For the top income decile, in particular, positive growth takes place during the sup-period after 1983. During the post-1983 period, both income and

wealth inequality exhibit strong growth, whereas the growth rates for the economy, personal consumption, and prices slowdown. Along with rising inequality, household debt in the form of home mortgages rises as well during that period.

According to the unconditional correlations of Table (E.2), the top income decile is strongly pro-cyclical whereas the top wealth decile is mildly counter-cyclical. Both income and wealth top deciles are negatively correlated with inflation. During the 1984-2009, however, the top income decile becomes positively correlated with inflation. Both debt measures, home mortgages and consumer credit, are positively correlated with the top income decile. The top wealth decile is positively correlated with debt during 1954-1983, but that correlation weakens and, in fact, becomes negative during 1984-2009.

Table E.1: Descriptive Statistics, First Moments

Growth (real)	1954-2009	1954-1983	1984-2009
Top Income Decile	0.40	-0.01	0.86
Top Wealth Decile	0.16	-0.24	0.62
Output	1.8	1.8	1.7
Consumption	2.0	2.1	1.9
Inflation	3.4	4.4	2.4
Home Mortgages	4.7	3.9	5.5
Consumer Credit	3.2	3.0	3.5

Notes: Annual Frequency. Average (real per capita) growth rates of output and consumption. Top 10% income and wealth shares. *Data sources:* FRED. World Inequality Database.

Table E.2: Descriptive Statistics, Correlations

	Y	C	π	HM	CC
1954-2009					
TIS	-0.07	-0.01	-0.33	0.02	-0.07
TWS	0.49	0.46	-0.16	0.34	0.32
1954-1983					
TIS	-0.01	0.09	-0.27	0.21	0.08
TWS	0.43	0.46	-0.19	0.37	0.43
1984-2009					
TIS	-0.22	-0.24	-0.21	-0.56	-0.47
TWS	0.68	0.56	0.37	0.23	0.19

Notes: Annual Frequency. Real per capita growth rates. Correlations. Top 10% income and wealth shares. *Data sources:* FRED. World Inequality Database.

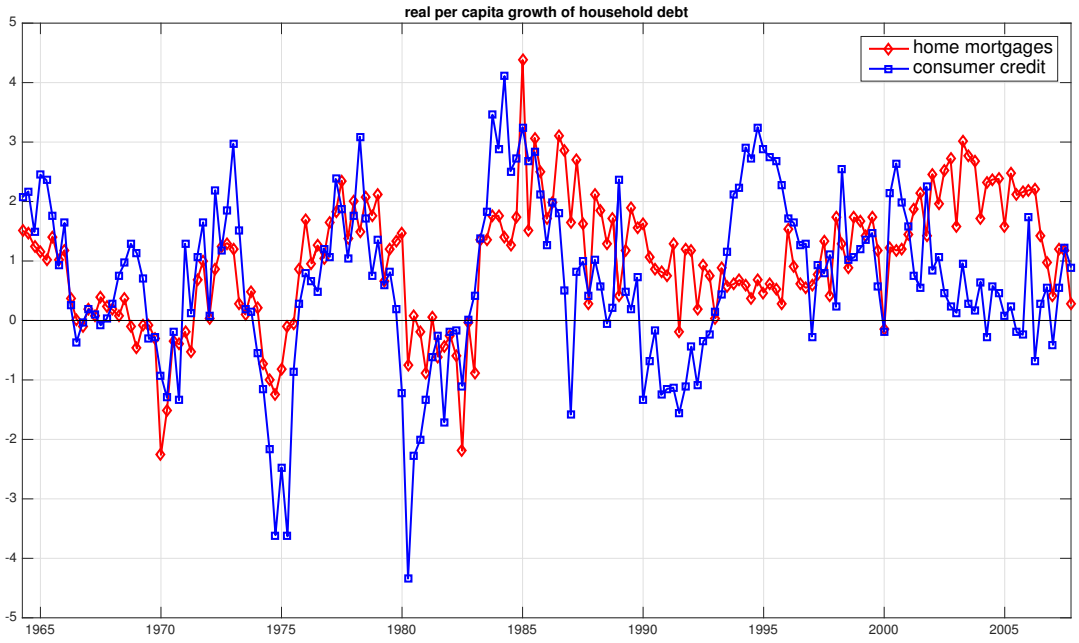
Figure (E.1) plots the evolution of the series for household debt: outstanding consumer

credit debt and home mortgage debt, both downloaded from FRED. The series are converted in real per capita terms using the GDP implicit price deflator. Their log-difference is displayed. After the early 1980s, the two series exhibit distinct differences in their evolution.

Fig.(E.2) plots the evolution of the top income and wealth deciles and of the (log-) real per capita household debt in terms of home mortgages and consumer credit. After the early 1980s, all the series exhibit an upward trend.

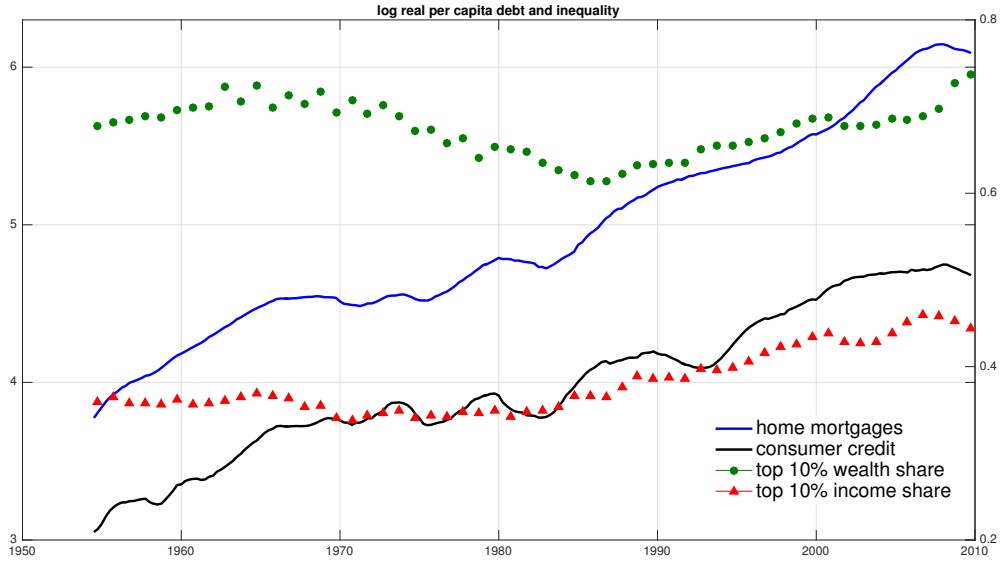
Fig.(E.3) reports the actual evolution of the top income and wealth deciles along with their cyclical components and the associated measurement errors of the observation equations. The cyclical top income decile is more volatile than the cyclical top wealth share. Furthermore, the cyclical component of the top income decile clearly exceeds its trend starting from the 1990s.

