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Limited Participation in Equity Markets and Business Cycles⋆

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Abstract. This paper studies how the rise in US households' participation in equity markets affects the transmission of macroeconomic shocks to the economy. I embed limited participation into a New Keynesian framework for the US economy to analyze the individual and aggregate effects of higher participation. I derive three main results. First, participants are relatively more responsive to shocks than nonparticipants. Second, higher participation reduces the effectiveness of monetary policy. Third, with higher participation the economy becomes less volatile. I contrast key predictions of my model with new micro-level empirical evidence on the response of consumption to monetary policy shocks.

Keywords: Limited Participation; Monetary Policy; Stock Market; Investment; Business Cycle
JEL: E32; E44; E22; G51.

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1. Introduction

Households' participation in equity markets in the United States is limited. In the mid-1980s, only 27% of households held equity, either directly or indirectly. However, better financial education and the development of new ways to participate in equity markets caused this fraction to double over the past decades, reaching 53% in the early 2000s.[1] This paper's contribution is to show that the rise in participation has a significant impact on the cyclical behavior of the economy. To this end, I embed limited participation into a dynamic New Keynesian framework for the US economy and show that the model is consistent with both aggregate facts and new micro-level empirical evidence.

The paper is divided into quantitative and empirical sections. In the former, I begin by laying out a dynamic model of the US economy that has three main features. First, the model exhibits limited participation in equity markets, as observed in the data. The participant household trades nominal risk-free bonds to finance her position in risky equity. The nonparticipant household only trades bonds to smooth out consumption. Equity is a claim on firms' cash flows, and its value varies with the cycle. Second, I introduce nominal rigidities and firms' investment, since these are important components for business cycle dynamics. Third, I assume recursive preferences and long-run productivity risk, which allow for high equity premia and volatile asset prices. In addition to these three features, I consider three types of macroeconomic shocks that are standard in the business cycles literature: productivity (TFP) shocks, monetary policy (MP) shocks and marginal efficiency of investment (MEI) shocks. The model is then calibrated to jointly match business cycle and asset pricing moments, as well as a cross-sectional household portfolio moment.

The model yields three key mechanisms that drive my quantitative results. First, participant households bear more aggregate risk than nonparticipants, since they have a levered exposure to equity. As a result, their consumption is more responsive to shocks than nonparticipants'. Second, as participation rises, participants' per capita exposure to risk falls because the same amount of risk is spread over a larger set of households. This reduces their consumption responsiveness to macroeconomic shocks. Third, since participants own firms, a less responsive consumption profile translates into milder fluctuations in investment and asset prices.

In the quantitative analysis, I first focus on the effects of the interaction between MP shocks and limited participation on households' consumption and firms' investment. At the individual

[1]Estimates computed from the *Survey of Consumer Finances* (SCF). See Appendix Figure B3.

level, the model mechanisms imply that the participant's consumption is relatively more responsive to MP shocks than that of a nonparticipant, but that as participation rises the excess responsiveness of a participant household is dampened. At the aggregate level, the dampening effect over the participant's consumption (intensive margin) dominates over the effects of having a larger fraction of participants whose consumption is relatively more responsive (extensive margin). As for investment, MP shocks induce changes in the cost of capital that affect firms' incentives to invest. With higher participation, however, variations in the cost of capital are milder, so that the effects over investment are also dampened. The combination of the dampening effects over consumption and investment cause monetary policy to become less potent with higher participation.

I then analyze the effects of higher participation on the transmission of investment and productivity shocks. A positive TFP shock induces positive labor and capital income effects that expand households' consumption and firms' investment. With higher participation, each participant benefits less from the positive equity valuation effects and therefore consumption expands by less. As a result, the response of output is dampened with higher participation. A positive MEI shock incentivizes firms to invest more, but it also generates a crowding-out effect of investment over consumption, which reduces the initial expansion of aggregate demand. With higher participation, lower leverage and a milder crowding-out effect mitigate the negative impact over the participant's consumption so that the effect on output is amplified. Although the effects of higher participation on output's response depend on the nature of the shock, when simulating the economy under the full set of structural shocks I find that with higher participation, the economy becomes less volatile: Output volatility and equity premia fall, and the participant's consumption also becomes relatively less volatile.

I provide various robustness checks and model extensions that support the main results of my model. One of the extensions is to allow for passive traders who represent purely indirect holders of equity, as observed in the data. Empirical evidence suggests that a fraction of the rise in participation is due to a larger mass of 401K/IRA holders. I calibrate the extended model to match this fact and find that the main quantitative results of the baseline model still hold. Another model extension is to introduce a state-contingent participation rate. This extension is motivated by the empirical cyclical behavior of this variable, which, although orders of magnitude smaller than the stark rise observed during the 90s, still provides a valid concern regarding the effects of endogenous participation. To address this issue, I calibrate the participation rate to match the procyclicality observed in the data, and find that the main results of the baseline model still hold.

In the empirical section, I provide new evidence to support the model's prediciton that a participant household is more responsive to MP shocks than a nonparticipant. To this end, I run panel regressions using household-level consumption data and well-identified MP shocks for the period 1996-2007.[2] I find that upon a 1–sd contractionary MP shock, the consumption of a participant falls by 0.53 pp more than that of a nonparticipant. This finding is supported by a series of robustness checks. To contrast my model predictions with this finding, I run the same regression using simulated data and obtain that a participant's consumption falls by 0.28 pp more. I also provide various robustness checks for this empirical finding.

Another prediction of the model is that MP becomes less potent with higher participation, in the sense that MP shocks induce milder responses in aggregate consumption and output. Providing evidence on this effect is challenging, since requires clear identification of changes in participation in a short period of time. Instead, I present suggestive evidence by exploiting regional variation in participation rates. In effect, I find that states with high participation have a 0.4 pp milder response on average consumption than states with low participation. In the appendix, I also perform a time-variation analysis and document that output response to MP shocks is roughly 40% milder for the subsample with higher participation.

Related Literature

The starting point for my analysis is the growing body of empirical literature that documents and analyzes the existence of limited participation in equity markets; see Mankiw and Zeldes (1991); Malloy, Moskowitz, and Vissing-Jrgensen (2009); Vissing-Jorgensen (2002) and Parker and Vissing-Jorgensen (2009). More recently, Guvenen (2009) and Chien, Cole, and Lustig (2011) build a model with heterogeneous agents to analyze the effects of limited participation on the macroeconomy. My paper is closely related to Guvenen (2009), whose model matches a set of business cycle moments while delivering high and countercyclical equity premia. I build on this model, and expand it by choosing a New Keynesian environment to analyze the effects of monetary policy shocks in an economy with limited participation. Furthermore, this allows me to contrast key predictions of my model with micro-level data. In particular, I find that the model and data are aligned in terms of the excess response of participants to MP shocks.

[2]Consumption data are constructed from the *Consumer Expenditure Survey* (CEX), and the series for monetary policy shocks is obtained from Gertler and Karadi (2015).

Another strand of the literature studies the effects of changes in participation on asset prices. For examples, see early work by Calvet et al. (2004) and, more recently, Favilukis (2013). My work complements these studies by showing how the conditional responses of the economy to vary shocks varies with participation. In particular, I analyze the transmission of monetary policy shocks to asset prices. In this sense, my work is also related to Bernanke and Kuttner (2005); Rigobon and Sack (2004); Gürkaynak et al. (2005); and Gertler and Karadi (2015), who find strong empirical evidence in changes on monetary policy affecting stock prices.

My work is also related to the literature on heterogeneity in New Keynesian models. McKay, Nakamura, and Steinsson (2016); Gornemann, Kuester, and Nakajima (2016); McKay and Reis (2016); Kaplan, Moll, and Violante (2018); Auclert (2019); and Bilbiie (2019) have focused on the transmission of monetary policy shocks in an economy with incomplete markets and idiosyncratic risk. In work contemporaneous with mine, Kekre and Lenel (2019) analyze the effects of monetary policy shocks on equity premia. In particular, they highlight the role heterogeneity in the marginal propensity to invest has on required excess returns and the transmission of monetary policy shocks to investment. My work complements their findings by highlighting another source of heterogeneity: limited access to equity markets. I show that this dimension of heterogeneity has direct implications for the investment channel of monetary policy through its effects on the volatility of firms' cost of capital.

The remainder of the paper proceeds as follows. Section 2 describes the model of limited participation and provides useful qualitative analysis of the model's implications to better understand the results of the quantitative section. Section 3 calibrates the model, presents a set of untargeted moments from the real and financial sectors, and describes the impulse response of the economy to the three types of shocks. In Section 4, I make use of rotating panels surveys and aggregate time series to provide empirical support for my model predictions, and also show that my model predictions are aligned with changes in unconditional moments in the real and financial sectors. Section 5 concludes.

2. A Model of Limited Participation

2.1. *Description of the Model*

In this section, I construct a framework to analyze the extent to which variations in participation rates in equity markets affect the propagation of aggregate shocks to the economy. My model of the US economy consists of three broad sectors: households, firms, and the government. The *households* sector is formed by two types of households: *participants*, who actively trade equity, and *nonparticipants*, who only save in nominal bonds.[3] As is standard in New Keynesian models, the *firms* section contains perfectly competitive intermediate producers, monopolistically competitive retailers, a representative final good producer, and a representative labor-aggregating agency. Equity is defined as a claim on aggregate cash flows coming from intermediate good producers and retailers. The *government* sector is represented by a standard Taylor rule. For simplicity, there is no government debt or taxation. The economy is subject to three types of shocks: monetary policy, productivity, and marginal efficiency of investment. I further assume nominal rigidities, as in Rotemberg (1982), on both the price of goods and wages.

Households Sector

There is a measure φ of participant households and $1-\varphi$ of nonparticipant households. The participant household can trade both bonds and equity. The nonparticipant household only trades bonds. To focus on the short-run effects of macroeconomic shocks, I keep the participation rate fixed in the baseline version of the model.[4] As discussed in Section 3.1, the model is calibrated so that the participant issues debt and saves in equity while the nonparticipant saves in bonds. Both types of households have recursive preferences and value consumption and labor under a wealth-neutral utility function, as in Greenwood, Hercowitz, and Huffman (1988). Each household i has a labor skill l_i that supplies under monopolistic competition, setting a nominal wage W_i given a quadratic cost of adjustment $\Phi_t(W_{it})$, as in Erceg, Henderson, and Levin (2000). In doing so, each household endogenizes the demand function derived from the labor agency's optimality problem. Participants are also subject to a debt-elastic interest rate schedule, which I introduce to capture default risk costs associated with debt issuance. In order not to complexify the model with default decisions, I assume an exogenous functional form for this schedule as in García-Cicco, Pancrazi, and Uribe (2010).

