Distributional Imbalances and the U.S. Business Cycle

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Abstract

This paper examines the influence of distributional imbalances on the business cycle. I propose a structural model featuring top and middle-class families, household debt, and three distributional shocks: a wage polarization, a wealth, and a credit shock. These shocks are coupled with aggregate disturbances and identified by *jointly* matching series for U.S. aggregates, debt, and top income and wealth shares during 1954–2009 via Bayesian mixed-frequency estimation.

Although distributional shocks, diffused through aggregate demand, have limited impact (less than 10%) on output cycles, they account for two thirds of debt fluctuations. Their impact may be non-monotonic depending on the degree of financial market imperfections. Given the pro-cyclical inflation response to them, aggressive monetary policy remains effective. Aggregate disturbances explain about a third of the swings in the top shares. The sizable influence of credit relaxation on the debt build up is overstated if inequality series or sizable wealth adjustment costs are not included.

Keywords: Distributional Shocks, Imbalances, DSGE, Bayesian Estimation

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1 Introduction

For a long time, distributional swings have been viewed as beyond the frequency of business cycles, and kept outside of models tailored for monetary policy analysis, the cornerstone of which is the postulate of perfect risk sharing with the corollary of a "representative agent" – the assumption that all individuals have the same preferences and resources. Although this assumption allows to simplify a complicated reality, it precludes understanding issues related to agent heterogeneity and inequality from a macro-economic perspective.

Surging inequality, though, has raised concerns about monetary policy [Greenspan, 1998; Bullard, 2014; Bernanke, 2015; Coeuré, 2012; Mersch, 2014; Panetta, 2015; Draghi, 2016], while the coincident rise of U.S. inequality and household debt since the 1980s, seen in Fig.(1), has raised voices urging the study of the financial markets and inequality nexus [Stiglitz, 2014, 2015]. In response, and as argued by Christiano et al. (2018), a developing, albeit young, research strand on the dynamic stochastic general equilibrium (DSGE) enterprise after the financial crisis involves heterogeneous agent models along the lines of Kaplan et al. (2018). Although aspects of the macro-inequality linkages, such as the coincident rise of inequality and debt (e.g. Iacoviello, 2008; Kumhof et al., 2015), are touched upon in that research strand, a crucial element is still missing, namely the identification of the causes and implications of fluctuations in U.S. inequality from a time series business cycle perspective.

The present paper fills this void by addressing four themes associated with it. First, do stochastic swings in income and wealth inequality extracted from the data, dubbed as "distributional" shocks, and pertaining to wage polarization, heterogeneous investment opportunities, and credit availability influence business cycle gyrations in U.S. output? Second, is inequality shaped only by distributional forces or by conventional "aggregate" shocks too? Third, are credit expansions and soaring household debt, like the ones observed in the decade before the Great Recession, linked to inequality? Fourth, how does monetary policy influence inequality, and how does it operate in the presence of the latter?

I tackle the above questions by examining U.S. aggregate and inequality series, namely the top deciles of the income and wealth distributions as well as the outstanding household debt, *jointly* and over five decades, since 1954 to 2009, through the lens of a structural model and of a full-information Bayesian approach. I enrich the workhorse medium-scale New Keynesian DSGE framework [Christiano et al., 2005; Smets and Wouters, 2007] with heterogeneous agents – the top and the middle class – and imperfect financial markets allowing for household debt taken up by the middle class. Furthermore, I couple aggregate sources of fluctuations with three distributional shocks.

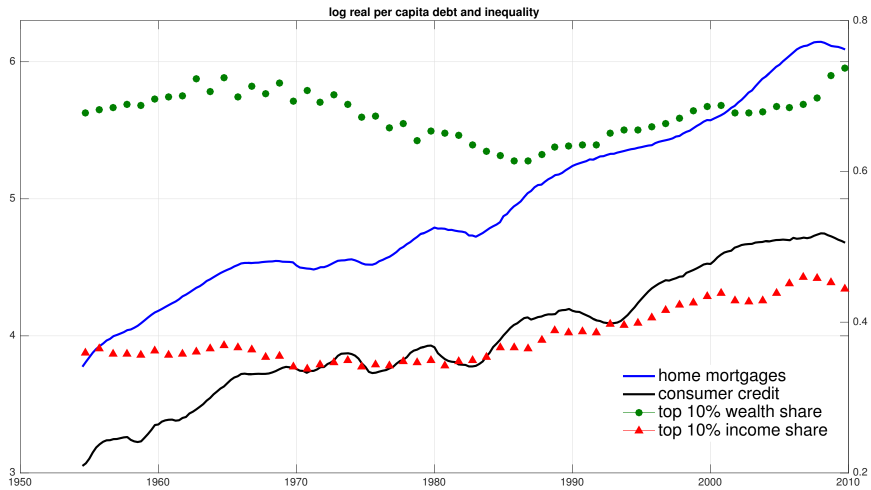
Wage polarization shocks pertain to a time-varying incomplete wage insurance scheme, and build on Walsh (2017) who introduces a similar, albeit deterministic, scheme[1]. In a similar spirit, Lansing and Markiewicz (2018) consider shocks in a labor aggregator reflecting changes in the skill premium. Wealth 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]. Contrary to them, the interaction of wealth shocks with heterogeneous household preferences for wealth (see below) leads to idiosyncratic shock influence reflecting unequal investment opportunities and returns. Heterogeneous returns across individuals are documented by Fagereng et al. (2018) using tax records, while Lee (2012) models partial insurance of financial returns. Credit supply shocks are modeled as stochastic variations in the borrowing limit [Justiniano et al., 2015].

Agent heterogeneity and imperfect insurance constitute structural distributional imbalances since they trigger heterogeneous household responses to aggregate shocks. Agent heterogeneity is projected in two dimensions – the "top" and "middle-class" families – which is a sufficient approximation to reality where a disconnect between the top and the rest of the distribution is observed. The families have heterogeneous preferences over wealth encapsulating Carroll (2000)'s argument that wealth confers social status[2]. Wealth is broadly defined in terms of firms' ownership determining the allocation of profits, and its availability to all households captures the fact that the middle-class' portfolio has assets as well as liabilities. The distributional shocks cannot be entirely hedged against due to imperfect financial insurance. Intra-family loans provide imperfect insurance since borrowers can renege on their obligations as in Kiyotaki and Moore (1997) – thus, lenders ask for collaterals.[3]

Last but not least, this is the first paper that adopts a state-of-the-art Bayesian mixed-frequency estimation approach to bring the structural model to both aggregate and inequality time series data and, thereby, to extract distributional shocks. Two series for household debt are used, namely series for household mortgage and consumer credit debt. The multiplicity of debt series strengthens identification by allowing to extract their common component.

[1] See Alichi et al. (2016), Phillippon and Reshef (2012), and Heathcote et al. (2010) for empirical evidence.
[2] Kumhof et al. (2015), Carroll et al. (2015), Tokuoka (2012), and Francis (2009) use that device too.
[3] The household discount factors are heterogeneous [Eggertsson and Krugman, 2012; Curdia and Woodford, 2010; Iacoviello, 2005] and render the middle class more impatient than the top.

Figure 1: Inequality And Household Debt



Notes: Log-real per capita home mortgage debt and consumer credit (left axis). Top 10% income and wealth shares (right axis). *Data sources:* see text.

1.1 Results.

The findings suggest a limited effect of distributional swings on business cycle fluctuations. Their combined effect accounts for less than 10% of output fluctuations. More precisely, polarization, wealth, and credit shocks account for 0%, 3%, and 4% of output cycles, respectively. This small influence is robust across a battery of checks, and mirrors a dichotomy in identification. Parameters associated with the aggregate dimension of the model are identified mainly by aggregate series. In contrast, inequality data are informative for the parameters associated with distributional imbalances. Hence, the estimation suggests persistent distributional shocks, polarization and wealth shocks of moderate volatility, and volatile credit shocks. The utility from wealth holdings is higher for the top than for the bottom consistently with the argument of Carroll (2000). It is worth mentioning that this result is obtained only when inequality series are included in the estimation and not otherwise.

Despite the above influence, the distributional shocks are not irrelevant to business cycles. They explain two thirds of the swings in debt as well as in the top income and wealth shares. More specifically, wealth and credit shocks account for a third of debt swings each. Wealth and polarization shocks account for a third of the swings in the top wealth share each. Polarization shocks account for about two thirds of the fluctuations in the top income share. The profound effect of distributional shocks on household indebtedness suggests that households leverage their portfolios in response to inequality swings, and corroborates the dynamics described in Kumhof et al. (2015), Iacoviello (2008), Stiglitz (2014, 2015).

A small degree of time variation in the influence of distributional shocks is detected. Polarization shocks become a tad more prominent only after the 1980s and during the surge of income inequality. Wealth shocks are more influential during the cycles before the 1980s when the top wealth share exhibits sizable gyrations, than after that period when the top wealth share follows an upward trajectory. Changes in credit relaxation boost output growth during the cycles of the 1980s-90s but have a negative net effect during the 2000s.

The propagation of distributional shocks takes place through shifts in aggregate demand. The data suggest that when those shocks hit the economy, the shifts in consumption across the population are heterogeneous, do not net out to zero, and trigger changes in aggregate demand. Polarization shocks lead to counter-cyclical responses in both top shares. Output decreases since the consumption increase of the top does not fully replenish the consumption decline of the middle class. Over the medium run, both wealth and credit supply shocks lead to counter-cyclical responses in the top income share since they increase the debt burden of the middle class. Although wealth shocks decrease wealth inequality since middle-class families gain ownership in economy's wealth, credit relaxations increase it.

This paper reveals that shocks conventionally labeled as "aggregate" have distributional ramifications, that is, an idiosyncratic effect. Their effect, filtered through structural imbalances, accounts for a third of the swings in debt and the top shares. Price markup and risk premium (technology and investment) shocks have a tad higher influence on the top income (wealth) share than the other shocks have. Expansions driven by demand side shocks are associated with low income and wealth inequality[4]. Due to rigidities, prices do not immediately adjust after demand expansions resulting in weakened profits for the top and a high purchasing power for the middle class used to increase wealth holdings. Along similar lines of reasoning, price markup shocks raise both forms of inequality. In contrast, wage markup shocks have an egalitarian character and decrease both types of inequality. Technological advances spur a reduction in income inequality but an increase in wealth inequality.

In terms of the nexus of inequality and financial markets, the present work documents that the steep debt build up in the decades that preceded the Great Recession was largely

[4]Only government spending shocks generate an expansion along with an increase in wealth inequality because they raise the tax burden for the middle class.

influenced by a credit relaxation. The latter accounts for about a third and half of the forces pushing towards a debt increase during the cycles of the 1980s-90s and the 2000s, respectively. Credit shocks, therefore, have a pronounced role in line with Mian and Sufi (2018), but they are not the only determinant of debt and only have limited implications for output in line with Justiniano et al. (2015). Their influence on debt, however, may be overstated if examined in the absence of wealth shocks, identified by jointly considering aggregate and inequality data, and/or high adjustment costs in the agents' wealth holdings.

Furthermore, a non-monotonic impact of distributional shocks depending on the degree of financial market imperfections is uncovered. With a high degree of imperfections, adversarial distributional shocks have the implications examined earlier. With a low degree of imperfections, however, the middle class can easily borrow instead of adjusting consumption downwards and, thus, temporarily alleviate the impact of those shocks. As a result, aggregate demand exhibits a small ephemeral increase. Over time, though, the debt burden accumulates and the economy resembles that under the regime of severe imperfections.

Finally, the results suggest that monetary policy surprises, defined as interest rate changes not explained by fundamentals, have a small effect on the evolution of top shares throughout the 1954-2009 period. In addition, monetary policy need not be concerned about its response to economic fluctuations depending on whether the origin of those fluctuations is found on distributional shocks. It operates effectively by responding to economy wide aggregates even if fluctuations are caused by inequality swings. In fact, the more dovish the policy is, the more effective in reducing fluctuations without considerably influencing the transition path of income and wealth inequality is. The reason is that a dovish policy is willing to take sizable interest rate cuts against falling inflation caused by distributional shocks, and thereby to ease the debt repayment of middle-class borrowers.

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 the coincident rise of U.S. inequality and debt, the present paper conceptually relates to Iacoviello (2008) and Kumhof et al. (2015). The former, through a heterogeneous agent model, shows that an income process extracted from the data is able to simulate debt dynamics similar to those observed. Kumhof et al. (2015) illustrate how changes in the top income share lead to debt accumulation and, thereby, to a high probability of crisis.

Nevertheless, the present paper's full-information approach on the macroeconomic implications of distributional shocks is fundamentally different from the above papers and the strand of studies building on the Aiyagari-Hugget framework. Those studies feature idiosyncratic risk and investigate how inequality influences aggregate 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; Kaplan et al., 2018; Auclert, 2015]. Nonetheless, they often involve exotic assumptions about income dynamics, simulation, and moment matching in arbitrarily chosen years. They, thus, preclude understanding the joint historical evolution of U.S. inequality and aggregate series.

Furthermore, by extracting distributional shocks from the data within a structural framework, this paper contributes in the strand of the NK-DSGE literature that features heterogeneous agents [Walsh, 2017; Eggertsson and Krugman, 2012; Lee, 2012; Curdia and Woodford, 2010; Gali et al., 2007; Iacoviello, 2005] but abstracts from explaining inequality series, ultimately precluding the use of information found therein.

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

Finally, the introduction of wealth in household preferences 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; with Kurz (1968) who examines non-linearities stemming from the utility from capital holdings in a growth model; with Iacoviello (2005) who introduces utility from housing services; and with Zou (1998) who studies utility from wealth and argues that the latter reflects Weber's spirit of capitalism[5].

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

2 Full-Fledged Model

The model builds on the medium-scale DSGE environment of Christiano et al. (2005) and Smets and Wouters (2007), and shares similarities with Iacoviello and Neri (2010) and Justiniano et al. (2015). Below I outline the model, putting emphasis on its novel parts.

Two families populate the economy. 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 families differ in terms of their wealth preferences and discounting. Perfect consumption insurance holds within families. Households participate in intra-family borrowing up to an endogenous limit at a rate determined by monetary policy, and in trading of firms' ownership shares. Each household consists of a measure one 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 Bottom Family. Household $i \in \mu$ chooses an infinite sequence of consumption, loans, and shares, $\{C_t^i, B_t^i, \Omega_t^i\}$, to maximize the present discounted value of future utility:

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

Preferences are log-separable, and depend on the deviation of consumption from last period's family-specific consumption, on labor disutility across j types, and on shares that confer social status. The latter yields a demand function for shares. η mirrors habit formation, χ is the inverse Frisch elasticity, and ϕ^μ captures the strength of preferences over shares. $\beta^\mu < \beta^\tau$ renders the bottom 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 associated parameters $\{\rho_\omega, \sigma_\omega\}$. The budget constraint is given by

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

$$Y_t^i \equiv \int_0^1 W_t^{i,h,r}(j) L_t^i(j) dj + F_t^\mu - B_{t-1}^i/(P_{t-1}\Pi_t) + \Omega_t^i V_t \tag{2.3}$$

Y_t^i is the pre-tax income. υ_t^b is an inter-temporal risk premium shock following an AR(1) process with associated parameters $\{\rho_b, \sigma_b\}$. $S_\omega(\cdot)$ stands for wealth adjustment costs and captures the sluggish evolution of wealth dynamics. It is postulated that $S_\omega(1) = S_\omega(1)' = 0$ and $S_\omega(1)'' \equiv S_\omega > 0$. Q_t is the shares' price in terms of the final good. Π_t stands for (gross) price inflation. V_t denotes the economy wide profits. 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 it is equal to the marginal disutility of type-j labor in terms of consumption:

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

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 real aggregate 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 involving transfers F_t^μ from the unions:

$$F_t^\mu = \frac{s_t W_t^r L_t}{n^\mu} - \int_0^1 W_t^{i,h,r}(j) L_t^i(j) dj \tag{2.5}$$

In particular, household members supply heterogeneous labor, pool together wages at the union level, but receive only a fraction of what would be otherwise allocated under perfect insurance. s_t, with steady state $\bar{s}$, stands for the equilibrium wage share of the bottom. $\widehat{s}_t \equiv ln(s_t/\bar{s})$ follows an AR(1) process with associated parameters $\{\rho_s, \sigma_s\}$. Thus, $\widehat{s}_t$ is an *income insurance* shock or, equivalently, a *wage polarization* shock. For $s_t = n^\mu$, the insurance scheme boils down to an equitable wage distribution.