Figure E.1: Outstanding Household Debt



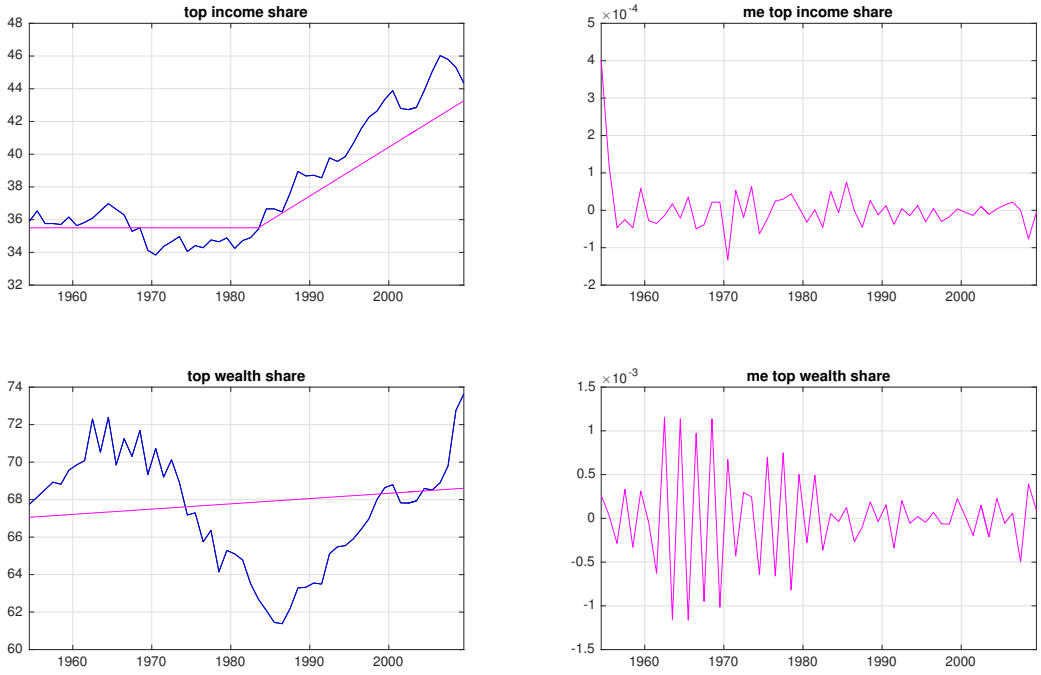
Notes: Real per capita household debt growth in the form of home mortgages and consumer credit. *Source:* FRED.

Figure E.2: Inequality And Household Debt



Notes: Logarithm of real per capita home mortgage debt and consumer credit (left axis). Top 10% income and wealth shares (right axis). *Data sources:* FRED, World Inequality Database.

Figure E.3: Income and Wealth Inequality: Trends, Cycles, Measurement Errors, and Data



Notes: Logarithm of real per capita home mortgage debt and consumer credit (left axis). Top 10% income and wealth shares (right axis). *Data sources:* FRED, World Inequality Database.

F Additional Results

F.1 Measurement Errors.

Tables (F.1) and (F.2) display the posterior standard deviation (std) of the measurement errors (m.e.) for the variables that are matched to a single observable. Their priors are tight and imply negligible measurement errors in order to preserve comparability with traditional estimated DSGE models that do not include measurement errors for those observables.

Table F.1: Posterior Distribution – Common Measurement Errors

	Prior	**Posterior** Mean [5-95%]	
		Rep. Agent	D. Imbalances
μ_w	IG(0.01,0.001)	0.0101[0.0085,0.0118]	0.0101[0.0085,0.0119]
μ_y	IG(0.01,0.001)	0.0100[0.0085,0.0116]	0.0101[0.0086,0.0120]
μ_c	IG(0.01,0.001)	0.0100[0.0085,0.0117]	0.0100[0.0085,0.0119]
μ_i	IG(0.01,0.001)	0.0100[0.0085,0.0117]	0.0100[0.0085,0.0119]
μ_π	IG(0.01,0.001)	0.0100[0.0085,0.0117]	0.0101[0.0086,0.0118]
μ_r	IG(0.01,0.001)	0.0100[0.0085,0.0116]	0.0100[0.0086,0.0118]
μ_l	IG(0.01,0.001)	0.0100[0.0085,0.0118]	0.0099[0.0085,0.0116]

Notes: Author's computations. "Rep. Agent" refers to the Smets and Wouters (2007) model estimated over the 1954Q3-2009Q4 period.

Table F.2: Posterior Distribution – Distributional Measurement Errors

		Prior	**Posterior** Mean [5-95%]
std m.e. income inequality	μ_{tis}	IG(0.01, 0.001)	0.01002 [0.00846, 0.01185]
std m.e. wealth inequality	μ_{tws}	IG(0.01, 0.001)	0.01004 [0.00852, 0.01183]

Notes: Author's computations. Estimates from the benchmark model.

F.2 Prior.

Table (F.3) displays the forecast error variance decomposition of the benchmark model at the prior mean 8/40 quarters ahead. The findings are considerably different from those at the posterior mean, suggesting that the postulated prior is not dogmatic. In other words, the results found in the paper do not depend on the prior specification.

F.3 Representative Agent Model.

Table (F.4) shows the FEVD in the representative agent model. Figures (F.1, F.2, F.3) display a comparison of the IRFs of aggregate variables in response to aggregate shocks between the present model and the representative agent model. Fig.(F.4) compares the output gaps in the present model and the representative agent model.

Table F.3: Business Cycles – The Role of the Prior

	variable							
shock	$\widehat{y}_t$	$\widehat{i}_t$	$\widehat{w}_t^r$	$\widehat{\pi}_t$	$\widehat{r}_t$	$\widehat{b}_t^r$	$\widehat{tis}_t$	$\widehat{tws}_t$
income	0/0	1/1	0/0	0/0	0/1	1/1	66/66	1/2
wealth	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0
credit	0/0	0/0	0/0	0/0	0/0	1/0	0/0	0/0
distributional	0/0	1/1	0/0	0/0	0/1	2/2	67/67	1/2
technology	15/15	2/3	2/2	1/1	1/1	2/3	1/1	3/3
price markup	9/9	8/7	75/63	31/31	10/10	4/4	6/6	4/4
wage markup	9/10	14/15	14/13	9/9	4/4	5/9	1/1	1/2
supply side	34/34	24/25	91/78	42/42	15/15	11/16	7/7	8/9
risk premium	56/54	41/40	7/11	49/49	74/73	73/53	24/24	84/82
investment	5/6	30/30	1/9	3/3	4/5	9/25	1/1	1/2
govt spending	1/1	1/1	0/0	0/0	0/0	0/1	0/0	0/0
policy	4/4	4/4	1/1	6/6	6/6	5/4	2/2	5/5
demand side	66/66	76/74	9/21	58/58	85/84	87/83	26/26	90/89

Notes: Forecast Error Variance Decomposition 8/40 quarters ahead, computed at the prior mean.