[3]Assuming that all participants are active traders is a model simplification. In the data, a large fraction of participants only have indirect holdings of equity, mainly through 401K/IRA accounts. My baseline model is consistent with the assumption that this type of participant invests in mutual funds that actively trade in equity markets. Nonetheless, in Appendix C.5 I show that my model's main predictions still hold in an economy in which indirect holders are passive traders with fixed portfolio shares.

[4]In fact, changes in participation in the US economy are slow moving. To put variations into perspective, the cyclical fluctuation of participation rates during the 1998-2016 period was only 1.8%, while its 10-year rise observed during the 1990s was of around 25 pp. Nonetheless, in Appendix C.4.2 I extend the model to allow for a procyclical participation rate—calibrated to match the data—and show that my model's main results still hold.

Given the setup, a participant household i solves

$$V_{it} = \max_{c_{it}, D_{it+1}, W_{it}, \theta_{it+1}} \left\{ (1-\beta)\left(c_{it} - z_{t-1}\vartheta_0 \frac{l_{it}^{1+\vartheta}}{1+\vartheta}\right)^{1-\rho} + \beta \left[E_t\left(V_{it+1}^{1-\gamma}\right)\right]^{\frac{1-\rho}{1-\gamma}} \right\}^{\frac{1}{1-\rho}}$$

subject to

$$\begin{aligned} c_{it} + Q_{dt}\theta_{it+1} + \Phi_{wt}(W_{it}) + \Phi_D(D_{it+1}) &= x_{it} + \frac{1}{P_t} W_{it} l_{it} + \frac{D_{it+1}}{P_t} + T_{it} \\ x_{it} &= -\frac{D_{it}}{P_{t-1}} \frac{1}{\Pi_t} R_{bt-1}(D_{it}) + \theta_{it}(Q_{dt} + d_t) \\ l_{it} &= \left(\frac{W_{it}}{W_t}\right)^{-\theta_w} L_t^d, \end{aligned}$$

where T_{it} are lump-sum transfers; $\Phi_{wt}(W_{it}) = z_{t-1}\frac{\xi_w}{2}\left(\frac{W_{it}}{W_{t-1}} - 1\right)^2 L_t$ are the wage adjustment costs; $\Phi_D(D_{it+1}) = z_t \frac{\nu}{2}\left(\frac{D_{it+1}}{P_t}\frac{1}{z_t} - D_{ss}\right)^2$ are debt adjustment costs; and $R_{bt}(D_{t+1}) = R_t + \psi\left(e^{\left(\frac{D_{it+1}}{P_t}\frac{1}{z_t} - \bar{D}\right)} - 1\right)$ is the debt-elastic interest rate. The parameter $\bar{D}$ is set so that the Euler equation on bonds holds in steady-state. Debt adjustment costs are introduced and chosen to be small enough to induce stationarity in the long run.[5] Transfers are set so that there is no loss on resources.

The problem for the nonparticipant is similar to that of the participant, except that she does not have access to equity. Furthermore, since the nonparticipant saves in bonds, she is not subject to the debt-elastic schedule:[6]

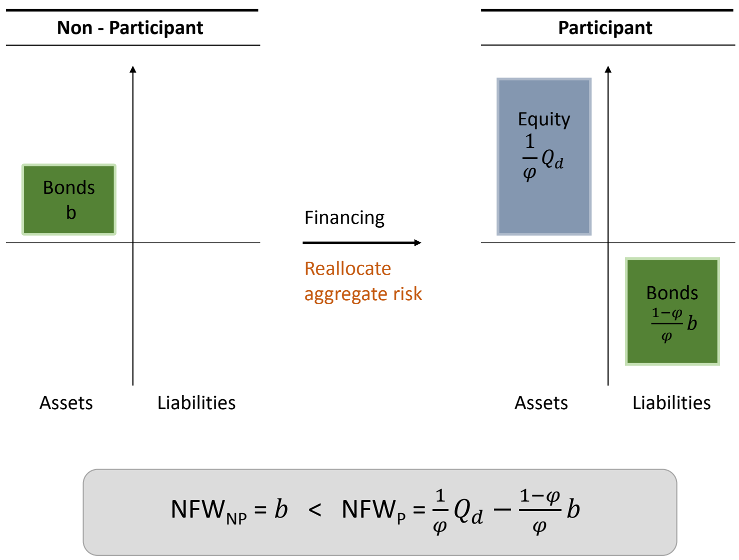
$$\begin{aligned} V_{it} &= \max_{c_{it}, b_{it+1}, W_{it}} \left\{ (1-\beta)\left(c_{it} - z_{t-1}\vartheta_0 \frac{l_{it}^{1+\vartheta}}{1+\vartheta}\right)^{1-\rho} + \beta \left[E_t\left(V_{it+1}^{1-\gamma}\right)\right]^{\frac{1-\rho}{1-\gamma}} \right\}^{\frac{1}{1-\rho}} \\ \text{s.t. } & c_{it} + \frac{b_{it+1}}{P_t} + \Phi_{wt}(W_{it}) = \frac{b_{it}}{P_{t-1}} \frac{1}{\Pi_t} R_{t-1} + \frac{1}{P_t} W_{it} l_{it} + T_{it} \\ & l_{it} = \left(\frac{W_{it}}{W_t}\right)^{-\theta_w} L_t^d \end{aligned}$$

[5]These are common practices in the international economics literature; see Schmitt-Grohé and Uribe (2003). Without these costs, the model is not stationary because in steady-state the cross-sectional distribution of wealth is not uniquely determined. Small quadratic costs induce a household to save (dissave) after a shock when debt is above (below) the initial steady-state values. In the calibration section I discuss how I pin down a steady-state.

[6]I also omit the small debt adjustment cost, since it is not quantitatively needed.

Figure 1 describes the interaction between a participant and a nonparticipant, given a level of participation. Since there is no idiosyncratic risk within types, from here on I consider a representative household for each type. The nonparticipant's net financial wealth is entirely composed of holdings of risk-free nominal bonds, which are used to smooth out consumption. These bonds are traded with the participant, who issues bonds to finance her position in risky equity. In equilibrium, the net financial wealth of the participant is positive and higher than that of the nonparticipant. Both the participant and the nonparticipant are exposed to aggregate risk through labor income. The participant is also exposed to aggregate risk through her position on equity.

FIGURE 1. Portfolios of the Participant and Nonparticipant



The first order conditions for debt, equity holdings, and wage setting, respectively, are

$$1 = E_t\left[\Lambda_{npt,t+1}\frac{R_t}{\Pi_{t+1}}\right]$$

$$1 - \Psi'_{Dt} = E_t\left[\Lambda_{pt,t+1}\frac{1}{\Pi_{t+1}}[R_{bt}(D_{t+1}) + D_{t+1}R'_b(D_{t+1})]\right]$$

$$Q_{dt} = E_t\left[\Lambda_{pt,t+1}\left(Q_{d,t+1} + d_{t+1}\right)\right]$$

$$\frac{\theta_w}{\theta_w - 1}z_{t-1}\vartheta_0 L_t^{\vartheta} = w_t + \frac{1}{\theta_w - 1}z_{t-1}\xi_w\left(\Pi_{wt} - 1\right)\Pi_{wt},$$

where $\Psi'_{Dt} = \nu(\frac{D_{t+1}}{z_t} - D_{ss})$, and in the last equation I use the equilibrium condition $W_{it} = W_t \forall i$. The last equation is the New Keynesian Wage Phillips curve (NKWP). Given the model assumptions, in equilibrium all households supply the same amount of labor and face the same wage, so labor income is homogeneous across households.[7] Note that the stochastic discount factor (SDF) for a household i is given by

$$\Lambda_{it,t+1} \equiv \beta \frac{\lambda_{it+1}}{\lambda_{it}} \left(\frac{V_{it+1}}{\left[E_t\left(V_{it+1}^{1-\gamma}\right)\right]^{\frac{1}{1-\gamma}}} \right)^{\rho-\gamma}, \tag{1}$$

where $\lambda_{it} \equiv \left(c_{it} - z_{t-1}\vartheta_0 \frac{L_t^{1+\vartheta}}{1+\vartheta}\right)^{-\rho}$ is the marginal utility of consumption.

Intermediate Goods Producer

Intermediate goods producers combine labor and installed capital to generate units of intermediate goods that are sold to retailers. Their production function is given by

$$y_{j,t} = k_{j,t}^{\alpha} \left(z_t l_{jt}\right)^{1-\alpha},$$

where the productivity shock follows $z_t = z_{t-1}e^{\eta_{zt}}$ with $\eta_{zt+1} = \rho_z \eta_{zt+1} + \epsilon_{zt+1}$, with $\rho_z \in (0,1)$ and $\epsilon_{zt+1} \sim \mathcal{N}(0, \sigma_{\epsilon_z})$. As shown in Swanson (2016), permanent TFP shocks and recursive preferences are necessary to generate high equity premia.[8] These firms make production and investment decisions to maximize the expected discounted flow of future payoffs. The law of motion of capital for an intermediate producer j is

$$k_{jt+1} = (1-\delta)\, k_{jt} + \upsilon_t \left(1 - \Phi\left(\frac{i_{jt}}{i_{jt-1}}\right)\right) i_{jt}, \tag{2}$$

where ν_t is a shock to the marginal efficiency of investment (MEI). The shock follows $\ln\upsilon_{t+1} = \rho_\upsilon \ln\upsilon_t + \epsilon_{\upsilon,t+1}$, where $\epsilon_{\upsilon,t+1} \sim \mathcal{N}(0, \sigma_\upsilon)$ and $\rho_\nu \in (0,1)$. The MEI shock only affects newly produced units of capital, so gross investment has to occur for the shock to be effective.

Being owned by participant households, firms use the participant's stochastic discount factor $\Lambda_{pt,t+1}$ to discount future payouts. Let $\mathcal{Q}_{kt}$ denote the Lagrange multiplier (i.e., Tobin's marginal Q). The objective function is given by

$$\max_{\{l_{j\tau}, i_{j,\tau}, k_{j\tau+1}\}} = \mathbb{E}_t \sum_{\tau \geq t} \Lambda_{p\tau}^{\$} \left(p_{m,\tau} y_{j,\tau} - P_\tau w_\tau l_{j,\tau} - P_\tau i_{j,\tau}\right)$$

[7] Homogeneity on this dimension helps to focus my analysis on the effects of heterogeneity induced by limited participation.