The financial structure of the economy plays a catalytic role: for distributional shocks to be influential, hurdles in perfect insurance need to exist. Along the lines of Kiyotaki and Moore (1997) and Iacoviello (2005), borrowers can default, in which case the lenders only receive a fraction m_t, with steady state m, of the posted collateral. $ln(m_t)$ follows an AR(1) process with associated parameters $\{\rho_m, \sigma_m\}$. Contrary to Iacoviello (2005), though, the collateral is broadly defined as shares rather than housing, and has no impact on the production function. Thus, borrowing $B_t^i/(e^{\upsilon_t^b} R_t P_t)$ is up to a period-t limit determined by:

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

Two remarks are in order. First, modeling the wage polarization shock through (2.5) allows for that shock to enter in the budget constraint that becomes relevant for equilibrium dynamics because of the financial market imperfection. In other words, under perfect insurance, shocks in wage polarization and the debt limit would play no role since the agents would be able to perfectly insure against them. Thus, the impact of distributional shocks emerges due to imperfect financial insurance along the lines of Stiglitz (2015). Second, the wage polarization shock does not affect the marginal labor disutility. If it did, it would appear in the wage Philips curve and be convoluted with wage markup shocks.

2.0.2 Top Family. Household i $\in \tau$ chooses an infinite sequence of consumption, loans, and shares, $\{C_t^i, B_t^i, \Omega_t^i\}$, to maximize the present discounted value of expected utility:

$$E_t \sum_{s=0}^{+\infty} (\beta^\tau)^s \left[ln\left(C_{t+s}^i - \eta C_{t+s-1}^\tau\right) - \theta \int_0^1 \frac{(L_{t+s}^i(j))^{1+\chi}}{1+\chi} dj + \phi^\tau \upsilon_{t+s}^\omega ln\left(\Omega_{t+s}^i\right) \right] \tag{2.7}$$

The utility function of the top is symmetric to that of the bottom. The strength of wealth considerations differs across families: $\phi^\mu \neq \phi^\tau$[6]. The budget constraint is given by:

$$C_t^i + B_t^i/(e^{\upsilon_t^b} R_t P_t) + Q_t \left[\Omega_t^i - \left(1 - S_\omega(\Omega_t^i/\Omega_{t-1}^i)\right)\Omega_{t-1}^i\right] + T_t^i/P_t = Y_t^i \tag{2.8}$$

$$Y_t^i \equiv \int_0^1 W_t^{i,h,r}(j) L_t^i(j) dj + F_t^\tau + B_{t-1}^i/(P_{t-1}\Pi_t) + \Omega_t^i V_t \tag{2.9}$$

After the unions' transfers to the top (F_t^τ) have taken place, the top households receive $(1-s_t)$ portion of aggregate labor income:

$$F_t^\tau = \frac{(1-s_t)W_t^r L_t}{n^\tau} - \int_0^1 W_t^{i,h,r}(j) L_t^i(j) dj \tag{2.10}$$

In a symmetric way to that for bottom households, the equilibrium marginal rate of substitution between type-j labor and consumption of top household i is given by:

$$W_t^{i,h,r}(j) = \theta (L_t^i(j))^\chi / \Xi_t^i = \theta L_t(j)^\chi / \Xi_t^\tau \tag{2.11}$$

2.0.3 Capital. With a representative agent, both centralized and decentralized capital production yield the same dynamics. Nevertheless, agent heterogeneity requires keeping track of type-specific capital holdings. In this paper, as in Chen et al. (2012), a representative capital producing firm 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, $K_t \equiv u_t \bar{K}_{t-1}$, subject

[6] Following the literature on housing, η, θ, χ are common across agents. This assumption, albeit stylized, ensures that the steady state of economy wide aggregates in the present model is the same as that in the representative agent model. That benchmark region is viewed as a natural starting point. In addition, identifying heterogeneous η and χ would require using family-specific consumption and labor supply data.

to utilization costs that are proportional to the last period's raw capital ($a(u_t)\bar{K}_{t-1}$). Capital is channeled to intermediate good producers at the rental rate R^k_t. The firm maximizes the present discounted value of future dividends,

$$E_t \sum_{s=0}^{\infty} \left(\frac{\Xi^{avg}_{t+s}}{\Xi^{avg}_t} \frac{P_t}{P_{t+s}} \right) \left[R^k_{t+s} K_{t+s} - P_{t+s} a(u_{t+s}) \bar{K}_{t+s-1} - P_{t+s} I_{t+s} - Z_{t+s} P_{t+s} \Phi_k \right], \tag{2.12}$$

subject to the law of capital accumulation,

$$\bar{K}_t = (1-\delta)\bar{K}_{t-1} + \upsilon^i_t \left(1 - S(I_t/I_{t-1})\right) I_t \tag{2.13}$$

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^i_t is an investment disturbance; $ln(\upsilon^i_t)$ follows an AR(1) process with associated parameters $\{\rho_i, \sigma_i\}$. $\Xi^{avg}_{t+1}/\Xi^{avg}_t$ stands for the average discounting between $t+s$ and t, defined as: $(\beta^\tau)^s[n^\tau \Xi^\tau_{t+s} + n^\mu \Xi^\mu_{t+s}]/[n^\tau \Xi^\tau_t + n^\mu \Xi^\mu_t]$[7].

2.0.4 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

$$Y_t = \left(\int_0^1 Y_t(i)^{(\lambda_{p,t}-1)/\lambda_{p,t}} di \right)^{\lambda_{p,t}/(\lambda_{p,t}-1)} \tag{2.14}$$

where $\lambda_{p,t}$ 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 given by

$$Y_t(i) = \left(\frac{P_t(i)}{P_t} \right)^{-\lambda_{p,t}} Y_t \qquad \text{and} \qquad P_t = \left(\int_0^1 P_t(i)^{1-\lambda_{p,t}} di \right)^{1/(1-\lambda_{p,t})} \tag{2.15}$$

2.0.5 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^k_t), in order to produce output $Y_t(i)$ according to the production function:

$$Y_t(i) = e^{\widehat{z}_t} K_t(i)^\alpha \left(Z_t L_t(i) \right)^{1-\alpha} - Z_t \Phi_y \tag{2.16}$$

[7] This definition simplifies the exact discount factor, $[(\beta^\tau)^s n^\tau \Xi^\tau_{t+s} + (\beta^\mu)^s n^\mu \Xi^\mu_{t+s}]/[n^\tau \Xi^\tau_t + n^\mu \Xi^\mu_t]$, which would severely complicate the equations governing capital and investment and their associated steady state expressions. In contrast, the chosen definition keeps them isomorphic to their representative agent analogues.

$\widehat{z}_t$ 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,

$$MC_t = (\alpha)^{-\alpha}(1-\alpha)^{-(1-\alpha)}(W_t)^{(1-\alpha)}(R_t^k)^{\alpha} Z_t^{-(1-\alpha)} e^{-\widehat{z}_t} \tag{2.17}$$

Each firm chooses price $P_t^{\circ}(i)$ with probability ζ_p in order to maximize the present discounted value of expected future profits subject to output demand (2.15). In periods in which the price cannot be optimally chosen, it is updated according to a convex combination of the one-period-lagged (gross) inflation and the 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 present discounted value of current and future profits is given by

$$E_t \sum_{s=0}^{+\infty} (\zeta_p)^s \left[(\Xi_{t+s}^{avg} P_t)/(\Xi_t^{avg} P_{t+s})\right] \left[P_{t+s|t}(i) - MC_{t+s}\right] Y_{t+s|t}(i) \tag{2.18}$$

2.0.6 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

$$L_t = \left(\int L_t(j)^{(\lambda_{w,t}-1)/\lambda_{w,t}} dj \right)^{\lambda_{w,t}/(\lambda_{w,t}-1)} \quad , \quad \forall j \in [0,1] \tag{2.19}$$

where $\lambda_{w,t}$ 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 with parameters $\{\rho_w, \sigma_w\}$. Profit maximization yields labor demand for each j type and aggregate wage:

$$L_t(j) = \left(\frac{W_t(j)}{W_t}\right)^{-\lambda_{w,t}} L_t \ , \ \forall j \in [0,1] \quad \text{and} \quad W_t = \left(\int W_t(j)^{1-\lambda_{w,t}} dj \right)^{1/(1-\lambda_{w,t})} \tag{2.20}$$

The type-j labor union, in turn, takes into account labor demand (2.20) 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 equations (2.4) and (2.11) and the uniform distribution of labor types within each household, the latter is given by:

$$W_t^h(j) = n^{\mu} W_t^{\mu,h,r}(j) + n^{\tau} W_t^{\tau,h,r}(j) = \theta L_t(j)^{\chi} [n^{\mu}/\Xi_t^{\mu} + n^{\tau}/\Xi_t^{\tau}] \tag{2.21}$$

The second equality makes use of the fact that members of the same union work the same hours regardless their family type. The wage is updated according to one-period-lagged and steady-state price inflation based on the indexation parameter ι_w in periods when the union cannot reset it: $W_{t+s|t}(j) = W_t^{\circ}(j)X_{t,s}^w$, 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:

$$E_t \sum_{s=0}^{+\infty} (\zeta_w)^s \left[(\Xi_{t+s}^{avg} P_t)/(\Xi_t^{avg} P_{t+s})\right] \left[W_{t+s|t}(j) - W_{t+s}^h(j)P_{t+s}\right] L_{t+s}(j) \tag{2.22}$$

2.0.7 Policy. Monetary policy follows a Taylor rule:

$$R_t/R = (R_{t-1}/R)^{\rho_r} \left[(\Pi_t/\Pi)^{\psi_\pi} \left(Y_t/Y_t^f\right)^{\psi_y} \left((Y_t/Y_{t-1})/(Y_t^f/Y_{t-1}^f)\right)^{\psi_{\Delta y}}\right]^{1-\rho_r} e^{\upsilon_t^{mp}} \tag{2.23}$$

$\rho_r \in (0,1)$ captures interest rate smoothing. $\upsilon_t^{mp} \sim N(0, \sigma_{mp}^2)$ is a white noise disturbance. Y_t^f denotes equilibrium output under flexible prices and wages and perfect insurance. Fiscal policy follows a balanced budget[8]: $P_t G_t = T_t$, 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 $\epsilon_t^g \sim N(0, \sigma_g^2)$. Since this paper already encompasses several complications, I postulate an equally distributed tax burden across households: $T_t^i = T_t^\mu = T_t^\tau = T_t$[9].

2.0.8 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 (2.16) and the capital-labor ratio, the aggregate production function reads as: $Y_t = e^{\widehat{z}_t} K_t^\alpha (Z_t L_t)^{1-\alpha} - Z_t \Phi_y$. 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, the economy wide profits distributed to households according to their shares are: $V_t = \Pi_t^{int} + Div_t$. Combining the household (2.3, 2.9) and government budget constraints, financial market clearing, and profits, yields the resource constraint:

$$C_t + I_t + G_t + AC_t + \Phi_k Z_t = Y_t \tag{2.24}$$

where the economy wide adjustment costs, AC_t, are pinned down by:

$$AC_t = a(u_t)\bar{K}_{t-1} + Q_t \left[n^\mu \Omega_{t-1}^\mu S_\omega \left(\Omega_t^\mu / \Omega_{t-1}^\mu\right) + n^\tau \Omega_{t-1}^\tau S_\omega \left(\Omega_t^\tau / \Omega_{t-1}^\tau\right)\right] \tag{2.25}$$

2.0.9 Equilibrium. The stationary model, the steady state, and the log-linearized equilibrium are reported in Appendix A. Thanks to the assumptions about capital production

[8] In the canonical model, the way in which government spending is financed, be it through taxation or issuing of one-period bonds held by households, is irrelevant in the log-linearized equilibrium. With heterogeneous households and financial frictions, the way those expenditures are financed no longer is irrelevant.

[9] Justiniano et al. (2015) consider some degree of differential taxation in a relatively similar framework.

outside of the households, the discount factor, and the common habit and Frisch elasticity across families, the steady state of economy wide variables is the same as the one derived in the representative agent economy. The interest rate is given by $R = \Pi e^{\gamma}/\beta^{\tau}$. Moreover, the steady state features family-specific consumption, debt, and shares, as well as a binding constraint (2.6) since $\beta^{\tau} > \beta^{\mu}$. I examine equilibria in which the constraint always 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 markups, government spending, investment, and monetary policy shocks. To the above set of shocks, 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, and how 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.

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 second series is loaded with a factor Ψ_b. The observation equations are reported below, where $\bar{\gamma} = 100\gamma$ and $dlnX_t \equiv 100(lnX_t - lnX_{t-1})$.

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

Moreover, I introduce observables for the annual *top* 10% *income* (TIS_T) and *wealth* (TWS_T) *shares* obtained from the World Inequality Database. The income share encom-

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

passes both wage and capital income. The model-consistent top income share is given by the sum of wages, profits, and interest over aggregate income, and is pinned down by:

$$\begin{aligned} TIS_T &= \sum_{j=0}^{3}\left(n^\tau Y^\tau_{t-j}\right)/\sum_{j=0}^{3}\left(n^\tau Y^\tau_{t-j}+n^\mu Y^\mu_{t-j}\right) \\ &\approx \overline{tis}+\sum_{j=0}^{3}\nu_j\left(\widehat{tis}^{ea}_{t-j}+\widehat{tis}^{b}_{t-j}+\widehat{tis}^{pr}_{t-j}\right) \end{aligned} \tag{3.2}$$

The approximation is obtained in equilibrium, after converting the ratio in terms of stationary variables and taking a first-order expansion around the steady sate (computations are relegated to Appx. D). The weight is given by $\nu_j \equiv e^{(3-j)\gamma}/[e^{3\gamma}+e^{2\gamma}+e^{1\gamma}+1]$. 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 $\overline{tis}_b \equiv n^\tau b^\tau/(e^\gamma \Pi w^r L)$ stands for bond income flowing to the top due to the non-zero asset position (steady state profits are zero). The terms $\{\widehat{tis}^{ea}_t, \widehat{tis}^{b}_t, \widehat{tis}^{pr}_t\}$ stand for earnings, bond income, and profits, respectively, and drive the swings of TIS_T. They are given by:

$$\widehat{tis}^{ea}_t = -\widehat{s}_t-\overline{tis}_b(\widehat{w}^r_t+\widehat{L}_t),\ \widehat{tis}^{b}_t=\overline{tis}_b(\widehat{b}^\tau_{t-1}-\widehat{\pi}_t),\ \widehat{tis}^{pr}_t=\widehat{\mathrm{v}}_t\left(y/w^rL\right)\left(n^\tau\omega^\tau-\overline{tis}\right) \tag{3.3}$$

According to (3.3), 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-consistent top wealth share is given by the sum of shares and assets over the value of all shares ($n^\tau\Omega^\tau_t Q_t + n^\mu \Omega^\mu_t Q_t = Q_t$) since family debt positions net out to zero:

$$\begin{aligned} TWS_T &= \sum_{j=0}^{3} n^\tau\left[Q_{t-j}\Omega^\tau_{t-j}+\frac{B^\tau_{t-j}/P_{t-j}}{e^{v^b_{t-j}}R_{t-j}}\right]/\sum_{j=0}^{3}Q_{t-j} \\ &\approx \overline{tws}+\sum_{j=0}^{3}\nu_j\left(\widehat{tws}^{\omega}_{t-j}+\widehat{tws}^{b}_{t-j}+\widehat{tws}^{q}_{t-j}\right) \end{aligned} \tag{3.4}$$

The approximation is obtained after converting the ratio in terms of stationary variables, and taking a first-order expansion around the steady sate (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. The terms $\{\widehat{tws}^{\omega}_t, \widehat{tws}^{b}_t, \widehat{tws}^{q}_t\}$, stand for shares, bonds, and asset price gains/losses, respectively, and drive the fluctuations of the top wealth share. They are given by:

$$\widehat{tws}_t^{\omega} = \widehat{\omega}_t^{\tau}(n^{\tau}\omega^{\tau}) \quad , \quad \widehat{tws}_t^{b} = \overline{tws}_b(\widehat{b}_t^{\tau} - \widehat{r}_t - \widehat{v}_t^{b}) \quad , \quad \widehat{tws}_t^{q} = -\overline{tws}_b \, \widehat{q}_t \tag{3.5}$$

According to (3.5), 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 increase, since both decrease the real value of outstanding debt. The net effect of shares' price increases ($\widehat{q}_t$) on TWS_T is negative.