Comparing the FEVD for the economy wide variables of the benchmark model with that of the representative agent model reveals that the two have some differences implying that introducing inequality and debt in the model has indirect implications for the influence of demand supply side shocks on economy wide variables. The influence of demand side shocks on output in the benchmark model is smaller in the short run (46% vs 67%) and larger in the long run (57% vs 36%) than it is in the representative agent model. The influence of demand shocks on inflation in the present model (22/27%) is higher than that in the RA model (1/2%). This result is also reflected in a higher inflation responsiveness to demand shocks in the benchmark model than in the representative agent model as it is seen in Fig.(F.2). As for the entire set of impulse response functions, those for the economy wide variables in the benchmark model are in line with those in the RA model. Their cumulative differences are described in the paper.

Finally, Fig.(F.4) displays the small implications of including heterogeneous agents and distributional imbalances for the evolution of the output gap (the largest deviation in the output gap between the representative agent model and the model of the present paper is at about 1%). It is worth pointing out that since the structure of the flexible equilibrium is the same in both the representative agent and the benchmark model, and features the same set of shocks, the small difference between the two model-implied output gaps emanates from

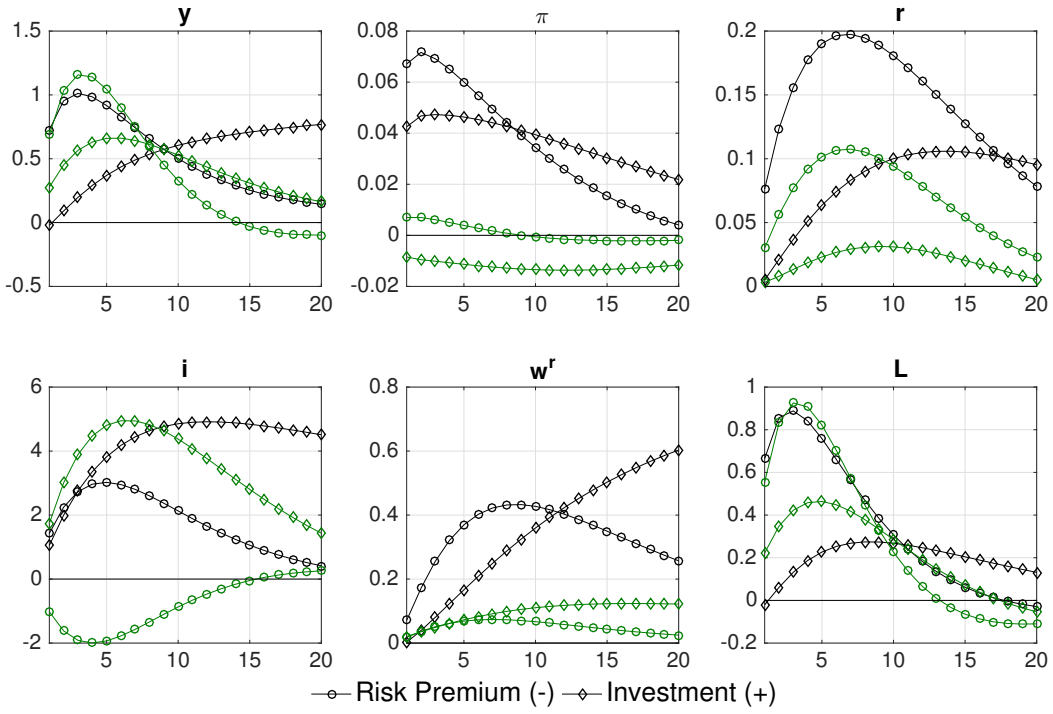
the interaction of distributional imbalances with nominal price and wage rigidities.

Table F.4: Business Cycles – Representative Agent Model

	variable				
shock	$\widehat{y}_t$	$\widehat{i}_t$	$\widehat{w}_t^r$	$\widehat{\pi}_t$	$\widehat{r}_t$
technology	25/56	3/13	7/45	7/9	4/7
price markup	8/6	6/6	26/20	81/74	22/19
wage markup	0/2	0/2	64/30	11/15	4/9
supply side	33/64	9/21	98/95	99/98	31/35
risk premium	38/18	12/7	1/1	0/0	20/26
investment	14/10	74/67	1/4	0/1	1/3
govt spending	3/1	0/1	0/0	0/0	0/1
policy	11/6	5/4	0/1	0/0	48/36
demand side	67/36	91/79	2/5	1/2	69/65

Notes: Forecast Error Variance Decomposition 8/40 quarters ahead, computed at the posterior mean.

Figure F.1: Demand Side Innovations: A Comparison Across Models



Notes: Impulse Response Functions (posterior mean). Black: benchmark model with Distributional Imbalances. Green: Representative Agent model.

F.4 Distributional Implications of Aggregate Shocks.

Fig.(F.5) displays the diffusion of demand side disturbances. More specifically, a reduction in the risk premium raises the consumption of both types of households; in fact, middle-class consumption rises more than top consumption does. Due to the workings of the aggregate demand channel, output expands and inflation exhibits a pro-cyclical response. Income inequality (tis) rises because the increasing profit margins (tis^{pr}) are unequally distributed across the population while the earnings (tis^{ea}) and capital income (tis^{b}) channels have a small effect. In contrast, wealth inequality decreases (tws). Low lending costs result in middle-class households borrowing from the top (tws^{b}) to raise their consumption and ownership of firms (tws^{ω} falls). The latter and the negligible asset price effect to the top (tws^{q}) edge out the increase in borrowing, and result in a plummeting top wealth share.

Investment and government spending shocks generate expansions that raise profits and the top income share. Nevertheless, both shocks depress aggregate consumption: (i) investment shocks lead to a sizable decrease in top consumption but to an increase in the assets of the top; (ii) government spending shocks raise the tax burden for middle-class families disproportionally since the model was built on the premise of an equal tax across households, and result in a consumption contraction. In response to both shocks, thus, the top ownership of shares rises (tws^{ω}) and along with the borrowing of the middle class (tws^{b}) and the small asset price effects generate an increase in wealth inequality (tws).