[8] Wei (2009) builds a RANK model with investment and shows that to a first order, the real effects of MP shocks are too weak and short-lived to generate high excess returns, and that transitory TFP shocks contribute little to equity premia.

where $\Lambda^{\$}_{p\tau}$ is the nominal SDF of a participant household. The FOC on labor implies

$$\frac{p_{m,\tau}}{P_\tau} = \frac{1}{1-\alpha} w_t \frac{l_{jt}}{y_{jt}}. \tag{3}$$

The first order condition for capital is

$$\mathcal{Q}_{kt} = \mathbb{E}_t \Lambda_{pt+1} \left\{ \alpha r^k_{t+1} + \mathcal{Q}_{kt+1} (1-\delta) \right\} \tag{4}$$

where $r^k_{t+1} \equiv \frac{p_{m,t+1}}{P_{t+1}} MPK_{t+1}$, and for investment

$$1 = \upsilon_t \mathcal{Q}_{kt} \left[1 - \Phi\left(\frac{i_{jt}}{i_{jt-1}}\right) - \Phi'\left(\frac{i_{jt}}{i_{jt-1}}\right) \frac{i_{jt}}{i_{jt-1}} \right] + \mathbb{E}_t \Lambda_{pt+1} \mathcal{Q}_{kt+1} \upsilon_{t+1} \Phi'\left(\frac{i_{jt+1}}{i_{jt}}\right) \left(\frac{i_{jt+1}}{i_{jt}}\right)^2. \tag{5}$$

Since intermediate firms are homogeneous, they all make the same choices. Any rent from capital is paid to participant households.

Labor Agency and Final Goods Producer

A representative labor-aggregating agency pools household-supplied labor using the CES aggregator

$$L^d_t = \left(\int l_{it}^{\frac{\theta_w - 1}{\theta_w}} dk \right)^{\frac{\theta_w}{\theta_w - 1}} \qquad \theta_w > 1.$$

It chooses l_{it} to maximize profits, yielding the following FOC:

$$l_{k,t} = \left(\frac{W_{kt}}{W_t} \right)^{-\theta_w} L^d_t,$$

which is taken as given by wage-setters. Since optimal wage setting depends only on aggregate variables, $W_{kt} = W_t$ and $l_{k,t} = L^d_t = L_t = \int l_{it} dk$.

A representative final goods producer uses the intermediate goods sold by retailers to produce the consumption good by means of a CES aggregator

$$Y_t = \left(\int_0^1 y_{j,t}^{\frac{\theta_p - 1}{\theta_p}} dj \right)^{\frac{\theta_p}{\theta_p - 1}} \qquad \theta_p > 1.$$

Optimality yields the standard demand curve

$$y_{j,t} = \left(\frac{p_{j,t}}{P_t} \right)^{-\theta_p} Y_t,$$

where the aggregate price index $P_t = \left(\int_0^1 p_{j,t}^{1-\theta_p} dj \right)^{\frac{1}{1-\theta_p}}$. The labor agency and the final goods producer make zero profits in equilibrium.

Retailers

These firms purchase good y_{jt} from intermediate production firms, repackage it, and sell it to the final good producer. They sell it at a differentiated price, but are subject to a quadratic adjustment cost $\Phi_p(\Pi_{jt}) = \frac{\xi_p}{2}(\Pi_{jpt} - 1)^2 Y_t$. Their objective is to maximize

$$\sum_{q=0}^{\infty} \Lambda^{\$}_{pt,t+q} \mathbb{E}_t \left\{ \left[p_{j,t+q} - P_{t+q} \mathrm{mc}_{jt+q} \right] y_{j,t+q} - P_{t+q} \frac{\xi_p}{2} \left(\frac{p_{j,t+q}}{p_{j,t+q-1}} - 1 \right)^2 Y_{t+q} \right\}$$

subject to $y_{j,t} = \left(\frac{p_{j,t}}{P_t}\right)^{-\theta_p} Y_t$, where $\mathrm{mc}_t = \frac{p_{mt}}{P_t} = \frac{1}{1-\alpha} w_t \frac{L_t}{Y_t}$. They discount future payoffs using participants' nominal SDF. Optimality and symmetry yield the New Keynesian Phillips curve (NKP)

$$\theta_p \mathrm{mc}_{jt} Y_t + \mathbb{E}_t \Lambda_{pt,t+1} \xi_p (\Pi_{pt+1} - 1) Y_{t+1} \Pi_{pt+1} = \xi_p (\Pi_{pt} - 1) Y_t \Pi_{pt} + (\theta_p - 1) Y_t. \tag{6}$$

These firms also make positive profits, which are distributed to stockholders.

Closing the Economy

In what follows I describe the final ingredients of the economy. As mentioned before, the government sector only consists of a standard Taylor rule

$$R_{b,t} = R_{b*} \left(\frac{R_{b,t-1}}{R_{b*}} \right)^{\mu_R} \left[\left(\frac{\Pi_t}{\Pi_*} \right)^{\phi_\pi} \left(\frac{Y_t}{Y_t^*} \right)^{\phi_y} \right]^{1-\mu_R} e^{\eta_{R,t}},$$

where $R_{bt} = \frac{1}{Q_{bt}}$, and R_{b*}, Π_* and Y_t^* are the steady-state values for the interest rate, inflation, and output. As in Coibion and Gorodnichenko (2012), the innovation term follows $\eta_{R,t} = \rho_{\eta_R} \eta_{R,t-1} + \epsilon_{Rt}$, with $\epsilon_{R,t} \sim \mathcal{N}(0, \sigma_{\eta_R})$.

Participants' equity cash flows are given by payouts stemming from intermediate producers and retailers. Producers' profits are given by

$$d_t^m = \frac{\alpha}{1-\alpha} w_t L_t - I_t$$

and retailers' profits are

$$d_t^r = Y_t - \frac{1}{1-\alpha} w_t L_t - \frac{\xi_p}{2} (\Pi_t - 1)^2 Y_t.$$

Therefore, total cash flows received by participants are

$$d_t \equiv Y_t - w_t L_t - I_t - \frac{\xi_p}{2} (\Pi_t - 1)^2 Y_t. \tag{7}$$

Households' lump-sum transfers $T_{it} = T_t$ are defined so that there is no output loss coming from the debt-elastic interest rate

$$T_t = D_t \frac{1}{\Pi_t} \left[R_{bt-1}\left(D_t\right) - R_{t-1} \right]. \tag{8}$$

Thus, by adding up the budget constraints and using the definition of unlevered aggregate dividends, we get the aggregate resource constraint

$$Y_t = C_t + I_t + \underbrace{\Phi_w\left(W_t\right)}_{\substack{\text{wage adj.}\\ \text{cost}}} + \underbrace{\Phi_p\left(p_t\right)}_{\substack{\text{price adj.}\\ \text{cost}}} + \underbrace{\varphi\Phi(D_t)}_{\substack{\text{debt adj.}\\ \text{cost}}}. \tag{9}$$

Since the economy is subject to permanent productivity shocks, I normalize by z_{t-1} to render the system stationary. The full system of stationary equilibrium equations, as well as the steady-state equilibrium, can be found in Appendix A.1.

Definition of Equilibrium

Let i index a household by its particular labor skill supplied l_{it}. There is a measure one of households, a fraction φ of which are participants and the remaining $1-\varphi$ are nonparticipants, so that $\{D_{it}, \theta_{it}\} = \{D_{pt}, \theta_{pt}\}$ if the household is P and $\{0, 0\}$ otherwise, and $b_{it} = b_{npt}$ if the household is NP and 0 otherwise. Definition 1 defines a competitive equilibrium in the economy.

DEFINITION **1.** *Given households' initial portfolio positions $\{D_{i0}, \theta_{i0}, b_{i0}\}$ and stochastic processes $\{\epsilon_{zt}, \epsilon_{Rt}, \epsilon_{\nu t}\}_{t=1}^{\infty}$, a competitive equilibrium in the economy is a sequence of prices $\{w_t, \{w_{it}\}_{i\in[0,1]}, \Pi_{pt}, \Pi_{wt}, R_t, R_{bt}, Q_{dt}, \mathcal{Q}_{kt}\}_{t=1}^{\infty}$ and allocations for households $\{\{c_{it}\}_{i\in[0,1]}, \{b_{it}\}_{i\in[0,1]}, \{D_{it}\}_{i\in[0,1]}, \{\theta_{it}\}_{i\in[0,1]}\}_{t=1}^{\infty}$; intermediate firms $\{L_t, K_t, I_t\}_{t=1}^{\infty}$; retailers $\{\{p_{jt}\}_{j\in[0,1]}\}_{t=1}^{\infty}$; the final good producer $\{\{y_{jt}\}_{j\in[0,1]}\}_{t=1}^{\infty}$; and for the labor agency $\{\{l_{it}\}_{i\in[0,1]}\}_{t=1}^{\infty}$, such that*

i. Allocations solve agents' problems at equilibrium prices,

ii. The nominal interest rate is given by the Taylor rule,

iii. Prices are such that markets clear

- *Assets: equity $\rightarrow \theta_{pt} = \frac{1}{\varphi}$, bonds $\rightarrow \varphi D_{pt} = (1-\varphi) b_{npt}$*
- *Labor: $l_{it} = l_t = L_t$ and $w_{it} = w_t$ for any i*
- *Goods: $Y_t = C_t + I_t + \Phi_w(w_t) + \Phi_p(p_t) + \varphi\Phi_D(D_t)$, and*

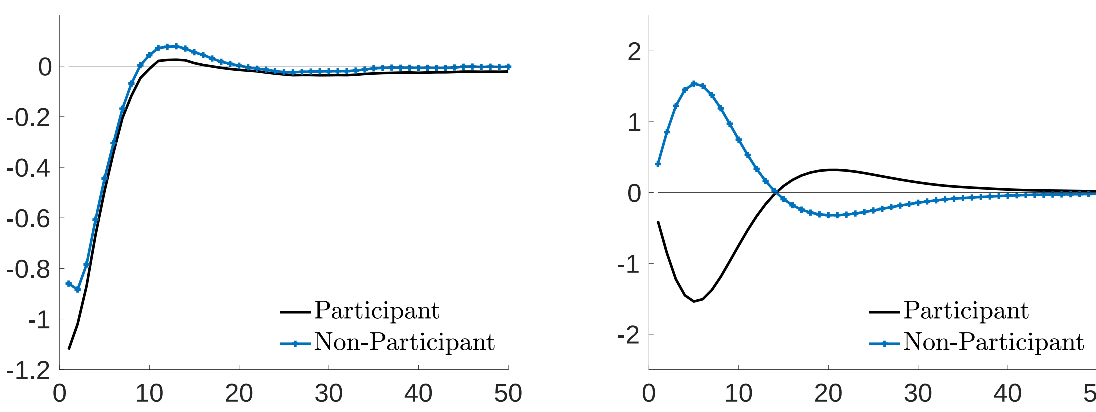
iv. Real wages and inflation are related by $w_t \Pi_{pt} = w_{t-1}\Pi_{wt}$.