Thus, (3.2) and (3.4) connect the observed top income and wealth shares to the latent states. In both, measurement errors $\epsilon_T^{tis} \sim N(0, \mu_{tis}^2)$ and $\epsilon_T^{tws} \sim N(0, \mu_{tws}^2)$ are included. It is worth mentioning the assumptions underlying (3.1, 3.2, 3.4). (3.1) implies that the observed debt pertains to the bottom 90% of the income distribution[11]. Although that implication is supported by data from the Survey of Consumer Finance [Ravenna and Vincent, 2014], it might not hold exactly across the entire population. Thus, including measurement error and multiple debt indicators helps extract the part of debt fluctuations that is relevant for the model. In addition, including a measurement error in both top shares aims at mitigating potential inconsistencies from assuming that the top 10% of the income and wealth distributions coincide. Admittedly, that is a simplifying assumption, but it allows to examine the joint dynamics of inequality and economic aggregates. It is also in the background of Kumhof et al. (2015) and Iacoviello (2008). Moreover, (3.2) and (3.4) suggest that the top shares revolve around their steady state. Put differently, they are not viewed as non-stationary. Furthermore, 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. Examining that feedback, albeit important, is beyond the scope of this work.

3.2 State Space And Likelihood.

I stack the measurement equations for aggregates series and (3.1) vertically to obtain:

$$\Upsilon_t = \Gamma_q + H_0\zeta_t + H_1\zeta_{t-1} + M_t \quad , \quad M_t \sim N(0, \Sigma_q) \tag{3.6}$$

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 of the measurement equations. ζ_t is the period-t $(n_\zeta \times 1)$ state vector. I link the inequality series

[11] Including the top 1% instead of the top 10% income share would imply a more stringent assumption.

to the model by stacking (3.2) and (3.4) vertically to obtain:

$$\Upsilon_T = \Gamma_a + H_{30}\zeta_t + H_{31}\zeta_{t-1} + H_{32}\zeta_{t-2} + H_{33}\zeta_{t-3} + H_{34}\zeta_{t-4} + M_T \quad , \quad M_T \sim N(0, \Sigma_a) \quad (3.7)$$

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 (3.4).

Eq.(3.6) appears for four consecutive quarters until the end of a year when the inequality series are observed and linked to the model via (3.7). Stacking over time yields:

$$\begin{bmatrix} \Upsilon_{t=1} \\ \Upsilon_{t=2} \\ \Upsilon_{t=3} \\ \Upsilon_{t=4} \\ \Upsilon_{T=1} \\ \Upsilon_{t=5} \\ \Upsilon_{t=6} \\ \Upsilon_{t=7} \\ \Upsilon_{t=8} \\ \Upsilon_{T=2} \\ \vdots \end{bmatrix} = \begin{bmatrix} \Gamma_q \\ \Gamma_q \\ \Gamma_q \\ \Gamma_q \\ \Gamma_a \\ \Gamma_q \\ \Gamma_q \\ \Gamma_q \\ \Gamma_q \\ \Gamma_a \\ \vdots \end{bmatrix} + \begin{bmatrix} H_0 & \dots & \dots & \dots & \dots & \dots & \dots & \dots & \dots \\ H_1 & H_0 & \dots & \dots & \dots & \dots & \dots & \dots & \dots \\ \dots & H_1 & H_0 & \dots & \dots & \dots & \dots & \dots & \dots \\ \dots & \dots & H_1 & H_0 & \dots & \dots & \dots & \dots & \dots \\ H_{33} & H_{32} & H_{31} & H_{30} & \dots & \dots & \dots & \dots & \dots \\ \dots & \dots & \dots & H_1 & H_0 & \dots & \dots & \dots & \dots \\ \dots & \dots & \dots & \dots & H_1 & H_0 & \dots & \dots & \dots \\ \dots & \dots & \dots & \dots & \dots & H_1 & H_0 & \dots & \dots \\ \dots & \dots & \dots & \dots & \dots & \dots & H_1 & H_0 & \dots \\ \dots & \dots & \dots & H_{34} & H_{33} & H_{32} & H_{31} & H_{30} & \dots \\ \dots & \ddots & \ddots & \ddots & \ddots & \ddots & \ddots & \ddots & \ddots \end{bmatrix} \begin{bmatrix} \zeta_{t=1} \\ \zeta_{t=2} \\ \zeta_{t=3} \\ \zeta_{t=4} \\ \zeta_{t=5} \\ \zeta_{t=6} \\ \zeta_{t=7} \\ \zeta_{t=8} \\ \vdots \end{bmatrix} + \begin{bmatrix} M_{t=1} \\ M_{t=2} \\ M_{t=3} \\ M_{t=4} \\ M_{T=1} \\ M_{t=5} \\ M_{t=6} \\ M_{t=7} \\ M_{t=8} \\ M_{T=2} \\ \vdots \end{bmatrix} \quad (3.8)$$

The matrix representation of (3.8) is given by

$$\Upsilon = \Gamma + H\zeta + M \quad , \quad M \sim N\left(0_o, \Sigma_M \equiv I_{n_T} \otimes diag\left(diag[I_4 \otimes \Sigma_q]; diag[\Sigma_a]\right)\right) \qquad (3.9)$$

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 (3.9), 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 log-linearized equilibrium conditions are casted in the form: $\Gamma_0(\Theta)\zeta_t = \Gamma_1(\Theta)\zeta_{t-1} + \Psi(\Theta)\epsilon_t + \Pi\eta_t$, where the system matrices $\{\Gamma_0, \Gamma_1, \Psi\}$ are functions of the parameter vector Θ, and η_t collects the expectational errors. The structural shocks are grouped in the $(n_\epsilon \times 1)$ vector ϵ_t, and are fewer than the number of observables $(n_\epsilon < o_q + o_a)$. (3.10) gives the VAR(1) representation of the rational expectations solution of Sims (2002).

$$\zeta_t = \Phi_1(\Theta)\zeta_{t-1} + \Phi_2(\Theta)\epsilon_t \ , \quad \epsilon_t \sim N(0_{n_\epsilon}, I_{n_\epsilon}), \qquad \forall t \geq 2 \qquad (3.10)$$

$\{\Phi_1, \Phi_2\}$ are non-linear functions of Θ. ζ_1 is initialized with covariance D being the steady state covariance of the state vector evaluated at the prior mean of Θ. Defining the reduced-form errors, $\tilde{\epsilon}_t = \Phi_2 \epsilon_t$ for $t > 1$ and $\tilde{\epsilon}_1 = \epsilon_1$, and stacking (3.10) across time yields:

$$\begin{bmatrix} I_{n_\zeta} & \dots & \dots & \dots \\ -\Phi_1 & I_{n_\zeta} & \dots & \dots \\ \dots & \ddots & \ddots & \dots \\ \dots & \dots & -\Phi_1 & I_{n_\zeta} \end{bmatrix} \begin{bmatrix} \zeta_1 \\ \zeta_2 \\ \vdots \\ \zeta_T \end{bmatrix} = \begin{bmatrix} \tilde{\epsilon}_1 \\ \tilde{\epsilon}_2 \\ \vdots \\ \tilde{\epsilon}_T \end{bmatrix}, \qquad \begin{bmatrix} \tilde{\epsilon}_1 \\ \tilde{\epsilon}_2 \\ \vdots \\ \tilde{\epsilon}_T \end{bmatrix} \sim N\left(0_{n_\zeta n_q}, \begin{bmatrix} D & \dots \\ \vdots & \Omega \otimes I_{T-1} \end{bmatrix}\right) \tag{3.11}$$

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

$$Z\zeta = \tilde{\epsilon} \qquad , \qquad \tilde{\epsilon} \sim N(0_{n_\zeta n_q}, K_{\tilde{\epsilon}}^{-1}) \tag{3.12}$$

$\tilde{\epsilon} \equiv [\tilde{\epsilon}_1', \tilde{\epsilon}_2' \dots, \tilde{\epsilon}_T']'$ 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 $(\widehat{\zeta})$ is computed from (3.13) below based on the efficient simulation of Chan and Jeliazkov (2009).

$$P\widehat{\zeta} = K\tilde{\zeta} + H' \Sigma_M^{-1} (\Upsilon - \Gamma) \tag{3.13}$$

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: $\log P(\Upsilon|\Theta) = +logP(\Upsilon|\Theta, \widehat{\zeta}) + logP(\widehat{\zeta}|\Theta) - logP(\widehat{\zeta}|\Upsilon, \Theta)$, where all terms can be computed fast using the block-banded nature of the precision matrices.

3.3 Sampler And Priors.

The Random Walk Metropolis-Hastings algorithm is used to simulate draws from the non-tractable posterior[12]. I estimate the model described above as well as alterations of it and its representative agent version (obtained for $n^\tau = 1$ and $\phi^\tau = 0$).

The priors of the parameters appearing in both the representative agent model and this paper's benchmark model are conventional[13] and reported in Table (1). As for the

[12] The covariance of the jumping distribution is initialized at the prior and updated every 100k draws.

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

parameters associated with the distributional dimension, the share of top agents is 10% in accordance with the observed top 10% income and wealth shares. β^{τ} is set to 0.99, and β^{μ} is fixed at 0.95 which is the calibrated value in Iacoviello (2005). The steady state debt limit (m) is fixed at 0.3, a value within the range of numbers usually considered in studies building on Iacoviello and Neri (2010). The prior for $\bar{s}$ follows a Beta around 0.8 (0.02 std); it is close but above the sample average bottom income share (0.62) since wage income is less unequally distributed than overall income that includes capital income. The strength of preferences over wealth (ϕ^{τ}, ϕ^{μ}) is sampled from the Beta centered at 0.1 (0.04 std) – the prior mean is the value often considered in calibrations. In the benchmark estimation, the curvature of wealth adjustment costs (S_{ω}) is set to 1. The robustness and implications of this choice are thoroughly examined. The combination of the above priors yields a disperse distribution of the steady state top income and wealth shares around the sample averages shown in Table (2). The prior for the credit shock is aligned with that considered for all other shocks. The prior std for the polarization and wealth shocks is the same as that considered for all other shocks; their prior persistence is a tad higher (0.7) than that of the other shocks.

4 Findings

I first shed light on the identification of parameters. I then assess the economy wide effects of distributional shocks and the distributional implications of aggregate shocks. In the subsequent sections, I delve into the interplay between inequality and credit, as well as between inequality and monetary policy. A battery of robustness checks closes the analysis.

4.1 Posterior Estimates.

The estimates for the parameters that appear in both the benchmark model and the representative agent (RA) model, and are associated with the aggregate dimension of the economy, are displayed in Table (1). The estimates across the two model configurations reveal some, albeit small, differences in magnitude[14]. The starkly small differences imply a *dichotomy* in the identification: parameters associated with the aggregate dimension of the model are mainly identified by aggregate data series appearing in the estimation of both models rather than by the inclusion of inequality and debt series.

[14]The benchmark model implies higher price indexation and volatility of price markup shocks, as well as a lower price markup persistence, than the RA model does. Nevertheless, the swing between persistence and indexation highlights the close substitutability between those two parameters. Moreover, the estimates for the RA model reveal a lower persistence for wage markup shocks and a higher wage indexation to price inflation than those obtained in Smets and Wouters (2007). This result likely has to do with the inclusion of the 1954-64 and 2006-09 periods of volatile wages that are not included in the estimation of those authors.

Turning to the parameters associated with agent heterogeneity, I examine their *joint* implication in terms of the posterior distribution of the steady state top income and wealth shares. According to Table (2), the posterior of those shares is tightly distributed around a value close to the sample average despite the disperse prior. This observation suggests that these parameters are influenced by the use of inequality and household debt data.

Table 1: Posterior Distribution – Common Parameters

	Prior	**Posterior** Mean [5-95%]	
		Rep. Agent	Benchmark
α	N(0.30, 0.05)	0.21 [0.19, 0.24]	0.16 [0.13, 0.18]
η	B(0.70, 0.10)	0.77 [0.71, 0.82]	0.67 [0.63, 0.71]
χ	N(2.00, 1.00)	4.14 [2.94, 5.39]	3.88 [2.51, 5.37]
ψ	B(0.50, 0.10)	0.37 [0.24, 0.56]	0.50 [0.41, 0.60]
S	N(4.00, 1.00)	6.74 [5.45, 8.01]	6.76 [5.47, 8.12]
ζ_w	B(0.60, 0.10)	0.90 [0.84, 0.95]	0.85 [0.79, 0.96]
ζ_p	B(0.60, 0.10)	0.91 [0.87, 0.94]	0.86 [0.84, 0.89]
ι_p	B(0.50, 0.15)	0.07 [0.03, 0.12]	0.84 [0.74, 0.92]
ι_w	B(0.50, 0.15)	0.75 [0.61, 0.87]	0.69 [0.39, 0.88]
ρ_r	B(0.75, 0.10)	0.90 [0.88, 0.92]	0.89 [0.87, 0.91]
ψ_π	N(1.70, 0.25)	1.88 [1.55, 2.22]	2.27 [1.68, 2.65]
ψ_y	N(0.12, 0.05)	0.20 [0.13, 0.26]	0.21 [0.14, 0.28]
$\psi_{\Delta y}$	N(0.12, 0.05)	0.23 [0.14, 0.31]	0.24 [0.16, 0.32]
ρ_b	B(0.60, 0.20)	0.80 [0.71, 0.88]	0.91 [0.88, 0.94]
σ_b	IG(0.15, 1.00)	0.12 [0.09, 0.15]	0.07 [0.06, 0.09]
ρ_z	B(0.60, 0.20)	0.99 [0.98, 0.99]	0.97 [0.96, 0.98]
σ_z	IG(0.15, 1.00)	0.55 [0.51, 0.60]	0.65 [0.59, 0.71]
ρ_i	B(0.60, 0.20)	0.85 [0.75, 0.98]	0.82 [0.76, 0.87]
σ_i	IG(0.15, 1.00)	0.30 [0.25, 0.36]	0.25 [0.22, 0.30]
ρ_p	B(0.60, 0.20)	0.81 [0.74, 0.87]	0.10 [0.03, 0.22]
σ_p	IG(0.15, 1.00)	0.07 [0.05, 0.08]	0.20 [0.17, 0.22]
ρ_w	B(0.60, 0.20)	0.13 [0.05, 0.22]	0.18 [0.07, 0.30]
σ_w	IG(0.15, 1.00)	0.60 [0.54, 0.67]	0.62 [0.54, 0.71]
σ_{mp}	IG(0.15, 1.00)	0.24 [0.22, 0.26]	0.25 [0.23, 0.27]
ρ_g	B(0.60, 0.20)	0.97 [0.95, 0.99]	0.93 [0.91, 0.97]
σ_g	IG(0.15, 1.00)	0.46 [0.42, 0.50]	0.49 [0.45, 0.53]
ρ_{gz}	B(0.50, 0.20)	0.32 [0.26, 0.38]	0.31 [0.24, 0.39]
γ	N(0.40, 0.03)	0.39 [0.35, 0.43]	0.36 [0.33, 0.39]
π	N(0.80, 0.03)	0.83 [0.78, 0.87]	0.87 [0.82, 0.92]
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]	0.26 [0.21, 0.31]
$\bar{l}$	N(0.00, 0.10)	0.03 [-0.12, 0.20]	0.01 [-0.16, 0.19]
$logL$		-1433	-2901

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

In Table (3), the strength of preferences over wealth (ϕ^μ, ϕ^τ) is heterogeneous across households, and implies that the parameter homogeneity often postulated in models featuring

Table 2: Steady State Distributional Imbalances

	Data, 1954-2009 mean [min, max]	Steady State, Mean [5-95%] Prior	Posterior
top 10% income share	38 [34, 46]	33 [24, 46]	36 [35, 36]
top 10% wealth share	67 [61, 74]	68 [51, 83]	64 [62, 66]

Notes: Author's computations. Figures in %. For data sources, see text.

housing might be restrictive – Justiniano et al. (2015) consider the case of heterogeneous calibrated parameters. In fact, the estimates suggest $\phi^{\tau} > \phi^{\mu}$ which is consistent with Carroll (2000)'s argument about the top of the distribution deriving higher utility from wealth than the rest does. Polarization, wealth, and credit shocks are all persistent. Only credit shocks are highly volatile. 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 ($\Psi_d = 0.72$). The posterior mean of the middle-class' steady state wage share ($\bar{s}$) is a tad higher than its prior mean.