Fig.(F.6) reports the transmission of supply side innovations. Stochastic increases in price markups generate pro-cyclical responses in both income and wealth inequality. In response to exogenous increases in prices, the consumption of all agents falls by about the same amount, and drives down production, labor, and the real wage. Given the low borrowing costs due to high inflation, the middle class partially smoothes its consumption by borrowing from the top (tws^{b}) and expands its ownership of shares (tws^{ω} falls). As a result, the top wealth share (tws) falls. Despite the price increases favoring the firms' profits, the demand contraction is sizable and results in low profits flowing to the top (tis^{pr}) and, thereby, in a falling top income share (tis). Wage markup shocks lead to economy wide conditions that are similar to those generated by price markup shocks, and to a similar, albeit smaller, decrease of income inequality due to weakened profits flowing to the top. Nonetheless, wage markup shocks raise wealth inequality because middle-class households deplete their real assets triggering an asset price decline (tws^{q} rises) that benefits the top who holds a larger

fraction of shares. Technological advances raise the consumption of both families, trigger an economic expansion, and boost profits which, in turn, spur an increase in income inequality. Interestingly, those advances generate a reduction in wealth inequality since the low borrowing costs help middle-class families debt-finance an increase in their ownership shares while boosting asset prices that negatively feed back to the top wealth share.

F.5 Collaterals and the Elasticity of Output to Wealth Shocks.

The analysis so far has not made clear how the transmission of distributional shocks depends on the degree of financial market imperfections and, in particular, on the importance of collaterals captured by the loan-to-value ratio (m); the higher the m, the lower the imperfections[19]. Fig.(F.7) displays the transmission of wage and wealth shocks under alternative values for m. It unveils that the elasticities of output to wage and wealth shocks are of the same sign but of different magnitude depending on m. The fact that even low values of m generate positive elasticities to the wealth shock illustrates that those shocks differ from the ones considered in Iacoviello (2005) where the output elasticity changes sign for low m.

More precisely, a high degree of financial market imperfections (low m) leads to a small output spike on impact and a highly persistent response of a small volatility subsequently. In contrast, a high m renders the collateral channel important and, thereby, (i) dampens down the debt reduction in the case of polarization shocks, and (ii) amplifies the debt buildup in the case of wealth shocks. In case (i), the easier access to credit does not require the middle class to massively deplete its assets; as a result, wealth inequality does not rise as much as it would for a low m. In case (ii), the massive increase of middle-class borrowing is channeled to increase the assets of the middle class; consequently, wealth inequality falls much more than that it would for a low m. The effect of the above shocks on the top income share does not depend on m as much as their effect on the top wealth share does.

F.6 Quantifying the Effect of Imbalances on Inflation.

Figures (F.8) and (F.9) display a graphical depiction of the influence of endogenous and exogenous distributional imbalances on aggregate demand and inflation described in detail in the paper. The figures corroborate that the distributional shocks as well as the channels of MPC differentials and imperfect insurance have a more profound influence on aggregate demand than on inflation.

[19] In terms of steady state effects, a higher m raises debt, as well as the top income and wealth shares.

Nevertheless, including inequality and debt series in the estimation attenuates to some degree the general equilibrium effects on inflation. The latter are reflected in an elevated indexation, a weakened price stickiness, an elevated volatility of price markup shocks, and an attenuated persistence of price markup shocks. They are observed in the bottom right panel of Fig.(F.9) where the shocks of the benchmark model are fed in the representative agent model and result in inflation series that deviate from the observed ones.

F.7 Marginal Propensity to Consume and Wealth Preferences.

Fig.(F.10) plots the difference in the MPC between the benchmark model with $\phi^{\tau} \neq \phi^{\mu}$ and an alternative model featuring $\phi^{\tau} = \phi^{\mu}$. According to the evidence displayed in the figure, the MPC difference in all panels has a moderate non-zero value suggesting that imposing homogeneous preferences over wealth attenuates the heterogeneity in the consumption responses in the population.

F.8 Five Decades of Business Cycles and Inequality Swings.

What is the historical influence of demand, supply, and distributional shocks on the swings of the top income and wealth shares across U.S. business cycles? Fig.(F.11) and (F.12) cope with that question. Fig.(F.11) suggests that the relative stability of the top 10% income share from the 1950s to the mid-80s is attributed to all shocks balancing out on aggregate. The rise of the top income share since the mid-80s is mainly explained by wage polarization, supply side shocks, wealth shocks, credit relaxation, and demand shocks to some extent.

The post-1990 rise of wealth inequality is driven by wage polarization, credit relaxation, wealth shocks. In contrast, in the pre-1990 period, worth mentioning are the inequality-increasing effect of technology shocks during the 1970s-80s, and the sizable influence of wealth shocks during the fluctuations of the top wealth share on the 1960s-70s.