2.2. *Limited Participation and the Transmission of Monetary Policy Shocks*

I now discuss the main channels through which limited participation affects the transmission of macroeconomic shocks. In this section, I focus on the transmission of an unexpected monetary policy shock, since this type of shock allows me to uncover and explain in detail all of the mechanisms at play in my model. In the quantitative Section 3.3, I extend the analysis to the other two types of shocks considered in this paper.

A crucial feature of limited participation is the heterogeneity in the composition of wealth across households. As shown in Figure 1, the nonparticipant saves in risk-free nominal bonds while the participant supplies these bonds in order to finance her position in risky equity. As a result, there is an implicit transfer of aggregate risk from the nonparticipant to the participant that leaves this type of household more susceptible to MP shocks. To illustrate this point, panel A of Figure 2 shows the response of cross-sectional consumption to a contractionary MP shock for a calibrated version of the model. In effect, the consumption of both types of households falls in response to the shock. As is standard in a New Keynesian framework, an unexpected rise in the interest rate creates a direct substitution effect for both types of households that induces higher savings and lower consumption. It also generates direct negative wealth effects—because the net present value (NPV) of total wealth falls due to a higher discount rate—which further reduce consumption. The consequent weaker demand is then translated into lower production and labor income in equilibrium, leading to additional indirect negative wealth effects on both types of households.

FIGURE 2. Cross-sectional Consumption and Savings in Nominal Bonds



(A) Cross-sectional Consumption (in %) (B) Savings in Nominal Bonds (in %)

Notes: The figure shows the response of quarterly consumption and savings in nominal bonds to a positive 1–sd MP shock under low participation, $\varphi = 25\%$. Units are percentage deviation from the ergodic steady-state. See quantiative Section 3.3 for details.

Panel A of Figure 2 also shows that the consumption of the participant household falls by more than that of the nonparticipant. In the model, this happens due to a combination of heterogeneous wealth effects and substitution effects across the two types of households. To understand the differential wealth effects, it is useful to formalize Figure 1 by deriving the intertemporal budget constraint for the participant household under perfect foresight,

$$\underbrace{\sum_{s=0}^{\infty} \frac{c_{pt+s}}{R_{bt,t+s}}}_{\text{NPV consumption}} = \underbrace{-\frac{D_t}{P_{t-1}} \frac{1}{\Pi_t} R_{bt-1}(D_t)}_{\text{Real debt}} + \underbrace{\sum_{s=0}^{\infty} \frac{w_{t+s} L_{t+s}}{R_{bt,t+s}}}_{\text{NPV labor income}} + \underbrace{\frac{1}{\varphi} d_t + \frac{1}{\varphi} Q_{dt}}_{\text{NPV equity}}, \tag{10}$$

where $R_{bt,t+s} = \prod_{j=1}^{s} \frac{R_{bt+j-1}(D_{t+j})}{\Pi_{t+j}}$ and $Q_{dt} = \mathbb{E}_t \sum_{s=0}^{\infty} \frac{d_{t+s} + Q_{dt+s}}{R_{bt,t+s}}$.[9] For a nonparticipant,

$$\underbrace{\sum_{s=0}^{\infty} \frac{c_{npt+s}}{R_{t,t+s}}}_{\text{NPV consumption}} = \underbrace{\frac{b_{npt}}{P_{t-1}} \frac{1}{\Pi_t} R_{t-1}}_{\text{Real savings}} + \underbrace{\sum_{s=0}^{\infty} \frac{w_{t+s} L_{t+s}}{R_{t,t+s}}}_{\text{NPV labor income}}, \tag{11}$$

with $R_{t,t+s} = \prod_{j=1}^{s} \frac{R_{t+j-1}}{\Pi_{t+j}}$. These equations show three sources of variation in households' wealth; the first is direct and the other two indirect (i.e., general equilibrium (GE) effects). First, a rise in future discount rates reduces the NPV of labor income and equity. Second, the drop in inflation increases the real value of debt, which transfers wealth from the participant to the nonparticipant.[10] Third, a fall in future labor income (equity cash flows) further reduces the NPV of labor income (equity).

Qualitatively, we cannot determine what type of household has stronger wealth effects. On the one hand, although both types face the same absolute variation in labor income, the relative impact on the nonparticipant's wealth is larger since she has a lower level of wealth. On the other hand, the participant is also subject to fluctuations in the NPV of equity. To the extent that equity is the main component of the participant's wealth, and that its price varies significantly with the MP shock, the model could deliver larger negative wealth effects for the participant than for the nonparticipant. If so, the participant could even find it optimal to increase borrowing in nominal bonds—and the nonparticipant to increase savings—an equilibrium outcome illustrated in panel B of Figure 2. Thus, fluctuations in the price of equity provide a potential source for the participant's excess sensitivity to MP shocks, which translate into a more volatile SDF. As I argue later, this excess sensitivity of the participant's SDF is

[9]Due to its small magnitude and for ease of exposition, I abstract from transfers and adjustment costs.

[10]The fact that firms use the SDF of the participant to make investment decisions implies that this transfer of resources is not innocuous.

especially relevant for firms' investment, and a main driver for the response of the price of equity.

However, even if the participant had stronger wealth effects, households could still trade bonds so that the consumption response is equalized across the two types. To illustrate this point, I first combine the Euler equation for bonds of the participant and the nonparticipant under CRRA preferences and no financial frictions, $\mathbb{E}_t\left[\left(\frac{c_{pt}}{c_{pt+1}}\right)^{\gamma}\right] = \mathbb{E}_t\left[\left(\frac{c_{npt}}{c_{npt+1}}\right)^{\gamma}\right]$. Assume a one-time contractionary MP shock and no additional shocks after that. According to this equation, the growth rate of consumption for subsequent periods after the shock would be the same across types, until convergence back to the steady-state. But then, in a stationary model, this equation would hold only if the initial drop in consumption is the same for both types of households. That is, even if the participant had stronger wealth effects, households would trade bonds so that consumption deviations from steady-state would be the same across types.

In the current model, however, this is not an optimal outcome due to cross-sectional differences in the Euler equations. The equalization of Euler on bonds yields:

$$\mathbb{E}_t\left[\underbrace{\frac{\lambda_{pt+1}}{\lambda_{pt}}}_{\text{growth MU}}\underbrace{\left(\frac{V_{pt+1}}{\left[E_t\left(V_{pt+1}^{1-\gamma}\right)\right]^{\frac{1}{1-\gamma}}}\right)^{\rho-\gamma}}_{\text{EZ wedge}}\underbrace{\left[R_{bt}(D_{t+1})+D_{t+1}R_b'(D_{t+1})\right]}_{\substack{\text{debt elastic}\\ \text{interest rate}}}\right] = \tag{12}$$
$$\mathbb{E}_t\left[\frac{\lambda_{npt+1}}{\lambda_{npt}}\left(\frac{V_{npt+1}}{\left[E_t\left(V_{npt+1}^{1-\gamma}\right)\right]^{\frac{1}{1-\gamma}}}\right)^{\rho-\gamma} R_t\right].$$

This equation defines an implicit function that, when combined with intertemporal budget constraints, produces the equilibrium consumption growth path for each type of household. The equation conveys two sources of heterogeneity in consumption growth, the most direct being the effective interest rate each type effectively faces. By allowing for a debt-elastic interest rate, the participant internalizes how the schedule changes as debt increases, therefore reducing the incentives to borrow to smooth out consumption. On top of that, the wedge induced by recursive preferences enhances the heterogeneity in consumption growth paths.

The previous analysis suggests that in order to observe a relatively stronger consumption response from the participant, the model should exhibit a high exposure of the participant to equity, a sharp drop in the price of equity, and heterogeneity in the SDFs. In effect, the calibrated version of the model produces an excess response from the participant household, as shown in panel A of Figure 2. This is a desirable feature of the model, since in Section

4.1 I provide empirical evidence that participants' consumption falls by relatively more upon a contractionary MP shock. In fact, I link the model to the data by running the same empirical regression using model–simulated data, and find that the estimated excess response of the participant in the model is similar to that in the data.

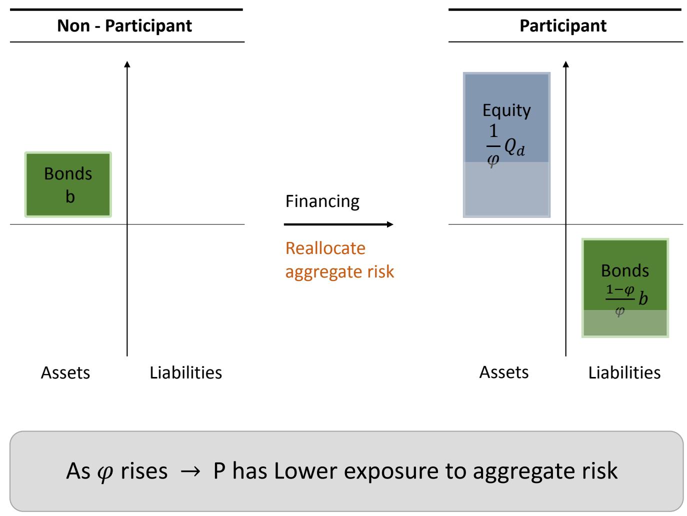
Monetary policy shocks are also transmitted to the economy through their effects on firms' investment. The main operating channel is a rise in the cost of capital that reduces firms' incentives to invest. To observe this, recall the dynamic equations for the price of equity and for Tobin's marginal Q

$$
\begin{aligned}
Q_{dt} &= \mathbb{E}_t \Lambda_{pt,t+1} \left(Q_{d,t+1} + d_{t+1} \right) \\
\mathcal{Q}_{kt} &= \mathbb{E}_t \Lambda_{pt+1} \left\{ \alpha r^k_{t+1} + \mathcal{Q}_{kt+1} \left(1 - \delta \right) \right\}.
\end{aligned}
$$

Both objects are sensitive to fluctuations in the participant's SDF, $\Lambda_{pt,t+1}$. To get high required excess return on equity—and a sharp drop in the price of equity—as obsereved in the data, the SDF must respond significantly to the shock. By doing so, it induces a drop in the marginal value of capital, $\mathcal{Q}_{kt}$, which is followed by a fall in investment. Since the latter accounts for roughly 20% of output, this can be a strong contractionary force on production due to both its current effects on aggregate demand and future effects on lower productive capital. In effect, related work by Kekre and Lenel (2019) and Melcangi and Sterk (2020) have also shown that the investment channel is critical for the transmission of monetary policy shocks, although through different mechanisms, namely, the redistribution of wealth and portfolio rebalancing.