Table 3: Posterior Distribution – Distributional Parameters

		Prior	**Posterior** Mean [5-95%]
bottom wealth preferences	ϕ_μ	B (0.10, 0.04)	0.12 [0.11, 0.14]
top wealth preferences	ϕ_τ	B (0.10, 0.04)	0.15 [0.12, 0.18]
bottom st.st. wage share	$\bar{s}$	N (0.80, 0.02)	0.85 [0.83, 0.86]
AR income	ρ_s	B (0.70, 0.20)	1.00 [0.99, 1.00]
std income	σ_s	IG (0.15, 1.00)	0.73 [0.61, 0.89]
AR wealth	ρ_ω	B (0.70, 0.20)	0.97 [0.96, 0.99]
std wealth	σ_ω	IG (0.15, 1.00)	0.11 [0.09, 0.14]
AR credit	ρ_m	B (0.70, 0.20)	0.98 [0.97, 1.00]
std credit	σ_m	IG (0.15, 1.00)	4.16 [3.63, 4.74]
factor for debt	Ψ_d	N (1.00, 0.50)	0.72 [0.60, 0.84]
std m.e. mortgage debt	μ_{hm}	IG (0.15, 1.00)	1.11 [0.89, 1.35]
std m.e. credit debt	μ_{cc}	IG (0.15, 1.00)	0.95 [0.79, 1.11]

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

4.2 Economy Wide Implications of Distributional Shocks.

4.2.1 Economy Wide Effect. I quantify the autonomous effect of distributional shocks on the U.S. business cycle in Table (4) which displays the forecast error variance decomposition of several variables two/ten years ahead. The striking result is that the combined effect of distributional shocks explains less than 10% of output fluctuations at any horizon. More precisely, wage polarization shocks have a negligible impact on output cycles. Wealth shocks explain 3/2% of output cycles in the short/long run. That influence is aligned with the findings of Iacoviello and Neri (2010), according to which a similar shock affecting the preferences over housing exerts about the same influence on output. Credit supply shocks, too, explain a small fraction (4/2%) of output cycles. The limited macroeconomic impact of credit shocks, is consistent with the findings of Justiniano et al. (2015). The small influence of distributional shocks is confirmed in the case of other aggregates as well.

Despite their aforementioned limited influence, the distributional shocks have a profound impact on household indebtedness. They explain about two thirds of household debt swings at any horizon. Both wealth and credit shocks contribute about equally to this result, whereas the influence of polarization shocks is still negligible. This paper's influence of distributional 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 adversarial swings in inequality.

Table 4: Business Cycles and Distributional Shocks

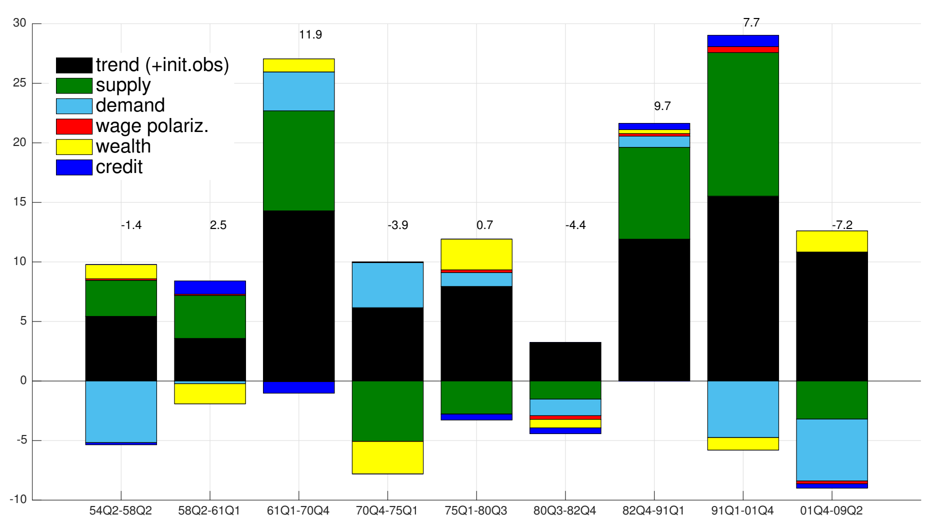
	variable							
shock	$\widehat{y}_t$	$\widehat{i}_t$	$\widehat{w}_t^r$	$\widehat{\pi}_t$	$\widehat{r}_t$	$\widehat{b}_t^\tau$	$\widehat{tis}_t$	$\widehat{tws}_t$
polarization	0/0	0/0	0/0	0/0	0/0	1/1	58/78	26/42
wealth pref.	3/2	1/1	0/0	1/1	1/2	40/36	2/1	35/25
credit supply	4/2	0/0	0/0	0/0	1/0	34/29	1/0	6/3
distributional	7/4	2/1	0/0	1/1	2/3	74/66	60/79	67/70
technology	26/47	5/19	23/66	13/12	8/5	18/14	2/6	16/17
price markup	14/9	12/8	26/11	44/42	9/10	2/2	12/4	5/2
wage markup	1/5	1/6	45/16	26/25	17/12	2/1	3/2	8/3
supply side	42/61	18/33	95/92	83/78	34/27	22/17	18/13	28/21
risk premium	26/15	12/8	2/1	9/10	34/40	2/2	11/4	2/1
investment	13/13	63/53	2/6	5/7	11/22	2/14	6/3	1/7
govt spending	2/1	1/2	0/0	0/0	0/1	0/1	1/0	1/0
policy	9/5	4/3	1/0	2/3	19/9	1/1	4/1	1/0
demand side	51/35	80/65	5/7	16/21	64/70	4/17	22/8	5/9

Notes: Forecast Error Variance Decomposition 8/40 quarters ahead, computed at the posterior mean. *Mnemonics:* $\{\widehat{y}_t, \widehat{i}_t, \widehat{w}_t^r, \widehat{\pi}_t, \widehat{r}_t, \widehat{b}_t^\tau, \widehat{tis}_t, \widehat{tws}_t\}$ stand for output, investment, the real wage, inflation, the interest rate, top household assets, top income share, top wealth share (% deviation from steady state).

It is worthwhile to elaborate on the labeling of polarization, wealth, and credit shocks as "*distributional*" shocks and document their impact on the top shares (Table 4). Although polarization shocks have revealed only a negligible influence so far, these shocks have a sizable impact on income and wealth inequality: they explain about two thirds and a third of the fluctuations in the top income and wealth shares, respectively. Wealth shocks, too, have a sizable influence on wealth inequality: they explain about a third of the fluctuations in the top wealth share. Interestingly, stochastic variations in credit availability have limited influence on the top shares. Nonetheless, given their sizable influence on agents' portfolios (34/29%), they are also viewed as a distributional disturbance. Overall, the combined effect of distributional shocks explains about two thirds of household debt and of the top shares.

4.2.2 Time-Varying Effect. Has the effect of distributional shocks on economy wide aggregates changed across the 1954-2009 period? To tackle this question, I plot the historical effect of distributional shocks on real output growth across U.S. business cycles in Fig.(2). The figure corroborates that these shocks do not have a sizable impact, and suggests a small degree of time variation in the latter. In particular, wealth shocks are more prominent before the 1980s than after that. In contrast, polarization shocks gain influence with the rise of income inequality starting in mid-80s. During the entire span of the two cycles of the 1980s-90s, polarization and credit supply shocks exert a net upward push to output, whereas, during the 2001-09 cycle, these shocks exert a net downward pressure to output.

Figure 2: Distributional Shocks and U.S. Output Growth Cycles



Notes: Historical decomposition of cumulative cyclical real output growth per capita (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. Trend growth is reported in black. All figures are in %.

4.2.3 Diffusion. In Fig.(3), I consider the way wage polarization, wealth, and credit supply shocks are diffused in the economy, and how they affect the top income and wealth shares. The analysis suggests that distributional shocks operate through an *aggregate demand channel*. The latter hinges on heterogeneous consumption responses across the population.

In response to wage polarization, the consumption of top rises whereas middle-class consumption falls. The two changes do net out to zero, and result in a gradual economy wide consumption decrease – an aggregate demand contraction – that eventually lowers production and generates a pro-cyclical inflation response. The workings of a demand channel are corroborated by the fact that the output and consumption drops are about coequal.

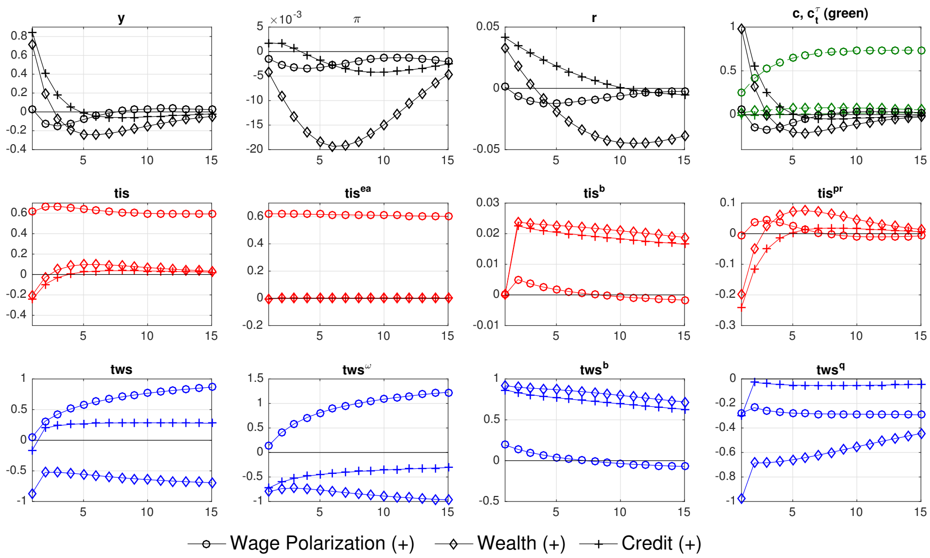
Changes in the desire for wealth accumulation and/or credit availability have non-monotonic effects. An increase in the desire for wealth or a credit expansion initially raises and then decreases middle-class and aggregate consumption. Top consumption exhibits a negligible and gradual increase. As a result, production initial rises and then falls. Section 4.4.3 traces the roots of non-monotonicity on the financial market imperfections.

Output changes in response to distributional shocks, therefore, are due to heterogeneous consumption shifts across the population that do not cancel out on aggregate. Worth pointing out is the fact that the inflation responses are pro-cyclical and of a smaller size than those of output. The pro-cyclicality implies no sizable trade off for monetary policy.

Turning to the effect of distributional shocks on income and wealth inequality, the evolution of top shares, as well as that of debt, is highly persistent compared to that exhibited by economy wide variables in response to the same shocks. This persistence mirrors the low-frequency shifts in the debt and inequality series captured by the estimation. Polarization is the only distributional disturbance that leads to counter-cyclical increases in both top shares. In contrast, wealth shocks lower wealth inequality since the middle class gains access to wealth holdings, but they quickly elevate income inequality after a short-run reduction in it because the middle class borrows from the top to finance the wealth purchases. Income inequality is quickly aggravated also after exogenous credit expansions for the same reason. Nonetheless, credit expansions elevate wealth inequality.

More specifically, polarization results in a higher share of earnings flowing to the top (tis^{ea}). The top families leverage their income to increase consumption (c_t^τ), issue bonds (tws^b), and raise their shares (tws^ω). The bonds bring interest payments (tis^b) over the medium run sustaining income inequality. Both credit relaxations and wealth shocks decrease income inequality on impact but quickly raise it. They do so because they lead to a short-

Figure 3: Economy Wide Implications Of Distributional Shocks



Notes: impulse response functions (posterior mean). Top row: economy wide variables. 2nd–3rd rows: $tis = tis^{ea} + tis^{b} + tis^{pr}$, $tws = tws^{\omega} + tws^{b} + tws^{q}$. *Mnemonics:* $\{tis, tis^{ea}, tis^{b}, tis^{pr}\}$ stand for the top income share, earnings, bond income, and profits, respectively. $\{tws, tws^{\omega}, tws^{b}, tws^{q}\}$ stand for the top wealth share, shares, bonds, and asset price gains/losses, respectively. c^{τ}_t refers to $(n^{\tau}c^{\tau}/c)\widehat{c}^{\tau}_t$, with $\widehat{c}_t = (n^{\tau}c^{\tau}/c)\widehat{c}^{\tau}_t + (n^{\mu}c^{\mu}/c)\widehat{c}^{\mu}_t$. All variables in % deviation from steady state.

lived output expansion to which prices cannot immediately adjust due to nominal rigidities. As a result, profits adjust and, given their unequal distribution across the population, lead to a decrease in tis^{pr}. Over time, prices adjust and profits rise. Both shocks lead to an expansion in the assets of the top that generate capital income (tis^{b}). The middle-class families borrow (tws^{b} rises) and 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 that both wealth and credit shocks lead to changes of the same sign in the variables of Fig.(3), the former drive down wealth inequality whereas the latter raise it. This difference happens because credit shocks do not increase the middle-class' ownership of shares as much as wealth shocks do, and do not generate an increase in shares' price (reflected in tws^{q}) as large as that observed after wealth shocks.

4.3 The Distributional Implications of Aggregate Shocks.

4.3.1 Aggregate Shocks and Inequality. Although demand and supply side shocks are labeled as "*aggregate*" shocks following convention, they may in fact have an idiosyncratic impact because their transmission is filtered through structural imbalances, namely agent heterogeneity and imperfect financial insurance. This section, therefore, reverses the tables compared to the previous one, and investigates the effect of aggregate shocks on inequality.

Table (4) demonstrates that the transmission of aggregate shocks entails profound idiosyncratic effects. The combination of exogenous shifts in the demand and supply sides explains about a third of the swings in the top shares and household debt at all horizons. More specifically, supply side shocks and, in particular, technology shocks exert a sizable influence on the top wealth share and household debt in both the short and long run. Over the long run, investment shocks increase their influence on the above two variables. Those two aggregate shocks (technology and investment) have sizable idiosyncratic consequences since their impact on the asset holdings is channeled through an unequal distribution of economy wide profits. As for the top income share fluctuations, those are distributed about evenly across aggregate shocks, with price markup and risk premium shocks exerting a tad higher influence than the other aggregate shocks in short horizons.