Figure F.2: Policy Innovations: A Comparison Across Models

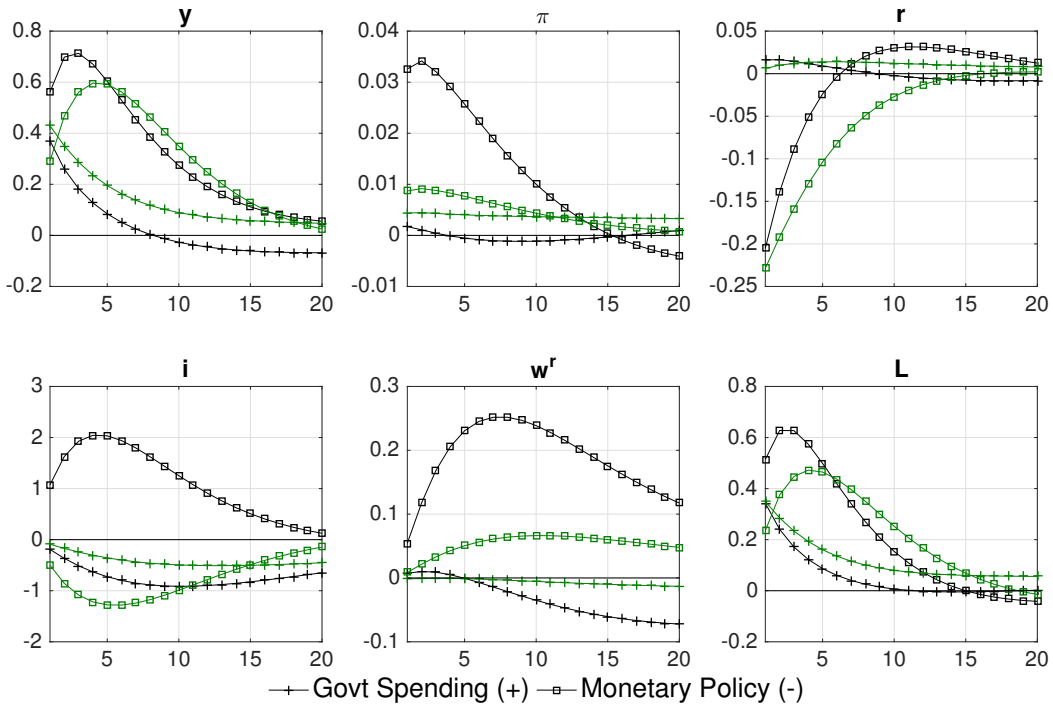
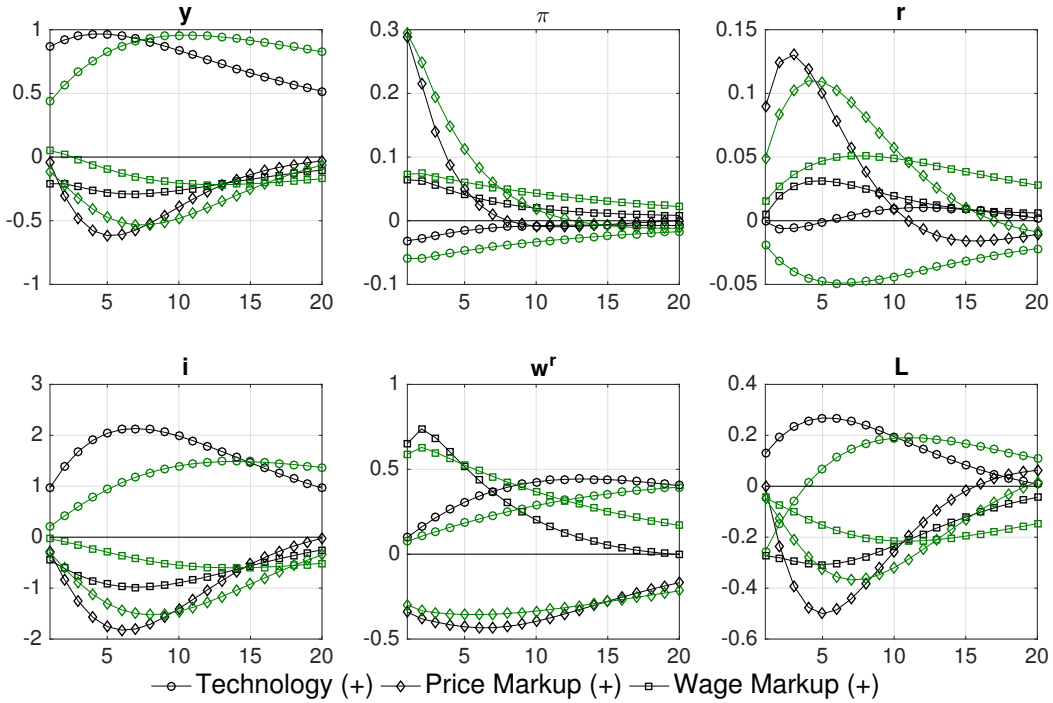
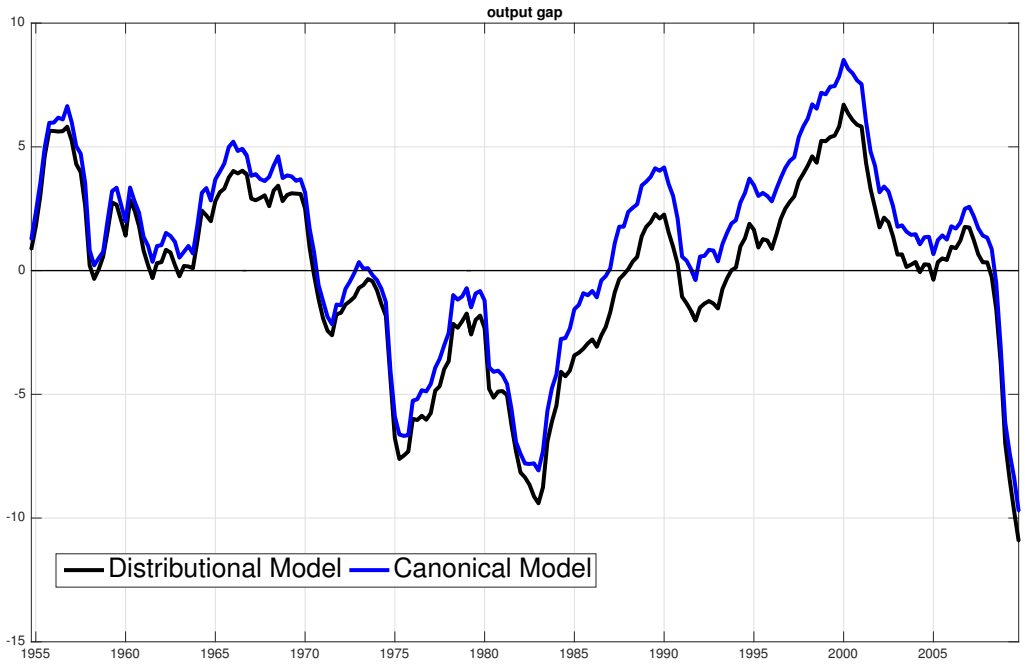


Figure F.3: Supply Side Innovations: A Comparison Across Models



Notes: Impulse Response Functions (posterior mean). Black: benchmark model with Distributional Imbalances. Green: Representative Agent model.

Figure F.4: U.S. Output Gap Fluctuations



Notes: Author's computations. Output Gap. Black: benchmark model with Distributional Imbalances. Blue: Representative Agent model.