The previous analysis assumed a fixed level of participation, but one of the main contributions of this paper is to analyze how transmission mechanisms vary with higher participation. Figure 3 describes what occurs to households' portfolios when there is an exogenous rise in the fraction of participants in the model. The level of savings for the nonparticipant remains the same, but the per capita exposure to equity and debt of a participant falls, since these are pooled into a larger set of households. As observed in equation (10), this implies that the average participant is less exposed to fluctuations in the value of equity, and therefore has milder wealth effects. In addition, a lower level of debt implies that the participant's exposure to changes in borrowing costs will also be milder, and movements in the interest rate schedule will be smoother. When combined, these effects generate a *dampening* effect on the excess response of a participant's consumption and SDF relative to a nonparticipant.

FIGURE 3. Households' Portfolios and Rise in the Participation Rate



However, the qualitative effects of higher participation over aggregate consumption are ambiguous. The definition of aggregate consumption,

$$C_t = \varphi c_{p,t} + (1 - \varphi)c_{np,t},$$

reveals the existence of two opposing forces. At the extensive margin, as participation rises ($\uparrow \varphi$) a larger share of the population has a consumption policy that is relatively more responsive to MP shocks. At the intensive margin, the responsiveness of the participant's consumption falls ($\downarrow dc_{p,t}/dR_t$). Quantitatively, I show in Section 3 that the second effect dominates and the response of aggregate consumption is *dampened* with higher participation.

The behavior of investment reinforces the previous result. As the participant's exposure to aggregate risk falls, her SDF responds less to the MP shock. This induces milder fluctuations in the cost of capital which, in turn, *dampens* the response of investment to the shock. When combining the dampening effects over aggregate consumption and investment, I derive one of the main results of my model: Monetary policy becomes less effective with higher participation.[11] In Section 4.2, I provide suggestive evidence that this dampening effect might be present in the data. In Section 3.3 I show that higher participation also has important effects on the transmission of productivity shocks and shocks to the marginal efficiency of investment.

[11] I solved a version of the model with similar parameters but no investment. In that case, the dampening effect of higher participation is sensitive to the specific set of parameters. However, results are robust once investment is added to the model.

3. Quantitative Results

In this section, I use the model to analyze in detail the effects of limited participation on the transmission of aggregate shocks to the economy. I start by calibrating the model under an assumed participation rate of 25%. A subset of model parameters is taken as standard from the literature, while the rest are calibrated to match a set of moments computed for the period from 1970q1 to 1989q4. I then shock the economy with positive monetary policy, productivity, and investment shocks, and detail to what extent limited participation gives shape to the transmission channels.

3.1. *Calibration*

Table 1. Predetermined Model Parameters

Parameter	Description	Value
New Keynesian		
$\theta = \theta_w$	Goods and wage elasticities	4.00
ξ_p	Price friction	29.52
μ_R	Taylor persistence	0.85
ϕ_Π	Taylor weight inflation	1.80
ϕ_Y	Taylor weight output	0.50
Shocks Structure		
σ_R	Volatility Taylor innovation	28bps
ρ_R	Persistence Taylor innovation	0.60
ρ_ν	Persistence investment shock	0.80
σ_ν	Volatility investment shock	0.05
ρ_z	Persistence productivity shock	0.27
Other		
$\rho_p = \rho_{np}$	Inverse of IES	4.00
α	Capital share on production	0.30
ϑ	Labor utility (slope)	1.00
ϑ_0	Labor utility (level)	0.90

Notes: This table shows the subset of parameters that are fixed in the calibration.

Table 1 describes the set of 16 predetermined parameters of the model. A period corresponds to a quarter. Five of the New Keynesian block of parameters are taken from Del Negro et al.

(2007): goods elasticity $\theta_p = 4$, wage elasticity $\theta_w = 4$, price friction $\xi_p = 29.52$, persistence of the Taylor rule $\mu_R = 0.85$, and the Taylor weight on inflation $\phi_\pi = 1.8$. The price friction is set through a first order equivalence between Calvo and Rotemberg pricing. The implied NK Phillips curve elasticity is 0.13, similar to Kaplan, Moll, and Violante (2018). The Taylor weight on output $\phi_Y = 0.5$ (slightly above Del Negro et al. (2007)) and the volatility of the innovation to the Taylor rule, $\sigma_R = 28$bps, are in line with Challe and Giannitsarou (2014). The persistence of the innovation $\rho_R = 0.6$ is taken from estimates by Coibion and Gorodnichenko (2012). The persistence of the investment shock $\rho_\nu = 0.80$, its volatility $\sigma_\nu = 0.05$, and the persistence of the productivity shock $\rho_z = 0.27$ follow from estimates by Justiniano et al. (2011). The (inverse) intertemporal elasticity of substitution parameters, $\rho_p = \rho_{np} = 4$, are based on Vissing-Jorgensen (2002) and Guvenen (2009). Since I compare economies with different degrees of participation, in my baseline model I equalize the IES for both types of households. In Appendix C.3, I allow for heterogeneous IES and show that my main results still hold. Parameters on the capital share on production, $\alpha = 0.30$, and on the Frisch elasticity of labor, $\vartheta = 1$, are standard in the business cycle literature. The level parameter on utility for labor was set to $\vartheta_0 = 0.90$ to obtain a level of labor of unity in steady-state.

Table 2 displays the set of calibrated parameters. My objective is for the model to jointly reproduce some business cycle moments, asset pricing moments, and a cross-sectional measure of net financial wealth. The model is calibrated to match a set of nine moments, computed using quarterly data from the period 1970q1 to 1989q4. Appendix B.1 explains in detail the data sources and Appendix B.2 the construction of variables. The set of targeted business cycle moments is output volatility, relative volatility of investment, ratio of investment to output, and the correlation between output and profits before investment. The set of targeted asset pricing moments is the annualized equity premium, annualized real risk-free rate, elasticity of equity price to a positive monetary policy shock, and relative volatility of equity payouts. For the cross-sectional moment, I match the ratio of net financial wealth of a participant household to that of a nonparticipant. This measure summarizes complex debt contracts between households and firms; see Appendix A.2 for further details.

The equity price elasticity measures how much the equity price falls upon a 1–sd contractionary monetary policy shock. Regarding the volatility of equity payouts, an adjustment must be made to match the model with the data. Work by Greenwald, Lettau, and Ludvigson (2019) uses total payouts to shareholders—defined as the sum of dividend payments and net equity repurchases; see Appendix B.2—as the relevant measure of payoffs to equity holders. Thus, total payouts are significantly more volatile than gross profits or dividends. To map the model to the data, I follow common practice in the macro-finance literature and define an auxiliary variable d^{λ_d} as a reduced-form way to increase the volatility of equity payouts; e.g., see Abel (1999) and Croce (2014). Let Q_{dt}^{lev} denote the ex-dividend price of that security, so that

$$Q_{dt}^{lev} = \mathbb{E}_t\left[\Lambda_{pt,t+1}\left(d_{t+1}^{\lambda_d} + Q_{dt+1}^{lev}\right)\right]$$

and the return on this levered security is given by

$$R_{dt+1}^{lev} \equiv \frac{d_{t+1}^{\lambda_d} + Q_{dt+1}^{lev}}{Q_{dt}^{lev}}.$$

Table 2. Calibrated Model Parameters

Parameter	**Description**	**Target**	**Parameter Value**
Business cycles			
σz	TFP volatility	Output volatility	0.009
δ	Capital depreciation rate	Investment over output	0.026
ϕ_k	Investment rate cost	Relative volatility investment	7
ξ_w	Wage friction	Correlation output and profits	11
Asset prices			
$\gamma_p = \gamma_{np}$	Household risk aversion	Equity premium	10
β	Discount rate	Real risk-free rate	0.994
ψ	Borrowing cost elasticity	Equity price elasticity	3.6e-05
λ_d	Payouts exponent	Relative volatility equity payouts	5.5
Cross-section			
b_{np}	Nonparticipant savings	Relative net financial wealth	36

Notes: This table shows the subset of parameters calibrated to match the targeted moments detailed in Table 3.

Even though parameters may affect more than one moment, there are some clear patterns, shown in Table 2. The set of target parameters that are relatively more related to business cycles moments is the volatility of TFP $\sigma_z = 0.9\%$; capital depreciation rate $\delta = 0.026$; investment adjustment cost $\phi_k = 7$; and wage setting friction $\xi_w = 11$.[12] Those more related to asset prices

[12]The σ_z parameter is in line with Guvenen (2009) (1.1%) and King and Rebelo (1999) (0.7%).

are risk aversion $\gamma_p = \gamma_{np} = 10$; the discount rate $\beta = 0.994$; the borrowing cost elasticity $\psi = 3.6e^{-05}$; and the exponent for payouts $\lambda_d = 5.5$. The steady-state level of savings for nonparticipants $b_{np} = 36$ helps to pin down the relative net financial wealth, as defined in the model by $\frac{\theta_{pt} Q_{dt} - D_{pt}}{b_{npt}}$.

TABLE 3. Target Moments: Model vs Data

Target	**Model**	**Data**
Business cycles		
Output volatility	2.1	2.2
Investment over output	0.19	0.17
Relative volatility investment	2.2	2.8
Correlation output and gross profits	80	72
Asset prices		
Equity premium	4.0	4.0
Real risk-free rate	2.1	2.0
Equity price elasticity	-2.9	-3.5
Relative volatility equity payouts	9.0	15.0
Cross-section		
Relative net financial wealth	12.0	12.0

Notes: This table shows the set of data moments targeted in the calibration and their model counterparts. See Appendix B.2 for details.

Table 3 contrasts the simulated moments with their data counterparts. The model is able to closely replicate almost all targeted moments. The equity premium is generated due to a reallocation of aggregate risk from the nonparticipant to the participant through the trading of bonds. In addition, the debt-elastic interest rate schedule allows for a close match with the equity price elasticity of -3.5%, as robustly estimated by Bernanke and Kuttner (2005) for the sample 1989:Q2-2002:Q4. Matching this moment is important, because it generates a relatively stronger response of the consumption of the participant household, not only due to a fall in the stream of equity payoffs but also to an increase in future discount rates that reduces the present value of equity. Furthermore, since firms use the participant's SDF to discount future profits, the resulting higher cost of capital induces firms to invest less, thus reinforcing the contractionary effects of the initial shock; see Section 2.2 for a detailed explanation.