4.3.2 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 the U.S. business cycles? Fig.(4) and (5) cope with that question. Fig.(4) 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. Nevertheless, the rise of the top income share since the mid-80s to 2009 is mainly explained by supply side shocks, a credit expansion, and wealth shocks (up to 2000). During that period, demand and polarization shocks exert a rather downward pressure to the top income share in net terms.

The determinants of the swings in the top 10% wealth share exhibit some time variation. The post-1990 rise of wealth inequality is driven by supply side shocks and a credit expansion. Worth mentioning are the inequality-increasing effect of wealth shocks during the 2000s and of wage polarization during the 1990s. In contrast, in the pre-1990 period, the swings in wealth inequality are ultimately determined by wealth shocks with credit supply shocks also playing some role. More precisely, the increase in inequality until the mid-60s, the subsequent flattening until the mid-70s, and the following decline until the mid-80s are heavily influenced by positive, negligible, and negative wealth shocks (and credit shocks to some extent), respectively, that edge out the net influence of the other disturbances.

4.3.3 Transmission. Although demand and supply side shocks have been shown to exert sizable influence on the gyrations of debt and of the top shares, still little is known about the

Figure 4: Cyclical Swings in the Top 10% Income Share, 1954–2009

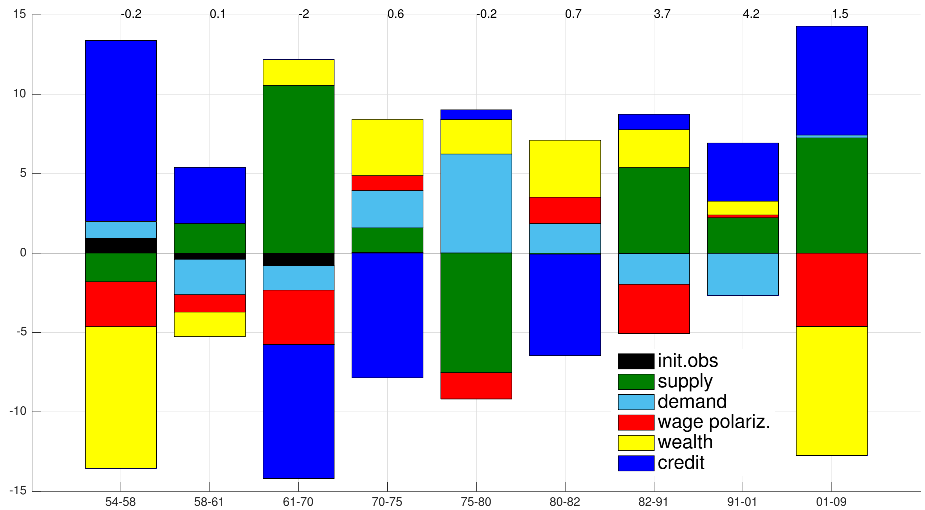
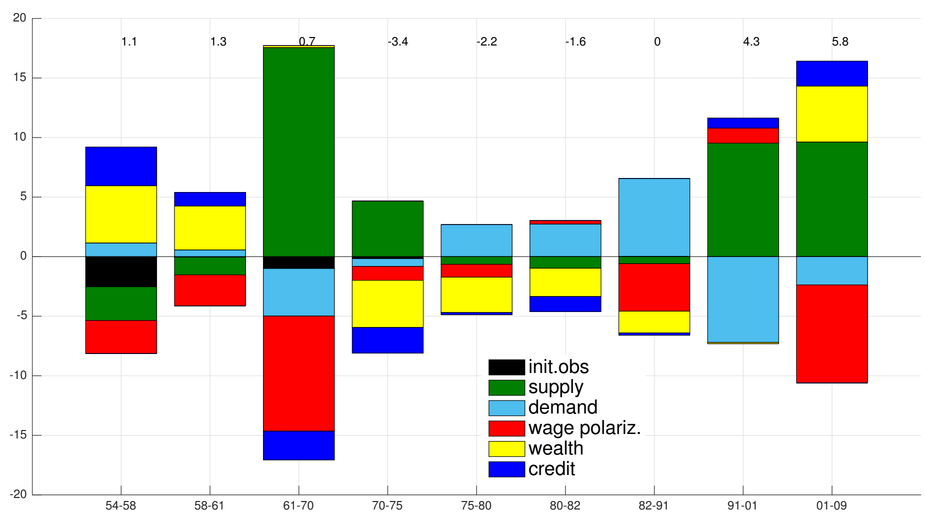


Figure 5: Cyclical Swings in the Top 10% Wealth Share, 1954–2009

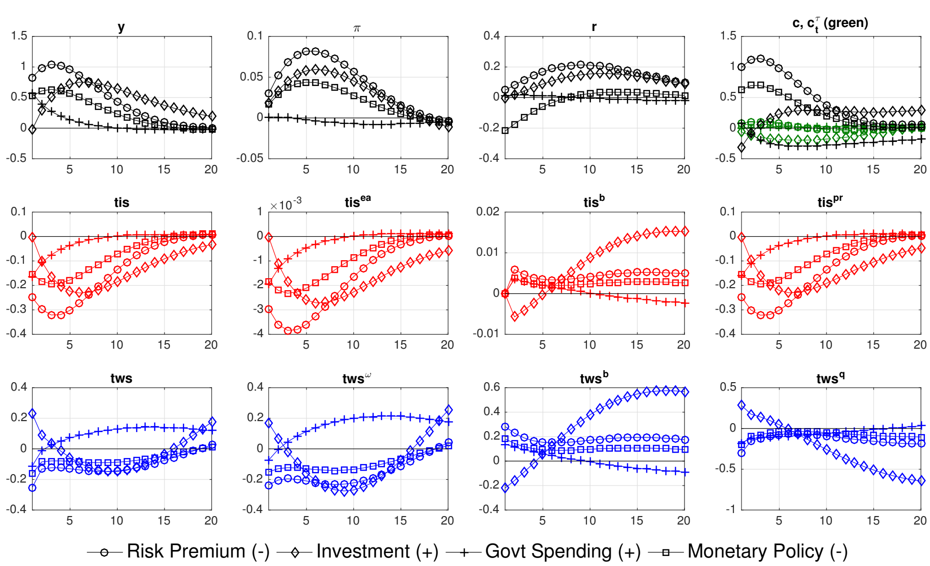


Notes: Historical decomposition of cumulative cyclical annual change (shown on top of each column) over a U.S. business cycle (trough to trough). Cumulative effect of each shock. Demand side shocks: risk premium, investment, interest rate, and government spending. Supply side shocks: technology, price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

exact nature of their transmission. In Fig.(6), I consider the diffusion of demand side disturbances. Demand-driven expansions, raising output and generating a pro-cyclical inflation response, decrease income inequality. They do so due to nominal price rigidities impeding prices to optimally adjust and resulting in lower profit margins and, thereby, lower profits flowing to the top (tis^{pr}). The responses of earnings (tis^{ea}) and of capital income (tis^{b}) are of a small magnitude. Furthermore, in response to all demand side shocks but to government spending shocks, wealth inequality decreases. The expansion results in middle-class households borrowing from the top (tws^b) to finance their consumption and purchases of shares (tws^ω falls). The middle-class' access to the ownership of firms and the negative asset price effect to the top (tws^q) edge out the increase in borrowing, and result in a plummeting top wealth share. Worth mentioning is the fact that economy wide consumption increases far more than top consumption does indicating that an aggregate demand channel is in place.

Government spending shocks have a dual effect. On the one hand, they (mechanically) raise output. On the other hand, they raise the tax burden for both families since the model was built on the premise of an equal tax across all households. This assumption implies that the tax burden falls heavier on the middle class given the unequal distribution of wage income and wealth. In response, middle-class families reduce consumption (more than top families do), take on loans (tws^b rises), and deplete their equity holdings (tws^ω increases). As a result, the the top wealth share (tws) soars. Demand-driven expansions, therefore, generate counter-cyclical responses in the top income and top wealth shares, with the exception of government spending shocks which generate a pro-cyclical response in wealth inequality.

Figure 6: Distributional Implications of Aggregate Demand Side Shocks



Notes: impulse response functions (posterior mean). Top row: economy wide variables. 2nd–3rd rows: $tis = tis^{ea} + tis^b + tis^{pr}$, $tws = tws^\omega + tws^b + tws^q$. *Mnemonics:* $\{tis, tis^{ea}, tis^b, tis^{pr}\}$ stand for the top income share, earnings, bond income, and profits, respectively. $\{tws, tws^\omega, tws^b, tws^q\}$ stand for the top wealth share, shares, bonds, and asset price gains/losses, respectively. c_t^τ refers to $(n^\tau c^\tau/c)\widehat{c}_t^\tau$, with $\widehat{c}_t = (n^\tau c^\tau/c)\widehat{c}_t^\tau + (n^\mu c^\mu/c)\widehat{c}_t^\mu$. All variables in % deviation from steady state.

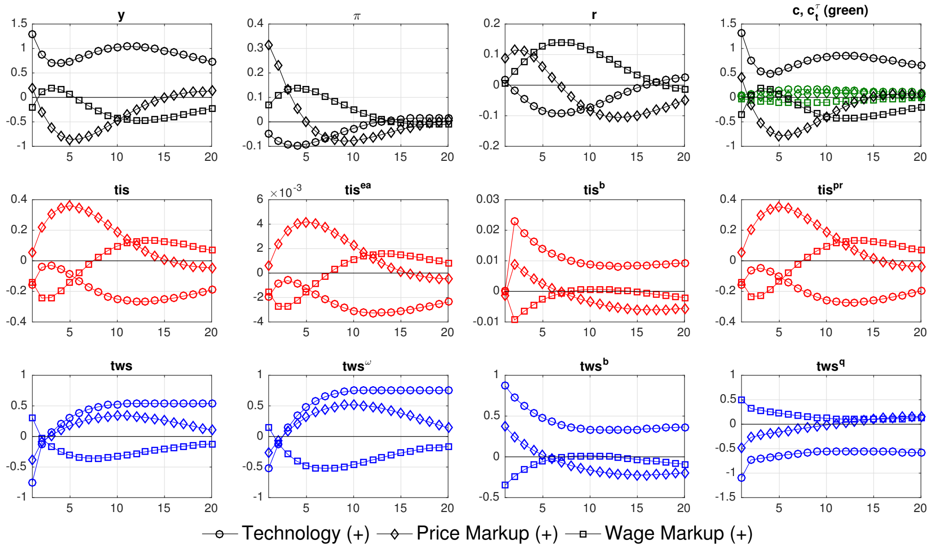
I turn to the transmission of supply side innovations in Fig.(7). Stochastic increases in price markups generate counter-cyclical responses in both income and wealth inequality. They bring in an economic contraction, while price increases favor the firms' profits flowing to the top (tis^{pr}). Due to the contraction, middle-class consumption falls far more than top consumption does. The middle class smoothes its consumption decline by borrowing from the top (tws^b) and depleting its assets (tws^ω rises). As a result, the top wealth share (tws) follows an upward trajectory. Contrary to price markup shocks, wage markup shocks decrease both income and wage inequality despite that they, too, generate an economic contraction. Both families decrease consumption by about the same amount. High wages trigger low profits since firms cannot optimally reset prices. The top family borrows from the middle class (tws^b is negative), and quickly depletes its equity holdings (tws^ω drops). Low profits and debt service payments decrease the top income share, while the severely hit portfolios of the top bring down the top wealth share.

In response to technological advances, income inequality decreases, whereas wealth inequality increases. The combination of those advances with nominal price rigidities negatively affects the profit income flowing to the top (tis^{pr}). The output increase is absorbed by middle-class' consumption since the top increases its consumption by a negligible amount. The middle-class consumption is debt financed and leads to interest receipts for the top (tis^b). These interest payments, however, are edged out by the negative effect of profits resulting in a decline in income inequality. The debt-financed consumption of middle class along with the increased shares of the top lead to a gradual increase in the top wealth share.

4.4 Credit And Inequality.

4.4.1 The Origins of Debt Fluctuations. Table (4) shows that wealth and credit shocks each account for about a third of household debt fluctuations. To deeper understand the role of inequality data, I re-estimate the benchmark model by excluding top income and wealth shares from the observation set as well as polarization and wealth shocks from the stochastic structure. The last column of Table (5) displays the FEVD from that estimation run. It shows that the short-run influence of credit shocks on debt rises from 34% (Table 4) when inequality series are included in the observation set to 45% when these series are not included. This change occurs despite the fact that those shocks still exert limited influence on output. Thus, part of debt swings that would otherwise be thought to be driven by a relaxation of credit might actually be due to changes in the desire for wealth accumulation.

Figure 7: Distributional Implications of Aggregate Supply Side Shocks



Notes: impulse response functions (posterior mean). Top row: economy wide variables. 2nd–3rd rows: $tis = tis^{ea} + tis^{b} + tis^{pr}$, $tws = tws^{\omega} + tws^{b} + tws^{q}$. *Mnemonics:* $\{tis, tis^{ea}, tis^{b}, tis^{pr}\}$ stand for the top income share, earnings, bond income, and profits, respectively. $\{tws, tws^{\omega}, tws^{b}, tws^{q}\}$ stand for the top wealth share, shares, bonds, and asset price gains/losses, respectively. c_t^{τ} refers to $(n^{\tau}c^{\tau}/c)\widehat{c}_t^{\tau}$, with $\widehat{c}_t = (n^{\tau}c^{\tau}/c)\widehat{c}_t^{\tau} + (n^{\mu}c^{\mu}/c)\widehat{c}_t^{\mu}$. All variables in % deviation from steady state.

In other words, the influence of credit supply disturbances might be overstated if studied in frameworks that do not take into account shifts in income and wealth inequality.

Disentangling wealth shocks from credit supply shocks, therefore, can be important in understanding changes in the economy and in inequality. The disentanglement is feasible thanks to the information provided by the inclusion of the top shares in the estimation. That information allows to discipline the path of variables associated with wealth heterogeneity and appearing in the observation equation for wealth (3.4). In particular, and as it is seen in Fig.(3), wealth shocks entail more volatile changes in those variables than credit shocks imply, despite the fact that both shocks generate qualitatively similar changes. As a result, credit relaxations increase wealth inequality, whereas wealth shocks decrease it.

4.4.2 The Origins of Debt Build Up. Although the findings of Table (4) suggest that credit supply shocks explain about a third of household debt fluctuations, they remain silent about the influence of those shocks during the debt build up of the decades that preceded the Great Recession. This is a controversial issue. For instance, Mian and Sufi (2018), and citations therein, argue that the U.S. credit expansion was one of the main factors behind that phenomenon. In contrast, Justiniano et al. (2015) find that such expansions in structural

Table 5: Business Cycles of Output and Inequality – Robustness Checks

	$S_w = 0.1$				estimated S_w				no ineq. data			
shock	$\widehat{y}_t$	$\widehat{b}_t^\tau$	$\widehat{tis}_t$	$\widehat{tws}_t$	$\widehat{y}_t$	$\widehat{b}_t^\tau$	$\widehat{tis}_t$	$\widehat{tws}_t$	$\widehat{y}_t$	$\widehat{b}_t^\tau$	$\widehat{tis}_t$	$\widehat{tws}_t$
polarization	2	5	71	57	6	0	34	21				
wealth pref.	0	54	0	15	1	15	1	27				
credit supply	0	0	0	0	1	25	1	9	2	45	4	8
distributional	2	59	72	72	8	40	36	56	2	45	4	8
technology	39	27	4	8	2	23	2	12	33	29	4	21
price markup	11	5	8	5	3	1	3	2	9	1	24	5
wage markup	1	3	1	7	7	10	12	13	5	4	10	4
supply side	52	35	13	20	12	34	16	28	47	34	38	31
risk premium	27	2	9	4	54	9	32	8	24	10	27	29
investment	7	3	2	2	17	9	10	3	11	4	14	8
govt spending	3	1	1	0	0	1	0	1	1	0	1	1
policy	8	0	3	1	10	8	5	4	14	6	15	22
demand side	46	6	15	8	81	26	48	16	51	21	57	61

Notes: FEVD, 8 quarters ahead, computed at the posterior mean. *Mnemonics:* $\{\widehat{y}_t, \widehat{b}_t^\tau, \widehat{tis}_t, \widehat{tws}_t\}$ stand for output, top household assets, top income share, top wealth share (% deviation from steady state).