Figure F.5: Distributional Implications of Demand Side Shocks

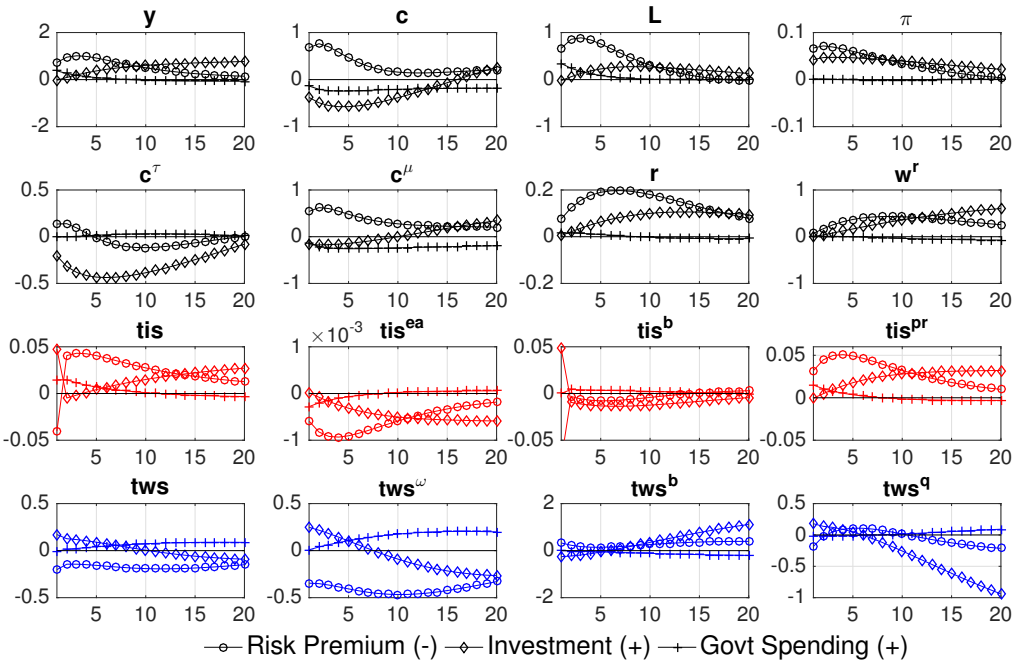
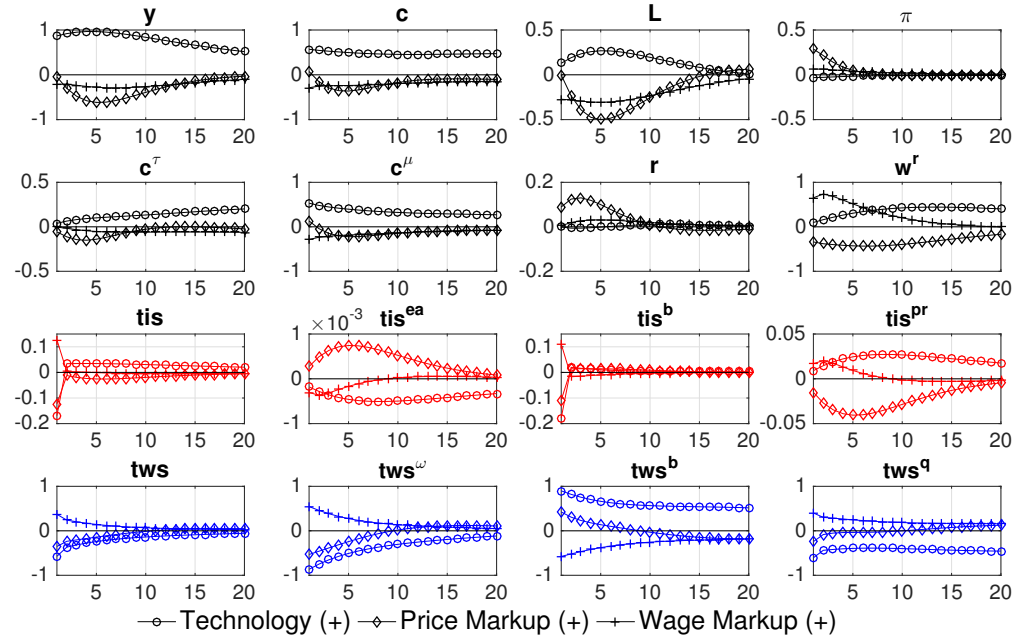
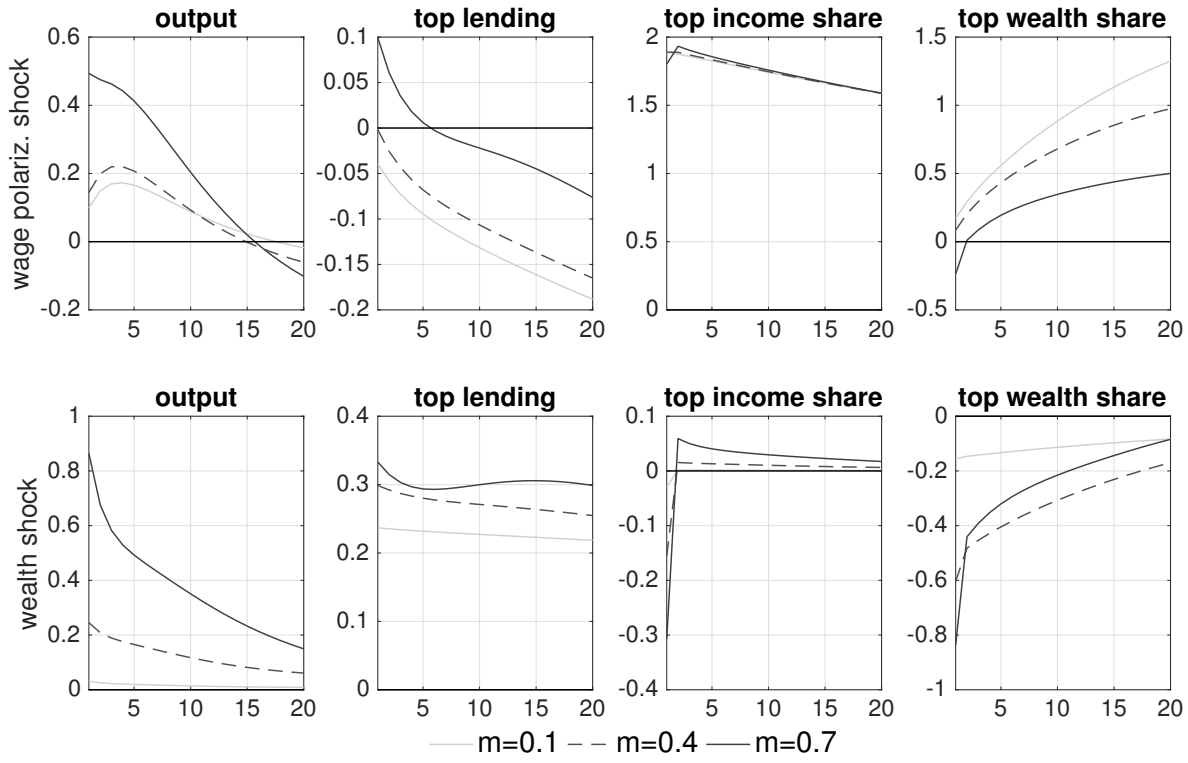


Figure F.6: Distributional Implications of Supply Side Shocks



Notes: impulse response functions (posterior mean). All variables in % deviation from steady state. 1st and 2nd row: aggregate variables. 3rd row:: top income share (tis): earnings (tis^{ea}), bond income (tis^{b}), and profits (tis^{pr}) channels, with $tis = tis^{ea} + tis^{b} + tis^{pr}$. 4th row:: top wealth share (tws): shares (tws^{ω}), bonds (tws^{b}), and asset price gains/losses (tws^{q}) channels, with $tws = tws^{\omega} + tws^{b} + tws^{q}$.

Figure F.7: Collaterals and the Transmission of Distributional Imbalances



Notes: Transmission of polarization & wealth shocks (posterior mean) across different loan-to-debt values.