In addition to my baseline calibration, in the appendix I study different model extensions and show that the main predictions of my model still hold. First, in Appendix C.3 I account for the heterogeneity in IES documented by Vissing-Jorgensen (2002), while avoiding changes in average IES as participation rises. Second, in Appendix C.4 I evaluate concerns related to endogenous participation, in terms of the existence of heterogeneous risk aversion and a state-contingent participation rate. In this way, I capture the effects of having higher risk aversion for the participant as participation rises, as well as the effects of a procyclical participation rate. Finally, in Appendix C.5 I consider the case in which the rise in participation is partly driven by indirect holders of equity—i.e., households with equity-based 401K/IRA accounts—as observed in the data. To this end, I decompose participants between active and passive—with the latter having fixed portfolio shares—and calibrate the model to match the fraction of each type of participant before and after the rise in participation.

3.2. *Untargeted Moments*

Tables 4 and 5 present the set of untargeted moments related to business cycles, the cross-section of households, and asset prices. Table 4 suggests that the model has a relatively good fit in terms of business cycles. In particular, the model has high correlation of investment and wage bill with output, and it also exhibits an aggregate consumption process that is relatively less volatile than output. At the cross-section, the model is also able to replicate a consumption process for the participant that is more volatile than that of the nonparticipant, as measured by Mankiw and Zeldes (1991) and Vissing-Jorgensen (2002); see Tables 4 and 1, respectively.

Table 5 shows that the model is capable of replicating a relevant set of asset pricing moments. In particular, the model delivers a price-dividend ratio and a countercyclicality of equity premia very close to the data. However, the Sharpe ratio is below the empirical counterpart due to too volatile excess returns. The last row of this table displays the debt to net worth ratio of the participant household.[13] This moment is also very close to the data counterpart, which is important since the participant's levered position is behind many of the model's mechanisms.

[13]The data moment is constructed accounting for the liability side of firms' equity. See Appendix B.2.

Table 4. Untargeted Moments: Business Cycles

Moments	**Description**	**Model**	**Data**
corr(I,Y)	Correlation investment - output	77%	95%
corr(wL,Y)	Correlation wage bill - output	91%	80%
sd(C)/sd(Y)	Volatility aggregate consumption	0.90	0.71
$\sigma(c_p)/\sigma(c_{np})$	Relative volatility consumption	1.61	1.53

Notes: This table shows a set of untargeted moments related to business cycles. The first three are aggregate moments computed using quarterly data from the period 1970q1 to 1989q4. These moments are the correlation of investment and wage bill with output, and the relative volatility of aggregate consumption. The fourth moment is the relative volatility of consumption between an average participant and an average nonparticipant. This is computed for the period 1984 to 1989 using data from the CEX. See Appendix B.2 for details.

Table 5. Untargeted Moments: Asset Prices

Moments	**Description**	**Model**	**Data**
sd(RF)	Volatility risk-free rate	4.7%	3.7%
Qd/d	Price-dividend ratio	28.7	25.0
corr(EP,Y)	Correlation equity premium - output	-44%	-46%
Sharpe	Sharpe ratio	0.11	0.24
$Debt_p/NFW_p$	Leverage of participant	0.26	0.23

Notes: This table shows a set of untargeted asset pricing moments. sd(RF) refers to the volatility of the annual risk-free rate, Qd/d is the ratio of equity price to annual dividends (adjusted by λ), and corr(EP, Y) is the correlation between required excess returns and the HP cycle of output. The Sharpe ratio follows the unconditional specification. Model moments are computed using simulated data. Data moments are computed from yearly frequency for the period 1970-1989. The computation of required excess returns in the data is detailed in Appendix D.5. Leverage in the data accounts for firms' debt; see Appendix B.2 for details.

TABLE 6. Untargeted Moments: Cambpell-Shiller Decomposition

Component	Model	Data
var(future ER)	62.3%	62.8%
var(real rate)	3.2%	6.4%
var(cash flows)	24.0%	31.5%

Notes: This table presents a variance decomposition of returns on equity, in which the components are future cash flows, future real rate, and future excess returns. For comparison, in both the model and in the data I compute the decomposition from a VAR estimate as in Campbell and Ammer (1993). The covariance terms are omitted. In the data, the VAR is estimated using quarterly data from the period 1970q1-1989q4. Variables included are equity excess returns, real return of a 90 day T-bill, log of dividend-price ratio, relative bill (90 day T-bill minus its 12-month lagged moving average), and 10-year Treasury spread. See Appendix C.1 for details.

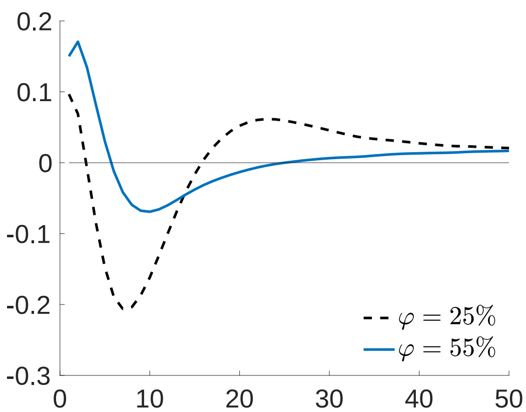
Table 6 provides more insights about the main drivers of asset prices in the model. I use the decomposition derived by Campbell and Shiller (1988), in which the current return on equity responds to variations in future cash flows, future real rates, and future excess returns. To render the analysis comparable to previous empirical work, I follow Campbell and Ammer (1993) and compute the expectations by means of a VAR(p). Appendix C.1 provides details on the decomposition and measurement. In line with the empirical asset pricing literature, the table shows that in the model the majority of the variation in current returns is explained by fluctuations in future excess returns, as opposed to movements in the real rate or equity cash flows. Challe and Giannitsarou (2014) build a RANK model that succesfully replicates the response of stock prices to MP shocks, but in their model the real rate is the main driver. This difference in findings suggests the importance of limited participation. In particular, the participant's discount rate endogenously becomes more volatile than the real rate, and therefore provides the right decomposition for asset pricing variation.

3.3. *Impulse Responses*

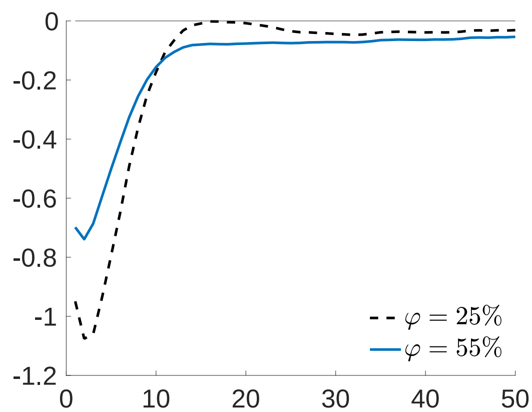
In this section, I analyze how different macroeconomic shocks are transmitted in the model, and its interaction with the level of participation. I compare the response of a low-participation economy, $\varphi = 25\%$, with that of a high-participation economy, $\varphi = 55\%$, in which the variation in participation is exogenous. By not recalibrating, I isolate the effects of limited participation and focus on the main operating channels. Overall, I find that while monetary and productivity shocks are *dampened* with higher participation, investment shocks are *amplified*. This suggests that as participation rises, shocks to the marginal efficiency of investment become relatively more important for business cycles.

3.3.1. *Monetary Policy Shocks*

FIGURE 4. Output Response to a Contractionary Monetary Policy Shock



(A) Nominal Rate (in %)



(B) Output (in %)

Notes: The figure shows the response of the quarterly nominal interest rate and output to a positive 1–sd MP shock under low (25%, dashed) and high (55%, solid) participation. Units are percentage deviation from the ergodic steady-state.

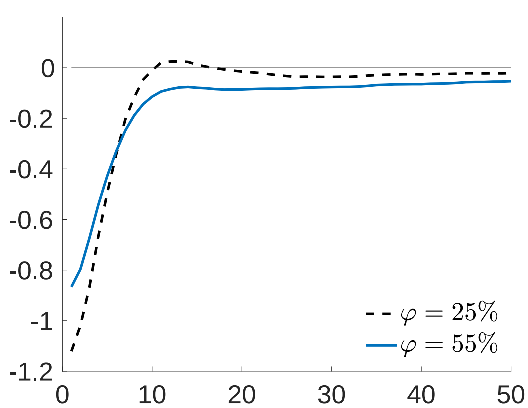
Figure 4 presents the response of the nominal rate and output to a 1–s.d. positive monetary policy shock. The dashed black line is the response for an economy with low participation, while the solid blue line is for an economy with high participation. Under low participation, the nominal rate rises by 10 bp on impact and output falls by 0.9%.[14] As explained in Section 2.2, the fall in output is driven by a drop in households' consumption and firms' investment, as depicted in Figures 5 and 6, respectively. Furthermore, Figure 5 shows that the consumption of the participant is relatively more responsive to the shock than that of the nonparticipant, falling by almost 0.3 pp more. This strong sensitivity of the participant's consumption—and SDF—has important implications for asset prices. In particular, Figure 7 shows that the contractionary shock causes a significant rise in the required excess returns and a consequent drop in the price of equity, as observed in the data.

[14]The overall drop in output is in between the estimates of Christiano et al. (2005) and Romer and Romer (2004), but in their estimates output falls with some lag. In the model, habit formation would help obtain that lag, but I purposely omit it for simplicity.

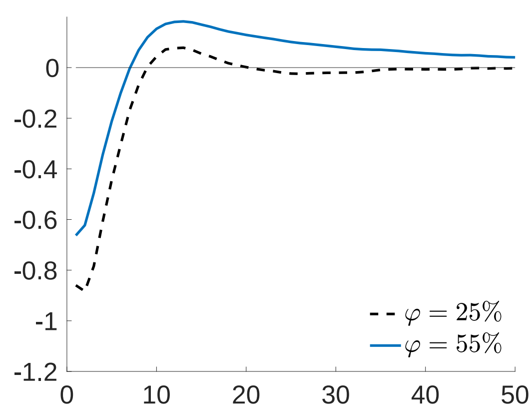
Importantly, Figure 4 also shows that the effects of the MP shock are *dampened* with higher participation. As mentioned in Section 2.2, there are two reasons for the dampening. The first is related to the participant's consumption and involves the trade-off between two forces. At the intensive margin, higher participation means that the participant's exposure to aggregate risk is pooled into a larger set of households. Therefore, each participant's consumption is less sensitive to the shock. At the extensive margin, there is a larger fraction of households whose consumption is more responsive to shocks. In equilibrium, the first force dominates and aggregate consumption falls by less.