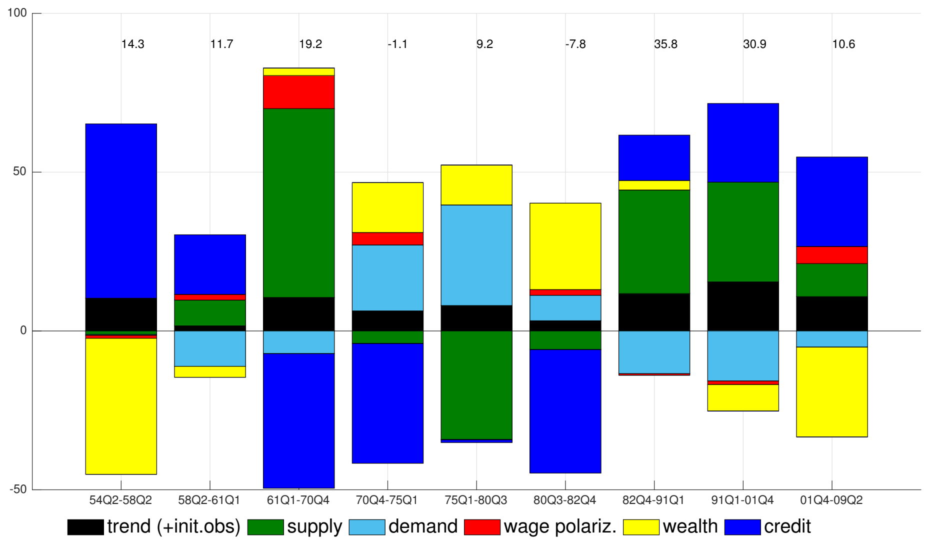
models do not suffice to account for the severity of the Great Recession and have limited influence on the economy[15]. Fig.(8) demonstrates that cyclical debt growth was by far the strongest during the three business cycles of the 1980s-2009 period. It suggests that credit relaxation contributed in all three debt expansions. Credit shocks account for about a third and half of the influence of shocks raising debt during the 1980s-90s and 2000s, respectively. Supply side shocks contribute significantly to the debt build up as well. Credit relaxation, therefore, contributes to the debt build up, without being the only determinant and having a sizable influence on the output drop though (Fig. 2).

4.4.3 Financial Market Imperfections. I now investigate how the transmission of distributional shocks depends on the degree of financial market imperfections captured by the steady state loan-to-debt ratio (m); the higher the m, the lower the imperfections[16]. Fig.(9) displays the transmission of polarization and wealth shocks under alternative scenarios for that parameter. Two take-away messages are unveiled. First, the responses in Fig.(9) under alternative values for m are broadly consistent with the responses seen in the benchmark model ($m = 0.3$). Thus, the latter calibration does not exert a sizable influence on the

[15]Mian and Sufi (2018) express reservations about modeling credit shocks as shifts in the debt limit.

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

Figure 8: The Debt Build Up



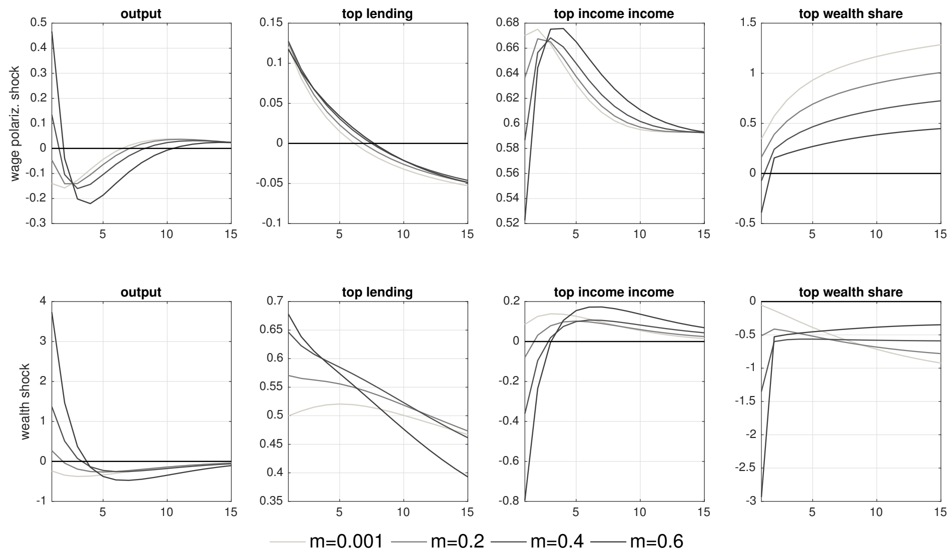
Notes: Historical decomposition of cumulative cyclical real household debt growth per capita (shown on top of each column) over a U.S. business cycle (trough to trough). Cumulative effect of each shock. Demand side shocks: risk premium, investment, interest rate, and government spending. Supply side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

results. Second, the degree of financial market imperfections alters the immediate impact of polarization and wealth shocks. More precisely, in terms of output, a high degree of financial market imperfections (i.e. a low m) leads to highly persistent output responses of a small volatility. The immediate and medium-run effects are aligned: increases in wage polarization and/or wealth shocks lead to an output decline.

In contrast, with a low degree of financial market imperfections (i.e. a high m), the immediate and the medium-run effects of polarization and wealth shocks can be different. In fact, their effect on output is non-monotonic: output first increases and then decreases. The non-monotonic output response occurs due to the lowdegree of financial imperfections: middle-class families are able to borrow and initially sustain their consumption level against the above adversarial shocks. Over time, however, interest payments kick in and the middle class decreases spending. The latter triggers a demand as well as an output contraction.

The above results for output carry on to debt and the top shares. For a high degree of financial market imperfections, the impact of distributional shocks is aligned with their medium-run effect. In contrast, for a low degree of financial market imperfections, their impact is different from their medium-run effect. More precisely, in response to a polarization shock, the easier the access to finance is (the higher the m is), the less amplified the increase in the top income and wealth shares are. Similarly, in response to wealth shocks, the easier the access to finance is, the lower income and wealth inequality are.

Figure 9: Financial Market Imperfections and the Transmission of Distributional Imbalances



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

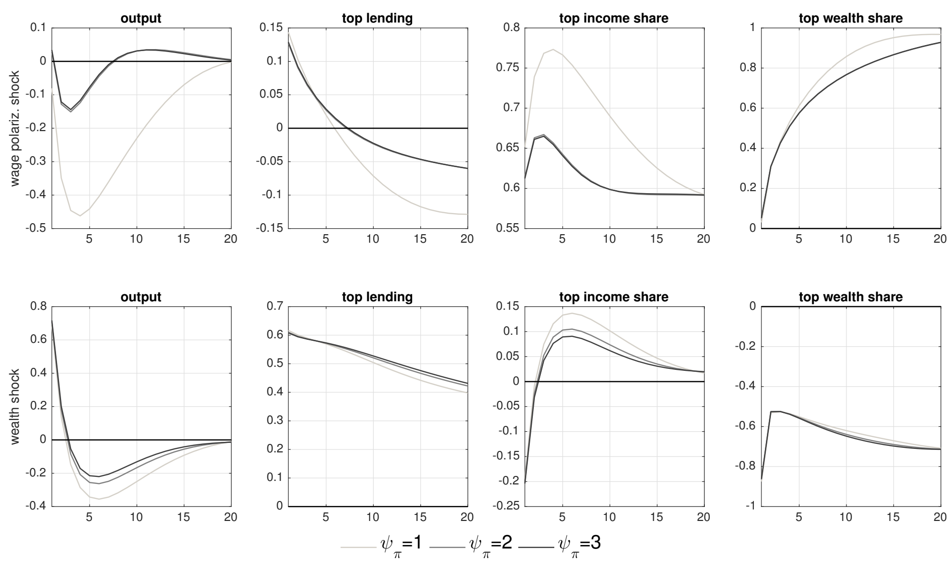
4.5 Monetary Policy and Inequality Swings.

4.5.1 The Monetary Policy Stance. Although Fig.(6) shows that expansionary monetary policy generates counter-cyclical shifts in income and wealth inequality, still little is known about how the propagation of stochastic swings in inequality depends on the monetary policy stance. Fig.(10) sheds light on this topic by plotting the response of output, debt, and the top shares to polarization and wealth shocks across different monetary policy regimes towards inflation. It demonstrates that different degrees of non-accommodative policy ($\psi_\pi = 2, 3$) trigger minor differences in the amplitude of the effect of distributional shocks on output and the top shares. Nevertheless, an accommodative monetary policy ($\psi_\pi = 1$) aggravates the propagation of distributional shocks compared to a non-accommodative policy. The depth of the output drop is larger under the former policy than under the latter. The same finding holds for the responses in household debt and the top shares. Moreover, it is worth mentioning that the various degrees of monetary policy responsiveness to inflation have a larger influence on the top income share than on the top wealth share.

The differences in the propagation of distributional shocks caused by the degree of policy responsiveness to inflation hinge on the role of household debt in the economy. In response to adversarial shocks, middle-class households borrow from the top in an environment of falling output and prices. In response to falling prices, the higher the stimulus emanating from monetary policy lowering the base interest rate, the smaller the burden of interest payments for the middle class. The lower the debt burden is, the lower the adjustment in their consumption is and, in turn, the smaller the demand and output drops are.

The above evidence entails another implication. In response to distributional shocks, monetary policy manages to stabilize the economy by monitoring aggregates, such as inflation, rather than household-specific variables. The reason behind this result is the procyclical response of inflation spurred by polarization and wealth shocks. Therefore, there is no need for monetary policy to actually identify the distributional shocks as the origin behind the observed swings in inflation. By responding to inflation, it stabilizes the economy across the business cycle, and in fact avoids sizable fluctuations in income and wealth inequality.

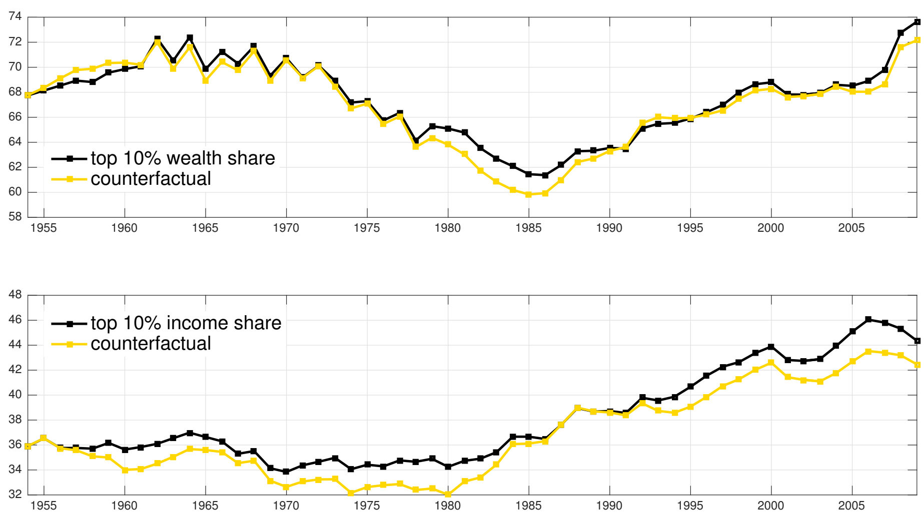
Figure 10: Monetary Policy Stance and the Transmission of Distributional Imbalances



Notes: Transmission of polarization & wealth shocks (posterior mean) across different monetary policy regimes towards inflation.

4.5.2 Half a Century of Monetary Policy and Inequality. The present paper allows to delve into another aspect of the multifaceted nexus of monetary policy and inequality. More specifically, it enables to quantify the effect of policy changes in the interest rate that are not explained by fundamentals (i.e. the policy "surprises") on income and wealth inequality during the entire 1954-2009 period. To that end, Fig.(11) displays how the U.S. income and wealth inequality would have looked like, had monetary policy been characterized by zero surprises during the above period. According to the findings, there are some differences of small magnitude (about 1-2% points) between the observed and the counterfactual series. In terms of wealth inequality, a small difference is observed during the 1980s: with zero policy surprises during that period, counterfactual wealth inequality would have been a tad lower than the observed inequality. In terms of income inequality, there are more profound differences between actual and counterfactual series reflecting the fact that policy surprises have a larger influence on income than on wealth inequality. In particular, during the 1960s, 1970s, and 1995-2000, income inequality would have been lower than the observed one if the policy surprises were absent (i.e. more expansionary than they were in reality).

Figure 11: Monetary Policy Surprises and Inequality Swings



Notes: Counterfactual: top 10% income/wealth share series for zero monetary policy surprises.

4.6 Robustness Checks.

4.6.1 Inequality Series and Identification Revisited. The present analysis has shown that aggregate parameters are identified by aggregate series. Although Table (2) implies that matching inequality series influences the joint effect of distributional parameters, and Table (5) gives inklings about the inequality series altering the importance of credit shocks, Table (3) cannot inform us on the influence of aggregate series compared to that of inequality series on the estimates for the parameters associated with distributional imbalances. To tackle this, I repeat the estimation of the benchmark model without including the top shares in the observation vector as well as the polarization and wealth shocks in the stochastic structure.

I display the distribution of the steady state top 10% income and wealth shares extracted from the model with and without the inequality observables in Table (6). The table suggests that the inequality series are informative: the estimates in the model without the inequality series are not only at odds with the benchmark estimates but also with the sample data. In particular, the alternative model suggests a low degree of wealth inequality far from what is observed in U.S. history, and an implausibly high degree of income inequality.

Table 6: Steady State Inequality – The Role Of Inequality Data

	Data, 1954-2009 mean [min, max]	Steady State, Mean [5-95%] Benchmark	No Ineq. Data
top 10% income share	38 [34, 46]	36 [35, 36]	128 [101, 159]
top 10% wealth share	67 [61, 74]	64 [62, 66]	52 [47, 57]

Notes: Figures in %. For data sources, see text.

Table (7) reports the estimates for the distributional parameters – the aggregate parameters are relegated to the Appendix and show small differences compared to the benchmark run. The table suggests sizable differences compared to the benchmark estimates, demonstrating that the inequality data are informative with respect to the distributional parameters. The ordering of the strength of wealth preferences across the population is reversed: $\phi^{\tau} < \phi^{\mu}$, suggesting that the middle class derives more utility from wealth than the top does. On the same time, both ϕ^{τ} and ϕ^{μ} are higher in the model without the inequality series than they are in the model with these series. Furthermore, credit supply shocks are about four times less volatile in the model without those series (1.01) than they are in the model with those series (4.16). Less weight is put on consumer debt (0.72) in the model with the inequality observables than in the model without those series (0.95).

4.6.2 Wealth Adjustment Costs. The parameter capturing adjustment costs in the ownership of shares (S_w) is calibrated at 1 in the benchmark specification. I now examine the implications of that calibration by considering two alternative scenarios: one postulating small costs (S_w is fixed at 0.1), and another one involving an agnostic approach (S_w is estimated with a disperse prior N(1,0.5)).