Figure F.8: Quantifying the Effect of Imbalances on Aggregate Demand

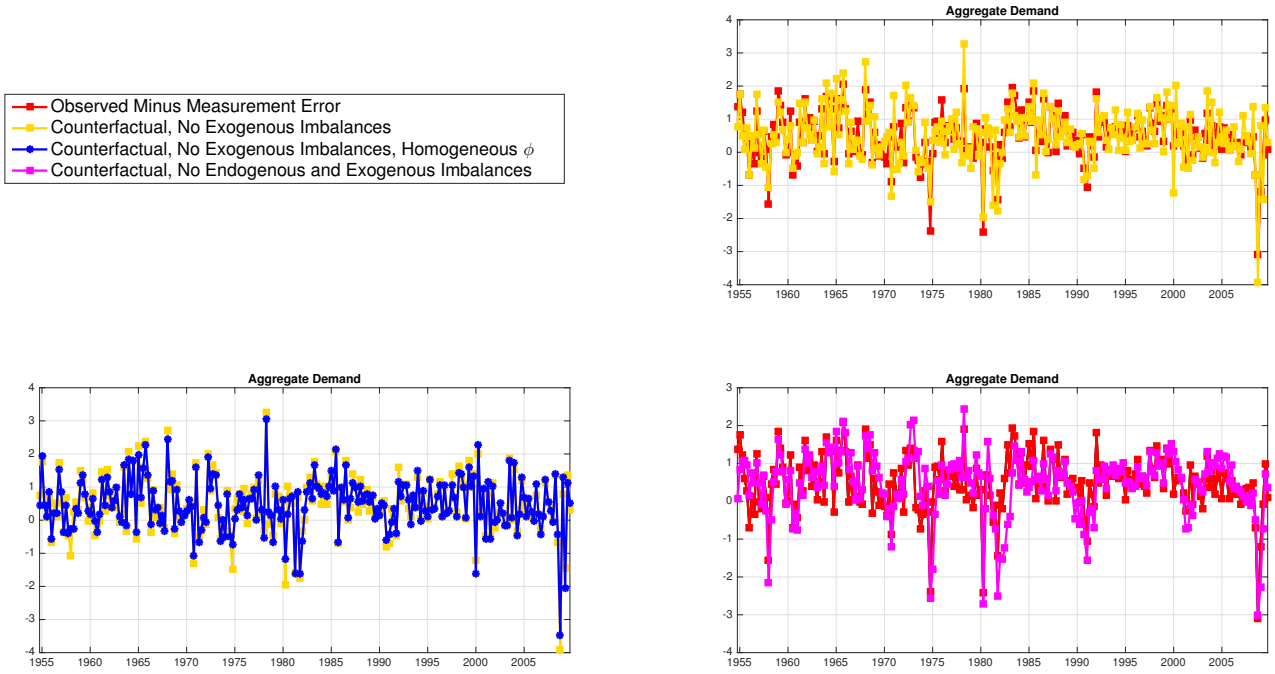
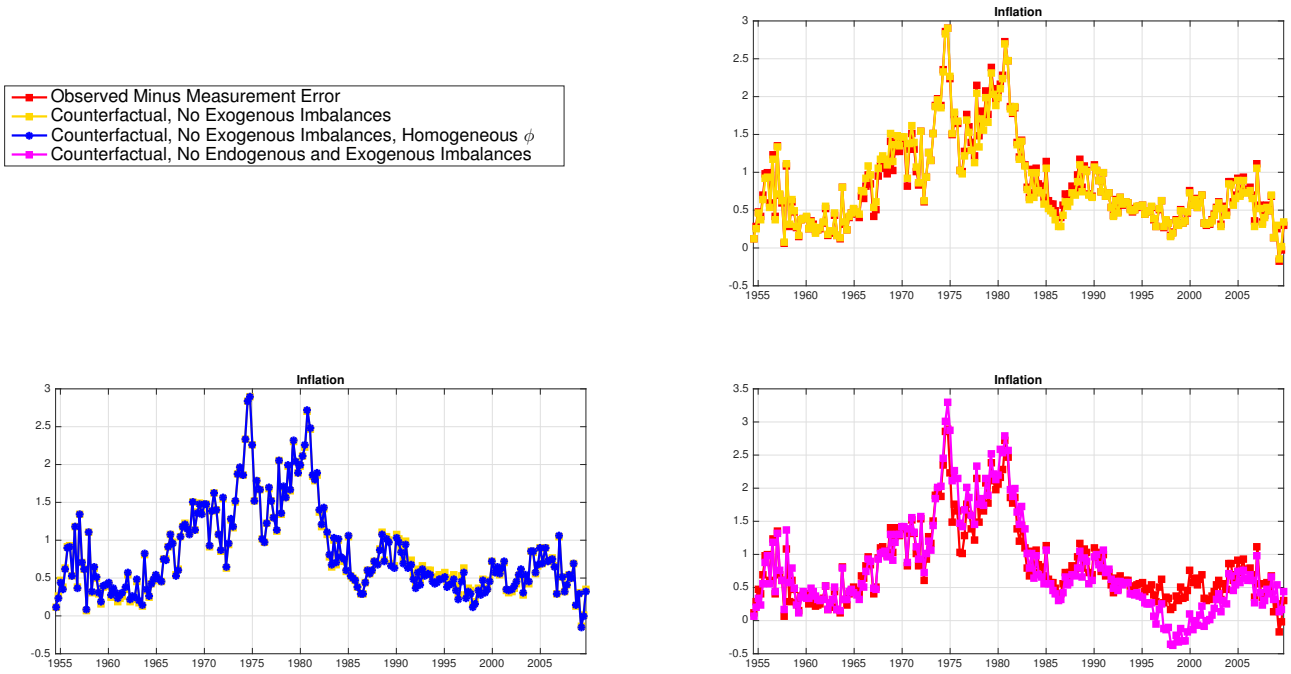
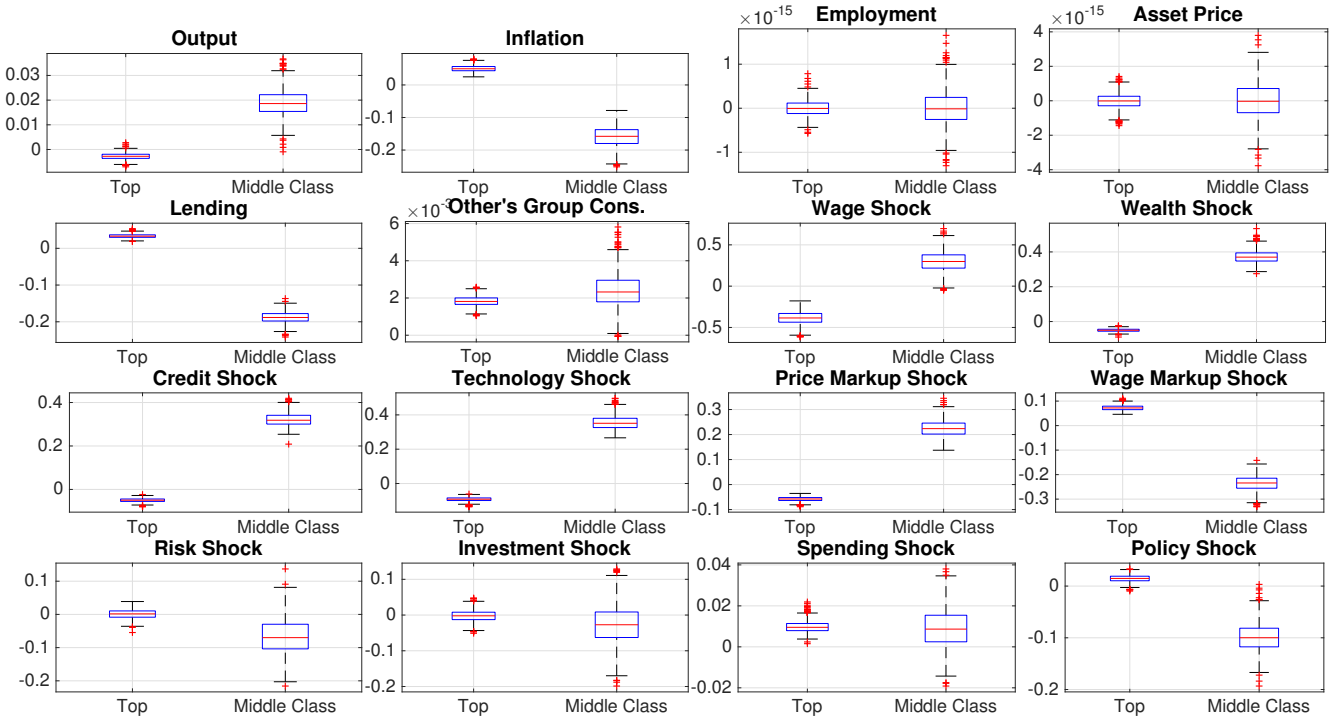