The second reason for the dampening effect is related to firms' investment. Equation (4) depicts a clear link between the participant's SDF and Tobin's marginal Q, and Figure 6 illustrates the implications of this link. A more stable SDF is translated into a lower response of Tobin's marginal Q. Given the positive relation between $\mathcal{Q}_{kt}$ and investment, the latter also falls by less. When combined, the dampening effects on the participant's consumption and firms' investment imply that aggregate demand falls by less; and by GE effects, so does output, labor income, and equity cash flows. Of course, this loops back into the consumption of both types of households and firms' investment, resulting in strong GE effects of higher participation. Finally, the lower exposure of the participant to the MP shock implies that equity premia also increases by less.

FIGURE 5. Cross-sectional Consumption Response



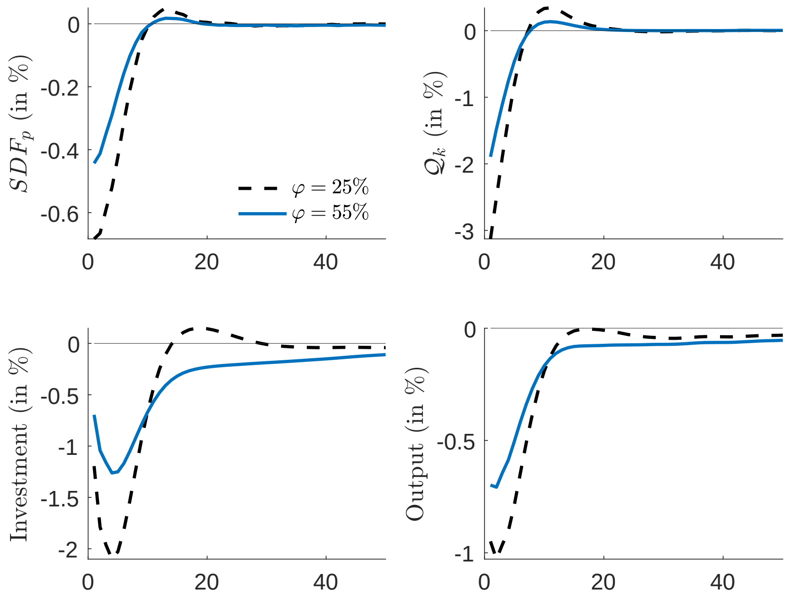
(A) Participant (in %)



(B) Nonparticipant (in %)

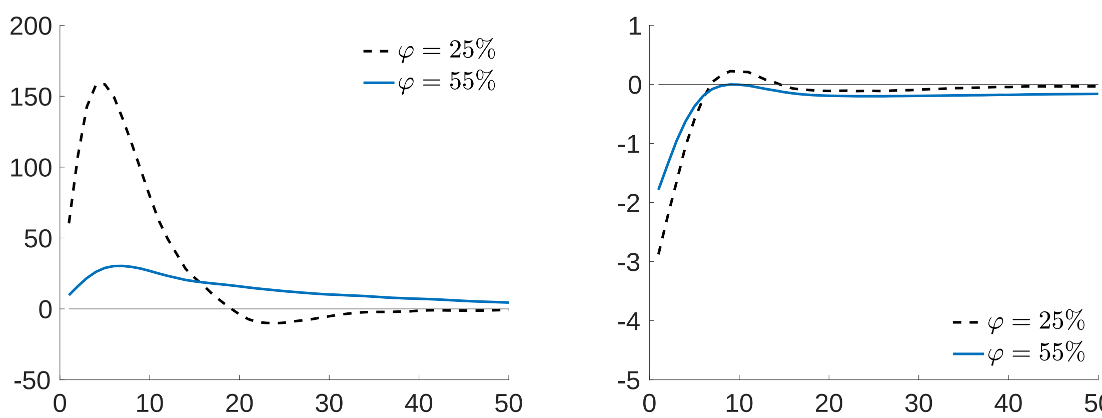
Notes: The figure shows the response of cross-sectional consumption to a positive 1–sd MP shock under low (25%, dashed) and high (55%, solid) participation. Units are percentage deviation from the ergodic steady-state.

FIGURE 6. Higher Participation: From Participant's Consumption to Investment



Notes: The figure depicts the relation between the participant's SDF and investment (see equation (4)). It shows the response of variables to a positive 1–sd MP shock under low (25%, dashed) and high (55%, solid) participation. Units are percentage deviation from the ergodic steady-state.

FIGURE 7. Asset Prices Response to a Contractionary Monetary Policy Shock



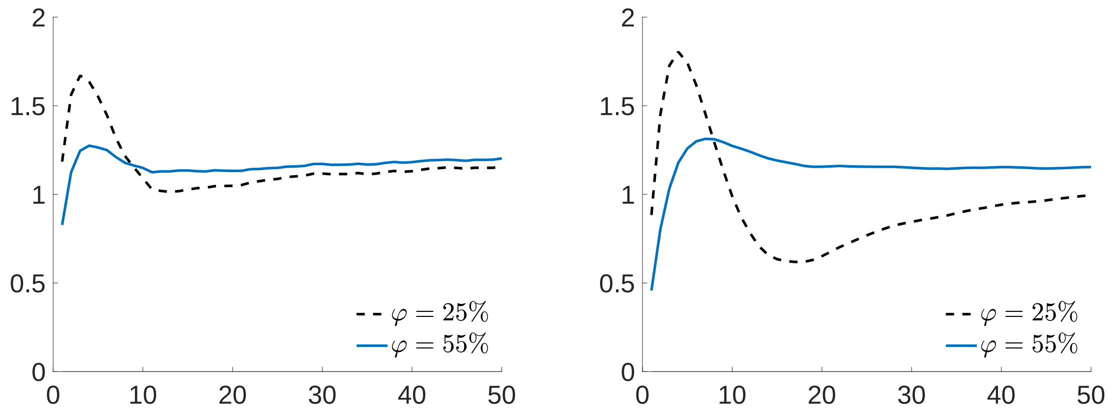
(A) Equity Premia (in anual bps) (B) Price of Equity (in %)

Notes: The figure shows the response of equity premia and of equity price to a positive 1–sd MP shock under two levels of participation (equity is adjusted by λ_d). Responses are deviations from the ergodic steady-state. The dashed line is the response under low participation (25%) and the solid is under high participation (55%).

3.3.2. *Productivity Shocks*

A TFP shock starts by raising firms' productivity. Being profit maximizers, they have incentives to produce more by hiring more labor. Higher production is feasible due to a stronger demand for consumption goods stemming from positive labor income effects on households, as well as an expansion of firms' investment. In addition, the participant observes a rise in cash flows that further expands her consumption.

FIGURE 8. Impulse Response to a Positive TFP Shock



(A) Output (in %)

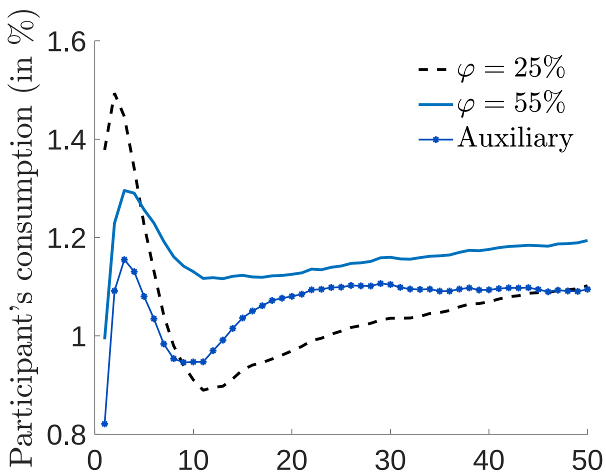
(B) Investment (in %)

Notes: The figure shows the response of output and investment to a positive 1–sd TFP shock under low (25%, dashed) and high (55%, solid) participation. Units are percentage deviation from the ergodic steady-state.

Figure 8 describes the response of non-normalized output and investment to a positive 1–sd productivity shock. Since the expansionary shock is permanent, it has ever lasting effects on output, consumption, and investment. However, its effect on output is *dampened* with higher participation. The key mechanism is that as participation rises, the participant benefits less from the permanent rise in equity cash flows and thus the expansion in consumption is hindered. In equation (10), this appears as a lower exposure to a given rise in the NPV of equity, Q_d. The milder consumption response then translates into a lower rise in future returns on capital and milder incentives to invest, which further dampens the response of aggregate demand.

To better understand the dampening effect, I quantify the direct effects of higher participation by constructing a case in which an auxiliary participant faces the equilibrium prices under low participation, but has the levered exposure to equity a participant would have under high participation. That is, for the auxiliary agent, I set $\varphi = 55\%$ in both the budget constraint and the Euler for bonds. While consumption and borrowing are endogenously chosen by the auxiliary participant, all other variables take the equilibrium path observed under low participation.

FIGURE 9. Partial Equilibrium Effects over Participant's Consumption



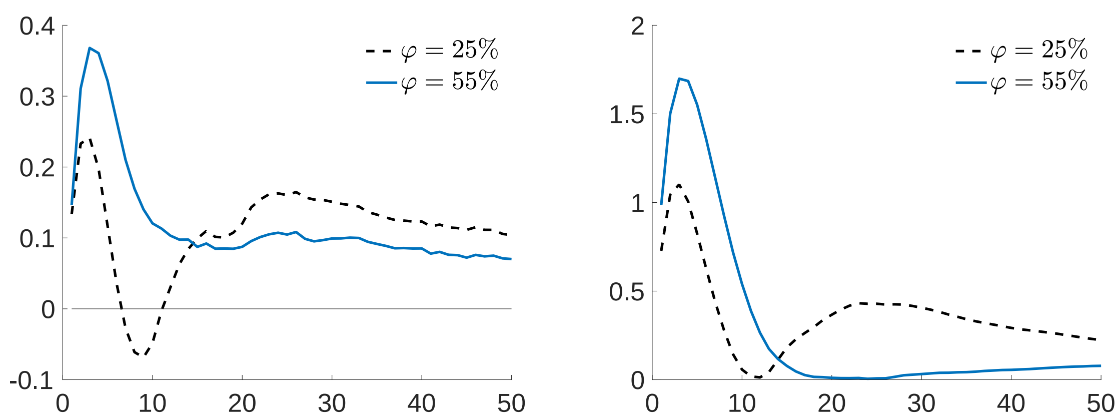
Notes: The figure compares the consumption response of a participant to a 1–sd expansionary TFP shock under different scenarios. The dashed black line is under low participation ($\varphi = 25\%$) and the solid blue line is under high participation ($\varphi = 55\%$). The blue dotted line is the construction of an auxiliary agent that is subject to the equilibrium price under low participation but has the exposure to equity (and leverage) a participant would have under high participation. Units are percentage deviation from the ergodic steady-state.