Low adjustment costs do not alter the benchmark analysis. They do not bring in significant changes in the estimates of the aggregate parameters – these are relegated to the Appendix. In terms of the distributional parameters shown in Table (7), low adjustment costs increase the utility from wealth for the top from 0.15 in the benchmark model to 0.20,

Table 7: Posterior Distribution – Distributional Parameters – Alternative Specifications

		Prior	**Posterior** Mean [5-95%]		
			$S_w = 0.1$	estimated S_w	no ineq. data
bottom wealth pref.	ϕ_μ	B (0.10, 0.04)	0.13 [0.12, 0.15]	0.26 [0.22, 0.30]	0.56 [0.50, 0.63]
top wealth pref.	ϕ_τ	B (0.10, 0.04)	0.20 [0.16, 0.25]	0.26 [0.21, 0.31]	0.21 [0.14, 0.29]
wealth adj. cost	S_ω	N (1.00, 0.50)	[,]	5.04 [4.50, 5.58]	1.49 [0.72, 2.42]
bottom wage share	$\bar{s}$	N (0.80, 0.02)	0.85 [0.84, 0.87]	0.84 [0.83, 0.86]	0.80 [0.77, 0.83]
AR income	ρ_s	B (0.70, 0.20)	1.00 [0.99, 1.00]	1.00 [1.00, 1.00]	[,]
std income	σ_s	IG (0.15, 1.00)	1.15 [0.79, 1.42]	0.48 [0.41, 0.56]	[,]
AR wealth	ρ_ω	B (0.70, 0.20)	0.99 [0.97, 1.00]	0.59 [0.46, 0.69]	[,]
std wealth	σ_ω	IG (0.15, 1.00)	0.53 [0.41, 0.74]	0.22 [0.15, 0.29]	[,]
AR credit	ρ_m	B (0.70, 0.20)	0.68 [0.30, 0.96]	0.99 [0.96, 1.00]	0.99 [0.98, 1.00]
std credit	σ_m	IG (0.15, 1.00)	0.52 [0.03, 3.24]	1.87 [1.43, 2.29]	1.01 [0.85, 1.19]
factor for debt	Ψ_d	N (1.00, 0.50)	0.12 [0.06, 0.22]	0.50 [0.38, 0.63]	0.95 [0.82, 1.08]
std m.e. mortgage	μ_{hm}	IG (0.15, 1.00)	3.76 [2.36, 4.46]	1.44 [1.19, 1.71]	0.89 [0.76, 1.02]
std m.e. credit	μ_{cc}	IG (0.15, 1.00)	1.43 [1.32, 1.53]	1.19 [1.04, 1.33]	0.91 [0.77, 1.05]

Notes: Author's computations. Estimates across alternative model configurations.

the volatility of polarization shocks from 0.73 to 1.15, and the volatility of wealth shocks from 0.11 to 0.53. Nevertheless, they bring down the persistence (from 0.98 to 0.68) and volatility (from 4.16 to 0.52) of credit supply shocks, and the loading factor for debt (from 0.73 to 0.12). According to Table (5), credit shocks now exert zero influence on aggregate variables, while wealth shocks explain more than half of the swings in debt and the top wealth share. This evidence, hence, suggests that when wealth adjustments costs are low, credit supply shocks lose importance while wealth shocks gain importance. Still, though, none of the two shocks exerts a sizable influence on output. With low S_w, polarization shocks explain about 2% of the fluctuations in the top income and wealth shares compared to the zero influence they had in the benchmark model. Finally, the (log-)likelihood of the model with $S_w = 1$ is above that in the model with $S_w = 0.1$ (-2901 compared to -2933; see Appx.).

Estimating S_w brings in changes in some parameter estimates. According to Table (7), the posterior mean of S_w takes a large value of 5. The strength of utility from wealth is about the same across the population and equal to 0.26 (i.e. higher than the benchmark estimates for both families). Wage polarization is much less volatile (0.48 compared to 0.73 in the benchmark model). With high wealth adjustment costs, the persistence of wealth shocks drops from 0.97 to 0.59, whereas their volatility rises a tad from 0.11 in the benchmark model to 0.22. The other distributional parameters obtain values similar to those in the benchmark run. Although the aggregate parameter estimates (relegated to the Appx.) remain largely unchanged, there are some noteworthy differences compared to the benchmark estimates. More precisely, the habit increases from 0.67 to 0.85; the elasticity of utilization costs increases from 0.5 to 0.8; the policy response to inflation drops from 2.27 to the low value of 1.0; the investment adjustment costs elasticity rises from 6.76 to 8.83.[17].

Despite the above changes, the main finding of the paper still holds: the combined impact of distributional shocks on output is less than 10% (8%, Table 5). Nevertheless, both wealth and credit supply shocks obtain a less profound role on both economy wide and inequality fluctuations. In particular, their combined short-run influence on output and debt declines considerably, from 7% to 2% and from 74% to 40%, respectively. Thus, instead of explaining about two thirds of household debt, the distributional shocks now explain about 40% of it. The influence of polarization shocks on output, however, increases from 0% in the benchmark model to 6%. On the same time, demand side shocks increase their influence on output by about 30%, whereas supply side shocks decrease their influence by about the same amount. The latter decrease is distributed across all supply side shocks, whereas the former increase is concentrated on risk premium shocks. Thus, with high wealth adjustment costs, the influence of both wealth and credit shocks on output and debt weakens, whereas that of polarization and risk premium shocks is strengthened. This result echoes to some extent the argument of Fisher (2015) about a close connection between the risk premium shock and a shock to the demand for assets which in this paper would be captured by the wealth shock.

As for the decomposition of the top income share, polarization shocks lose influence whereas risk premium shocks gain influence. The influence of the other shocks exhibits small changes. The decomposition of the top wealth share does not change much. Finally, it is worth mentioning that the inclusion of inequality series in the observation vector is highly influential for the identification of S_w. For instance, when the top income and wealth shares are not included in the observation vector, the posterior mean of S_w is 1.49 (Table 7) – that is, much lower than the estimate of 5. In addition, that elasticity is better identified, judging from the dispersion of the [5-95%] interval, when top shares are included than when they are excluded from the observation set.

4.6.3 Prior. I examine the impact of the postulated priors on the effect of distributional shocks on output, debt, and the top shares. At the prior mean, the combined effect of distributional shocks accounts only for 10%, 17%, and 25% of the short-run cycles in debt,

[17]The log-likelihood of the model improves from -2901 to -2851.

the top income share, and the top wealth share, respectively – detailed results are relegated to the Appendix. That influence is considerably smaller from the one obtained at the posterior mean (74%, 60%, and 67%, respectively; Table 4). The influence of distributional shocks on output is at 7% at the posterior mean and at 8% at the prior mean. Although the two numbers are similar, the decomposition of them across the distributional shocks is different: the prior implies that 3% and 0% of output fluctuations are attributed to polarization and credit shocks. That implication is at odds with the findings obtained at the posterior mean. Therefore, the prior specification is not dogmatic.

4.6.4 Representative Agent Model. I compare the business cycle implications of the benchmark model with those from the representative agent model in several terms. First, I consider the evolution of the U.S. output gap. 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, any difference between the two model-implied gaps emanates from the interaction of distributional imbalances with nominal price and wage rigidities. The evidence shown in the Appx. suggests that the output gaps are rather similar across the two models – the largest deviation between the two gaps is at about 1%. Including the top shares in the estimation, therefore, has minor implications for the path of the gap.

Second, comparing the FEVD for the economy wide variables of the benchmark model with that of the representative agent model reveals that the two are largely similar. The influence of demand side shocks and, in particular, of risk premium shocks on the real aggregates is a tad smaller in the benchmark model than it is in the representative agent model[18]. That lower influence of demand side shocks is associated with a small increase in the influence of supply side shocks and the small influence of distributional shocks in the benchmark model. Third, the IRFs for the economy wide variables in the benchmark model are in line with those in the representative agent model.

4.6.5 The Volatility of Distributional Shocks. An aspect of the data that the benchmark analysis might have failed to capture so far pertains to the heterogeneous volatility between the aggregate and the inequality series. More specifically, the volatility of the aggregate series is about ten (for output, consumption, etc) to twenty (debt) times higher than

[18]In contrast, the influence of those shocks on inflation is a tad higher in the benchmark model than it is in the representative agent model. The mirror image of this result is a higher inflation responsiveness to such shocks in the benchmark model than in the representative agent model.

that of the top income and top wealth shares. Postulating a volatility for the polarization and wealth shocks that is similar to that of aggregate shocks, therefore, might lead to a misleading high posterior volatility for those shocks. I run again the model estimation by specifying an inverse gamma prior for the volatility of polarization and wealth shocks that has a mean and a std that correspond to the benchmark ones scaled down by a factor of ten (i.e. IG(0.015,0.1)). Despite that change in the prior specification, the estimation results remain largely unchanged compared to the benchmark ones.

4.6.6 Debt Growth and Balanced Growth Path. Allowing for heterogeneous debt growth rates that differ from the balanced growth path rate $\bar{\gamma}$ for home mortgages and consumer credit in equation (3.1) improves the fit of the model a tad but does not alter the results of the paper. These findings are available upon request.

5 Concluding Remarks

The present paper constitutes the first study that jointly examines the time series properties of inequality and aggregate series over a period of five decades through the lens of an enriched version of the structural workhorse DSGE framework involving distributional shocks, heterogeneous agents, and financial market imperfections. The take-away message suggests that stochastic swings in inequality have limited effect on business cycle gyrations. Those swings, however, influence household debt accumulation to a large extent.

This paper sets the stage for further explorations across several dimensions. Investigating distributional swings in environments where debt plays a more crucial role for economic stability than that considered in this paper may reveal a larger influence of those swings. The latter may also be obtained in setups where those swings influence trend growth or capital accumulation. Furthermore, the present paper allows to examine optimal monetary policy and welfare in the presence of distributional imbalances. Moreover, incorporating heterogeneous habit and inverse Frisch elasticities would shift the economy's steady state away from that of the representative agent model, and could amplify the effect of changes in inequality. In addition, extending the estimation sample would pin down the drivers of inequality during the Great Recession. Finally, including additional inequality series could shed further light on the macro-inequality linkages.

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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:

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

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

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

$\{\Xi_t^\mu, \Lambda_t^\mu\}$ 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:

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

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

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

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 (2.12) 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 (2.18) 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 (2.15) 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 (2.22) 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. $c_t^j = C_t^j/Z_t$, $b_t^j = B_t^j/(P_tZ_t)$ 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: $\xi_t^j = \Xi_t^jZ_t$ 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:

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

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

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

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

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

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

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

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

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

and

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

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 (2.12) 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 (2.13) 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

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

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 (2.16) 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 (2.17) 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

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

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 (2.20) are given by:

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

The labor disutility (2.21) 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 (2.23) 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 $Y_t = e^{\hat{z}_t} k_t^\alpha L_t^{1-\alpha} - \Phi_y$. 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: $v_t = \pi_t^{int} + div_t$. The resource constraint (2.24) 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

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

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

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

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

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

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

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

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

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

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

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

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: $\widehat{s}_t \equiv s_t - s$.

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

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

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:

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

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:

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

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 (2.21), 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: $\{\widehat{\bar{k}}_t, \widehat{k}_t, \widehat{r}_t^{k,r}, \widehat{q}_t^k, \widehat{i}_t, \widehat{div}_t\}$. 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 (3.4). 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

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

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

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

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 (3.4) for the top income and wealth shares. The annual income share (TIS_T, 3.2) is:

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

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

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

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

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

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

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

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

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

The annual wealth share (3.4) of the top includes the equity shares and the outstanding household debt measured at the end of each period:

$$\frac{\sum_{j=0}^{3} n^\tau \left[Q_{t-j}\Omega^\tau_{t-j} + \frac{B^\tau_{t-j}}{e^{v^b_{t-j}} R_{t-j} P_{t-j}}\right]}{\sum_{j=0}^{3}\left[Q_{t-j}\right]} = \tag{D.9}$$

$$\frac{\sum_{j=0}^{3} n^\tau Z_{t-j} \left[\frac{Q_{t-j}}{Z_{t-j}}\Omega^\tau_{t-j} + \frac{B^\tau_{t-j}/Z_{t-j}}{e^{v^b_{t-j}} R_{t-j} P_{t-j}}\right]}{\sum_{j=0}^{3} Z_{t-j}\left[\frac{Q_{t-j}}{Z_{t-j}}\right]} = \tag{D.10}$$

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

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

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

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

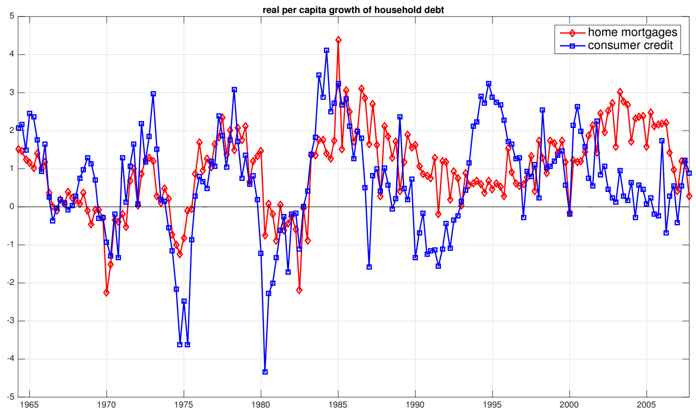
$$= \overline{tws} + \sum_{j=0}^{3} \nu_j \left[(n^\tau\omega^\tau)\widehat{\omega}^\tau_{t-j} + \overline{tws}_b \left(\widehat{b}^\tau_{t-j} - \widehat{r}_{t-j} - \widehat{v}^b_{t-j} - \widehat{q}_{t-j}\right)\right] \tag{D.15}$$

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

Figure (E.1) plots the evolution of the series for household debt: outstanding consumer credit and home mortgages, 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.

Figure E.1: Outstanding Household Debt



Sources: FRED. For data transformations, see text.

F Additional Results

F.1 Measurement Errors.

Tables (F.1) and (F.2) display the posterior std of the measurement errors 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	Benchmark
μ_w	IG(0.01,0.001)	0.0101[0.0085,0.0118]	0.0102[0.0086,0.0123]
μ_y	IG(0.01,0.001)	0.0100[0.0085,0.0116]	0.0102[0.0086,0.0121]
μ_c	IG(0.01,0.001)	0.0100[0.0085,0.0117]	0.0100[0.0085,0.0118]
μ_i	IG(0.01,0.001)	0.0100[0.0085,0.0117]	0.0100[0.0084,0.0118]
μ_π	IG(0.01,0.001)	0.0100[0.0085,0.0117]	0.0100[0.0085,0.0118]
μ_r	IG(0.01,0.001)	0.0100[0.0085,0.0116]	0.0101[0.0086,0.0118]
μ_l	IG(0.01,0.001)	0.0100[0.0085,0.0118]	0.0100[0.0085,0.0119]

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 [0.00840, 0.01174]
std m.e. wealth inequality	μ_{tws}	IG(0.01, 0.001)	0.01006 [0.00856, 0.01200]

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

F.2 Alternative Specifications.

Tables (F.3) and (F.4) display the measurement errors for the aggregate and inequality series across the alternative estimation runs. Table (F.5) collects the posterior estimates for the parameters associated with the aggregate dimension of the model across the alternative model configurations.

Table F.3: Posterior Distribution – Common Measurement Errors

	Prior	**Posterior** Mean [5-95%]		
		$S_w = 0.1$	estimated S_w	no ineq. data
μ_w	IG(0.01,0.001)	0.0102[0.0086,0.0119]	0.0102[0.0087,0.0119]	0.0103[0.0086,0.0122]
μ_y	IG(0.01,0.001)	0.0101[0.0085,0.0118]	0.0101[0.0086,0.0118]	0.0103[0.0086,0.0122]
μ_c	IG(0.01,0.001)	0.0098[0.0084,0.0115]	0.0101[0.0086,0.0120]	0.0100[0.0084,0.0118]
μ_i	IG(0.01,0.001)	0.0101[0.0086,0.0120]	0.0100[0.0085,0.0118]	0.0100[0.0085,0.0117]
μ_π	IG(0.01,0.001)	0.0099[0.0083,0.0114]	0.0100[0.0085,0.0117]	0.0100[0.0084,0.0120]
μ_r	IG(0.01,0.001)	0.0099[0.0082,0.0117]	0.0099[0.0085,0.0117]	0.0100[0.0084,0.0116]
μ_l	IG(0.01,0.001)	0.0100[0.0083,0.0120]	0.0099[0.0084,0.0117]	0.0101[0.0085,0.0119]

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

Table F.4: Posterior Distribution – Distributional Measurement Errors

	Prior	**Posterior** Mean [5-95%]		
		$S_w = 0.1$	estimated S_w	no ineq.
μ_{tis}	IG(0.01, 0.001)	0.00988 [0.00840, 0.01156]	0.00996 [0.00848, 0.01167]	[,]
μ_{tws}	IG(0.01, 0.001)	0.01004 [0.00862, 0.01169]	0.00993 [0.00844, 0.01153]	[,]

Notes: Author's computations. Estimates from the alternative model configurations.