Figure F.9: Quantifying the Effect of Imbalances on Inflation



Notes: Author's computations. All figures in %.

Figure F.10: MPC Differentials and Preferences over Wealth



Notes: Posterior distribution of the difference between the consumption responses across variables and sources of stochastic variation (shown in each panel's title) for top and middle-class households in the benchmark estimation and in the simulation featuring $\phi^{\tau} = \phi^{\mu}$.

Figure F.11: Cyclical Swings in the Top 10% Income Share, 1954–2009

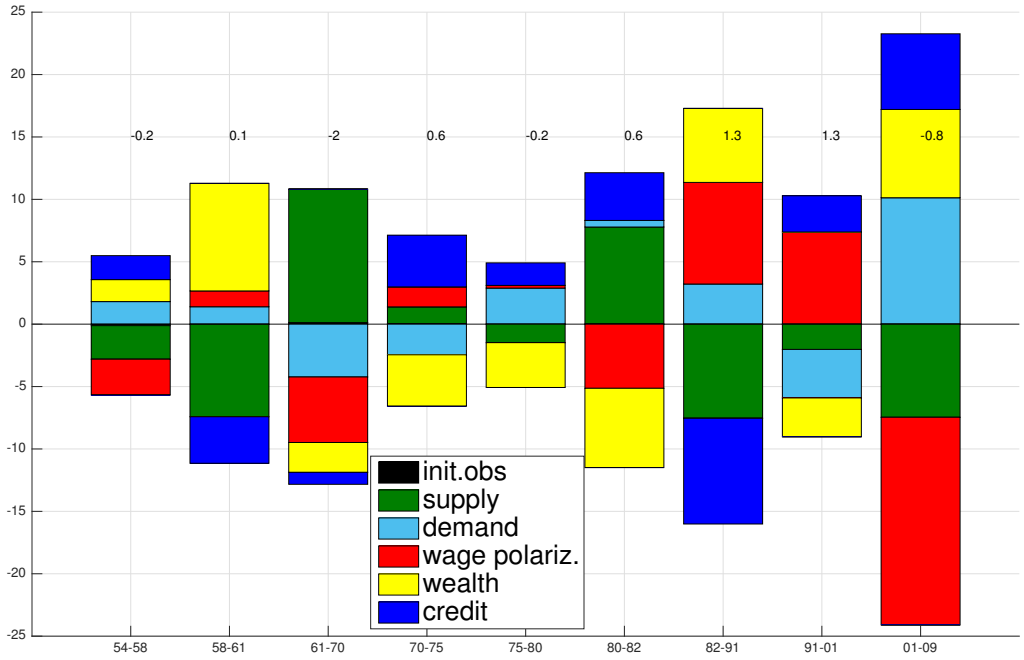
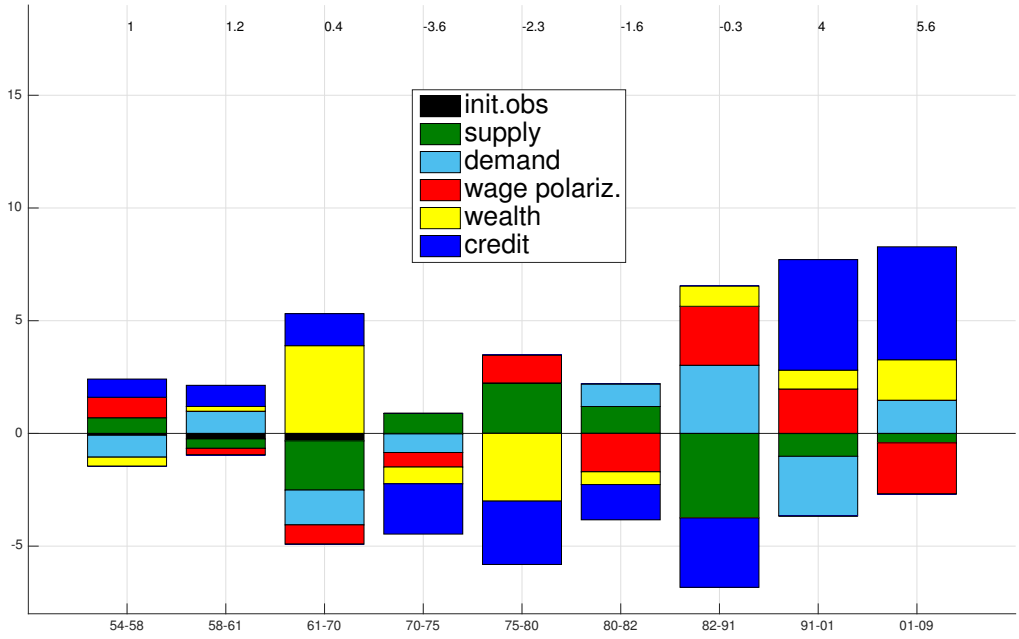


Figure F.12: Cyclical Swings in the Top 10% Wealth Share, 1954–2009



Notes: Historical decomposition of cumulative cyclical annual change (shown on top of each column) over a U.S. business cycle (trough to trough). Cumulative effect of each shock. Demand side shocks: risk premium, investment, interest rate, and government spending. Supply side shocks: technology, price markup, wage markup shocks. All figures are in %.