F.3 Prior.

Table (F.6) displays the forecast error variance decomposition of the benchmark model at the prior mean 8/40 quarters ahead.

F.4 Representative Agent Model.

Table (F.7) 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 benchmark and the representative agent model. Fig.(F.4) compares the output gaps in the benchmark and the representative agent model.

Table F.5: Posterior Distribution – Common Parameters

	Prior	**Posterior** Mean [5-95%]			
		benchmark	$S_w = 0.1$	estimated S_w	no ineq. data
α	N(0.30, 0.05)	0.16 [0.13, 0.18]	0.16 [0.13, 0.19]	0.19 [0.18, 0.21]	0.23 [0.21, 0.25]
η	B(0.70, 0.10)	0.67 [0.63, 0.71]	0.68 [0.64, 0.72]	0.85 [0.82, 0.87]	0.58 [0.47, 0.69]
χ	N(2.00, 1.00)	3.88 [2.51, 5.37]	3.92 [2.74, 5.24]	4.38 [3.20, 5.67]	4.99 [3.84, 6.21]
ψ	B(0.50, 0.10)	0.50 [0.41, 0.60]	0.49 [0.41, 0.58]	0.80 [0.74, 0.86]	0.84 [0.79, 0.89]
S	N(4.00, 1.00)	6.76 [5.47, 8.12]	6.34 [5.15, 7.52]	8.83 [7.71, 9.90]	3.11 [2.01, 4.35]
ζ_w	B(0.60, 0.10)	0.85 [0.79, 0.96]	0.81 [0.78, 0.84]	0.81 [0.79, 0.84]	0.73 [0.65, 0.79]
ζ_p	B(0.60, 0.10)	0.86 [0.84, 0.89]	0.87 [0.84, 0.90]	0.89 [0.88, 0.90]	0.86 [0.83, 0.88]
ι_p	B(0.50, 0.15)	0.84 [0.74, 0.92]	0.83 [0.73, 0.92]	0.69 [0.62, 0.74]	0.82 [0.74, 0.90]
ι_w	B(0.50, 0.15)	0.69 [0.39, 0.88]	0.78 [0.63, 0.90]	0.84 [0.75, 0.92]	0.69 [0.50, 0.85]
ρ_r	B(0.75, 0.10)	0.89 [0.87, 0.91]	0.88 [0.86, 0.90]	0.91 [0.90, 0.92]	0.87 [0.85, 0.89]
ψ_π	N(1.70, 0.25)	2.27 [1.68, 2.65]	2.39 [2.10, 2.69]	1.00 [0.94, 1.08]	2.18 [1.93, 2.44]
ψ_y	N(0.12, 0.05)	0.21 [0.14, 0.28]	0.17 [0.12, 0.23]	0.29 [0.24, 0.34]	0.19 [0.13, 0.25]
$\psi_{\Delta y}$	N(0.12, 0.05)	0.24 [0.16, 0.32]	0.25 [0.17, 0.34]	0.21 [0.13, 0.28]	0.30 [0.22, 0.39]
ρ_b	B(0.60, 0.20)	0.91 [0.88, 0.94]	0.85 [0.81, 0.90]	0.95 [0.95, 0.96]	0.95 [0.92, 0.97]
σ_b	IG(0.15, 1.00)	0.07 [0.06, 0.09]	0.10 [0.08, 0.12]	0.03 [0.02, 0.04]	0.06 [0.04, 0.09]
ρ_z	B(0.60, 0.20)	0.97 [0.96, 0.98]	0.98 [0.97, 0.99]	0.93 [0.91, 0.94]	0.95 [0.94, 0.96]
σ_z	IG(0.15, 1.00)	0.65 [0.59, 0.71]	0.65 [0.60, 0.71]	0.59 [0.54, 0.64]	0.58 [0.54, 0.63]
ρ_i	B(0.60, 0.20)	0.82 [0.76, 0.87]	0.78 [0.71, 0.84]	1.00 [0.99, 1.00]	1.00 [1.00, 1.00]
σ_i	IG(0.15, 1.00)	0.25 [0.22, 0.30]	0.30 [0.26, 0.35]	0.14 [0.11, 0.17]	0.67 [0.53, 0.84]
ρ_p	B(0.60, 0.20)	0.10 [0.03, 0.22]	0.12 [0.04, 0.24]	0.07 [0.02, 0.14]	0.08 [0.02, 0.16]
σ_p	IG(0.15, 1.00)	0.20 [0.17, 0.22]	0.20 [0.18, 0.22]	0.17 [0.16, 0.19]	0.19 [0.17, 0.21]
ρ_w	B(0.60, 0.20)	0.18 [0.07, 0.30]	0.14 [0.05, 0.23]	0.09 [0.03, 0.16]	0.38 [0.23, 0.58]
σ_w	IG(0.15, 1.00)	0.62 [0.54, 0.71]	0.66 [0.59, 0.74]	0.78 [0.70, 0.88]	0.57 [0.47, 0.68]
σ_{mp}	IG(0.15, 1.00)	0.25 [0.23, 0.27]	0.25 [0.23, 0.27]	0.25 [0.23, 0.27]	0.26 [0.24, 0.29]
ρ_g	B(0.60, 0.20)	0.93 [0.91, 0.97]	0.94 [0.91, 0.98]	0.90 [0.88, 0.92]	0.91 [0.89, 0.93]
σ_g	IG(0.15, 1.00)	0.49 [0.45, 0.53]	0.48 [0.44, 0.52]	0.48 [0.44, 0.53]	0.46 [0.42, 0.50]
ρ_{gz}	B(0.50, 0.20)	0.31 [0.24, 0.39]	0.33 [0.26, 0.40]	0.35 [0.28, 0.42]	0.38 [0.32, 0.45]
γ	N(0.40, 0.03)	0.36 [0.33, 0.39]	0.35 [0.32, 0.39]	0.40 [0.39, 0.42]	0.35 [0.33, 0.37]
π	N(0.80, 0.03)	0.87 [0.82, 0.92]	0.87 [0.82, 0.92]	0.79 [0.74, 0.84]	0.86 [0.81, 0.91]
υ_w	N(0.50, 0.03)	0.50 [0.45, 0.55]	0.50 [0.45, 0.55]	0.50 [0.45, 0.55]	0.50 [0.45, 0.55]
υ_p	N(0.30, 0.03)	0.26 [0.21, 0.31]	0.22 [0.17, 0.27]	0.29 [0.25, 0.32]	0.33 [0.30, 0.36]
$\bar{l}$	N(0.00, 0.10)	0.01 [-0.16, 0.19]	-0.03 [-0.19, 0.12]	0.01 [-0.16, 0.17]	0.08 [-0.08, 0.24]
$logL$		-2901	-2933	-2851	-2383

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

Table F.6: Business Cycles – The Role of the Prior

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	3/3	2/2	0/1	3/3	4/4	4/3	13/13	13/5
wealth	5/5	3/3	1/1	4/5	5/5	5/1	4/4	13/11
credit	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0
distributional	8/8	6/5	1/2	8/8	10/9	10/5	17/17	25/16
technology	3/3	4/4	0/1	5/5	5/5	7/5	1/1	18/7
price markup	27/26	30/28	76/66	23/23	17/19	28/26	38/37	28/19
wage markup	5/6	7/9	13/12	9/9	4/5	1/6	2/3	2/7
supply side	34/35	41/41	89/79	37/37	26/29	36/37	41/41	47/34
risk premium	44/43	14/12	7/6	32/32	40/35	29/10	33/33	22/9
investment	10/11	37/39	2/13	18/18	20/24	22/46	6/7	2/40
govt spending	0/0	1/1	0/0	0/0	0/0	1/1	0/0	1/1
policy	3/3	2/1	1/1	5/5	4/3	2/1	3/3	1/1
demand side	58/57	53/53	10/20	55/55	64/63	54/58	42/42	27/50

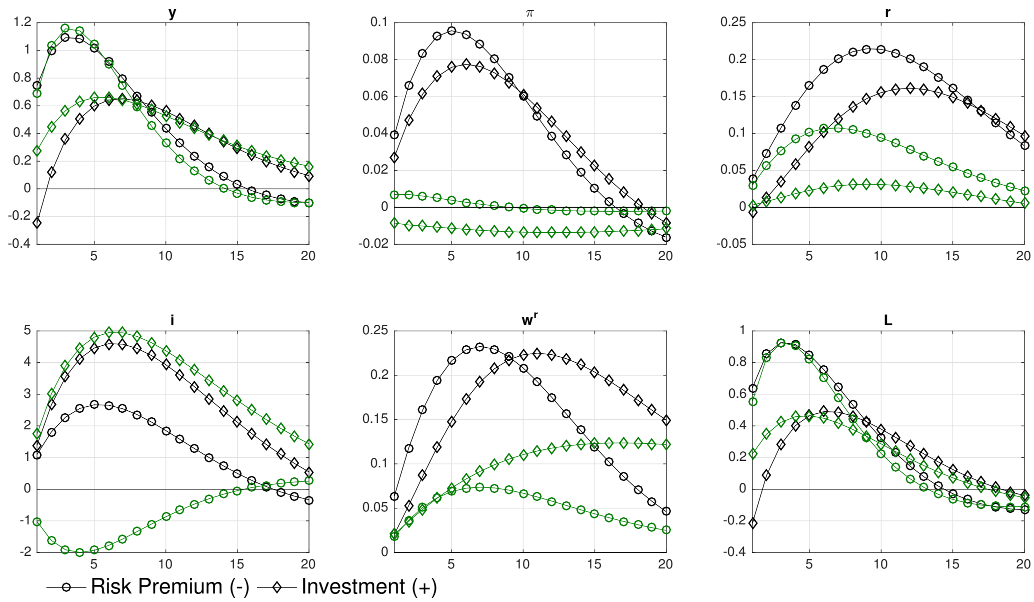
Notes: Forecast Error Variance Decomposition 8/40 quarters ahead, computed at the prior mean.

Table F.7: Business Cycles – Representative Agent Model

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

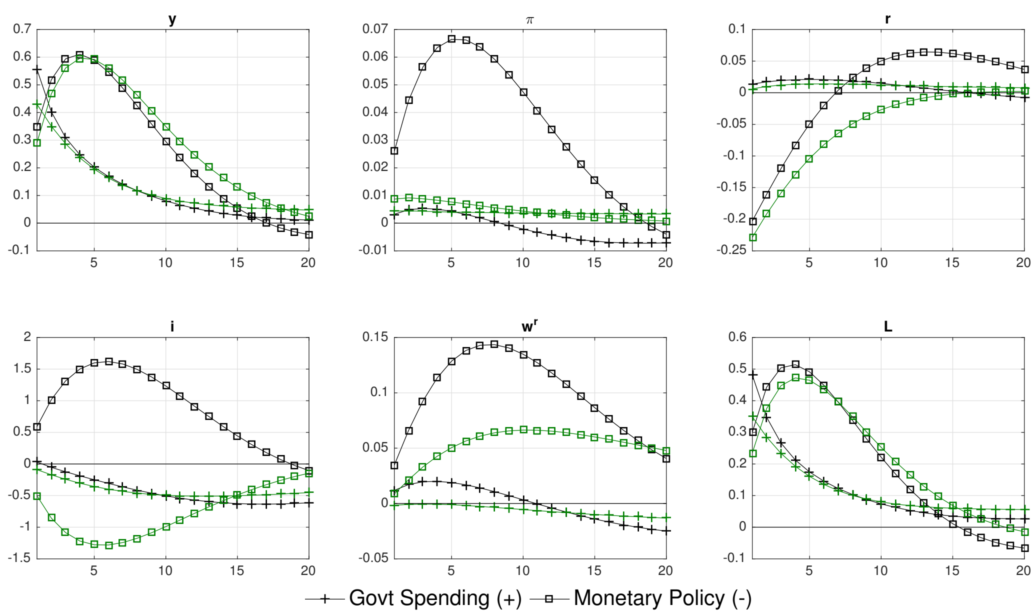
Notes: Forecast Error Variance Decomposition 8/40 quarters ahead, computed at the posterior mean.

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



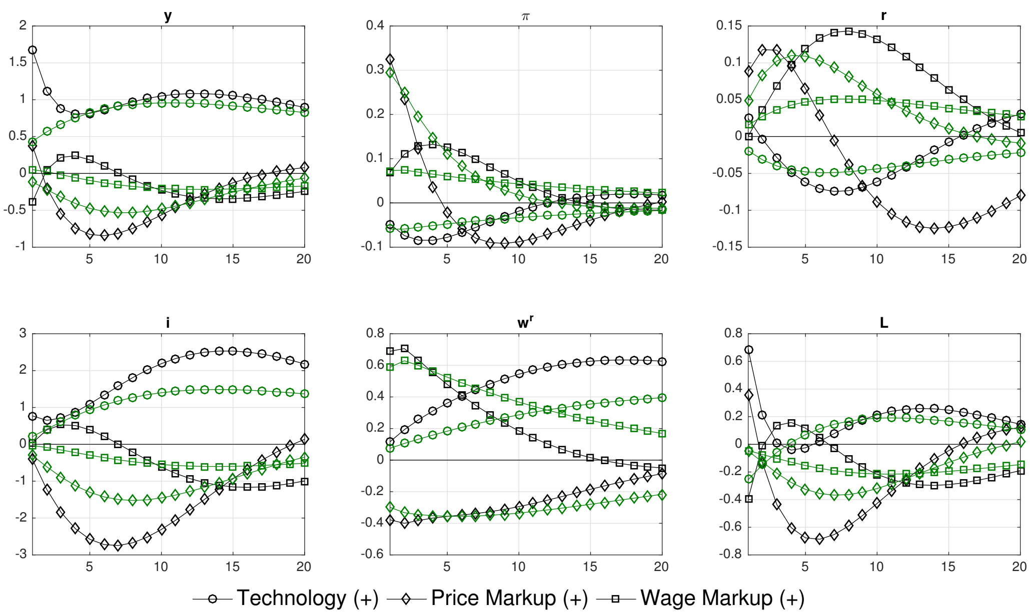
Notes: IRFs (posterior mean). Black/Green: Benchmark/Representative Agent Model.

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



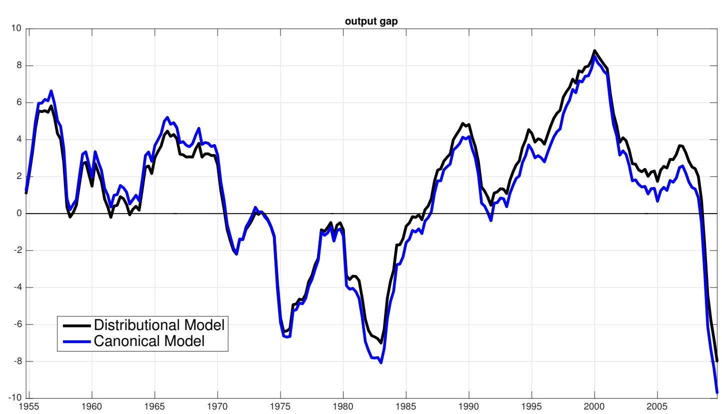
Notes: IRFs (posterior mean). Black/Green: Benchmark/Representative Agent Model.

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



Notes: IRFs (posterior mean). Black/Green: Benchmark/Representative Agent Model.

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



Notes: Author's computations.