Figure 9 shows the response of consumption to a 1–sd expansionary TFP shock for the auxiliary agent (dotted blue line) and for the participant under low (dashed black line) and high participation (solid blue line). The difference between the dashed black and dotted blue lines shows that the direct effects of higher participation are large. However, the dampening effect is actually mitigated when moving to the full high-participation case. The reason is that the interest rate imposed by the Taylor rule increases by less when moving from low to high participation.

3.3.3. *Marginal Efficiency of Investment Shocks*

When a firm invests, it uses units of consumption goods to create new capital. A positive MEI shock renders this transformation more efficient by requiring less consumption goods to generate the same amount of productive capital. This creates strong incentives for firms to invest, which expands aggregate demand and induces producers to hire more labor. The rise in labor income also boosts households' consumption, further expanding aggregate demand and output. However, since equity cash flows are net of investment, there also is a crowding out effect on the participant's consumption, which partially offsets the initial expansion in demand. More precisely, the crowding out effects have a negative impact on the participant's SDF, and therefore curbs the rise in $\nu_t \mathcal{Q}_{kt}$ and firms' investment.

FIGURE 10. Impulse Response to a Positive MEI Shock



(A) Output (B) Investment

Notes: The figure shows the response of output and investment to a positive 1–sd MEI shock under low (25%, dashed) and high (55%, solid) participation. Units are percentage deviation from the ergodic steady-state.

Figure 10 presents the response to a positive 1–sd shock to the marginal efficiency of investment. The shock is expansionary and, in contrast to the other two shocks, higher participation has *amplification* effects on output. The mechanism is as follows. As participation rises, the average participant has lower exposure to equity, so that the crowding out effect of investment is milder. In addition, the leverage of the average participant is also lower, so that the borrowing rate becomes less sensitive to changes in borrowing. Combined, these effects imply that the participant's consumption and SDF vary by less, which imply milder fluctuations in the cost of capital and stronger incentives to invest. In Appendix C.2, I show that the direct effects of higher participation on firms' investment are sizeable, as the main drivers for the amplification effects.

3.4. *Unconditional Moments and Limited Participation*

In the previous sections, I analyze the effects of higher participation in the economy, conditional on the realization of different types of shocks. In this section, I provide some insights on the implications of higher participation for a key set of unconditional moments: output volatility, required excess returns, and the volatility of consumption of a participant relative to a nonparticipant.

TABLE 7. Higher Participation and Fall in Volatility

	Model			Data
	$\varphi = 25\%$	$\varphi = 55\%$	% Change	% Change
Output Volatility	2.08	1.48	-28.7%	-28.8%
Equity Premium	4.03	3.62	-10.4%	-12.9%
Rel. Consumption Volatility	1.61	1.24	-23.2%	-26.1%

Notes: The first column shows model unconditional moments when participation is low ($\varphi = 25\%$); the second column when participation is high ($\varphi = 55\%$); the third column shows the resulting percentage variation of model moments; and the fourth column shows the empirical percentage variation. For output volatilty and equity premia, the periods of comparison are 1970q1-1989q4 and 2000q1-2018q4. For relative consumption volatility, the periods are 1984q1-1993q4 and 2003q1-2012q4. See Appendix B.2 for details on the computation of output and consumption, and Appendix D.5 for the computation of excess returns.

Table 7 shows what happens to the set of moments as I increase participation, keeping all other model parameters fixed. In each case, I simulate the model under the full set of structural shocks. The first column shows the model's unconditional moments when participation is low, $\varphi = 25\%$; the second column when participation is high, $\varphi = 55\%$; and the third column shows the resulting percentage variation. The main takeaway is that as participation rises, the volatility of output and the average excess return fall. The reason required excess returns fall is that the consumption process for the participant household becomes relatively less volatile. The third row of Table 7 shows that it falls by 23% relative to the volatility of consumption of the nonparticipant. To obtain a benchmark for the feasibility of these variations, I compute the data counterparts for the periods before and after the rise in participation.[15] Although many factors drive these variables in the US economy, it is reassuring to observe that the model provides realistic fluctuations for them.

4. Empirical Evidence

In this section, I explore the extent to which my model predictions are sustained by empirical evidence. Guided by data availability, I start by providing robust evidence that participant households react differently to MP shocks than nonparticipants. To this end, I use household-level consumption data and well-identified MP shocks, in which the source of variation is individual household participation. I then provide some insights on whether differences in the level of participation affect the response of aggregate consumption and output to MP shocks. Providing evidence on this effect is challenging, since it requires to clearly identify changes in participation in a short period of time. Instead, I present suggestive evidence by exploiting regional variation and time variation in participation rates, using household-level consumption and aggregate time series data, respectively. Being only suggestive evidence, I leave much of the latter work for the appendix.

4.1. *Cross-sectional Response of Consumption*

In order to document the differential response of consumption between a participant and a nonparticipant, I obtain household-level consumption data from the *Consumer Expenditure Survey* (CEX) administered by the Bureau of Labor Statistics (BLS). The CEX is a rotating panel survey that tracks individual households for up to 5 quarters. Interviews are conducted on a monthly basis, but each household is interviewed every 3 months. In each interview, a household provides information about consumption during the 3 months prior to the month of the current interview. On the fifth interview, households also provide information on wealth variables—in particular, whether they hold "stocks, bonds, mutual funds, and other such securities."

I also use the dataset provided by Gertler and Karadi (2015) on well-identified unexpected monetary policy shocks. These shocks are based on surprises in futures within a 30-minute

[15]For output volatilty and equity premia, the periods of comparison are 1970q1-1989q4 and 2000q1-2018q4. For relative consumption volatility, the periods are 1984q1-1993q4 and 2003q1-2012q4. I do not compute consumption after 2012, since the financial variable used for the classification of a participant household is no longer available in posterior surveys. See Appendix B.2 for details on the computation of output and consumption, and Appendix D.5 for the computation of excess returns.

window of the FOMC announcement and aggregated to monthly frequency using appropiate weights.[16] The authors consider two types of shocks, based on different futures contracts. The first, FF1, is the surprise in the current month's fed funds futures. The second, FF4, is the surprise in the 3-month-ahead monthly fed funds futures. In my analysis, I follow a conservative approach and focus on FF1, but I also show that the results are even stronger when using FF4 as the measure of MP shocks.

Given the design of the CEX survey, I construct quarterly variation in real consumption at the household level, using a different wave or set of households for each month. I aggregate monthly monetary policy shocks to quarterly frequency, ending in the month prior to the month of the interview. My classification of a participant household depends on whether the household has positive holdings of "stocks, bonds, mutual funds, and other such securities", or if it made transactions on this category.[17] Even though the SCF survey has a better description of financial wealth at the household level than the CEX, the former is a low-frequency cross-sectional survey and thus is not suitable for analysis of the effects of high-frequency monetary policy shocks. Appendix B.2 details construction of the database.

Next, I describe the benchmark cross-sectional POLS regression. The objective is to capture any cross-sectional difference between participants' and nonparticipants' consumption response to a MP shock. Let i denote a household, k a state, and t the month of the interview. Quarterly consumption variation, $\Delta \ln C_{it}$, and the monetary policy shock, FF_t, are for the 3 months prior to the time of the interview t. Let $\mathcal{I}_i^h$ denote a dummy that equals one if the household participates in equity markets. Then, the interactive dummy $\mathcal{I}_i^h \times FF_t$—the variable of interest—captures the additional response of a participant household's nondurable consumption to an unexpected monetary policy shock. To alleviate concerns about the stronger procyclicality of participants' labor income process, I allow for quarterly variation in the household's annual salary as a control variable. I also include as controls month-year time fixed effects (α_t) and household characteristics: age, education, gender, total income, and family size. I run the following regression for the period 1996m1 to 2007m12:

$$\Delta \ln C_{it} = \alpha_t + \alpha_k + \beta_0 + \beta_1 \mathcal{I}_i^h + \beta_2 FF_t \times \mathcal{I}_i^h + \gamma' X_{it} + \epsilon_{it}, \tag{13}$$

[16]See Gürkaynak, Sack, and Swanson (2005) and Nakamura and Steinsson (2018) for raw time series of the high-frequency shocks.

[17]According to estimates computed from the SCF for 1989-2016, 97% of households that have direct shares of mutual funds are exposed to equity (directly or indirectly). In addition, 86% of households that directly hold bonds (other than US government savings bonds) are exposed to equity.

where X_{it} is a control vector variable that includes variation in annual labor income and household-level characteristics.[18]

TABLE 8. Regression on the Cross-section of Consumption

	(1)	(2)	(3)	(4)
I_{it}^h	2.52***	3.33***	2.50***	2.51***
	(10.01)	(14.16)	(9.91)	(9.35)
$FF_t \times I_{it}^h$	-7.81*	-7.56*	-8.54*	-10.72**
	(-1.92)	(-1.87)	(-2.01)	(-2.53)
State FE	✓	✓	✓	✓
Time FE	✓	✓	✓	✓
HH Controls	✓		✓	✓
$\varphi_{kt} \times FF_t$			✓	
MP Shock	FF1	FF1	FF1	FF4
N	185,115	185,115	185,115	185,115

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Notes: This table shows the effects of a monetary policy shock on an individual household's consumption. The dependent variable is quarterly consumption growth (in pp) for household i. FF_t refers to the MP shock, I_{it}^h is a dummy that equals one if the household is a participant, HH Controls are household-level control variables, and $\varphi_{kt} \times FF_t$ is a variable controlling for state-level participation at the time of the MP shock. FF1 and FF4 are measures for MP shocks; see text for details. Column (1) shows results for baseline regression (13); Column (2) for specification (13), excluding household-level controls; and Column (3) for specification (13), including $\varphi_{kt} \times FF_t$. Standard errors are clustered at the state level, and t-statistics are shown in parentheses. See Appendix B.2 for data details.

A feasible concern is that the results are influenced by general equilibrium effects at the state level. For example, assume there are two states A and B. State A has participation of 5% and state B has participation of 95%. According to my model, these extreme values for participation rates could strongly influence consumption on each state due to GE effects. By

[18]Some households do not report labor income. To control for this, $\gamma' X_{it}$ includes the interactive dummy control variables $\beta_3 \mathcal{I}_{it}^L + \beta_4 \mathcal{I}_{it}^L \times d\ln(LI)_{it}$. This specification allows me to control for respondents vs nonrespondents, and for the intensive margin in variation in labor income.

pooling all observations into one regression, this could affect the point estimates. To mitigate this concern, I interact the state-level participation variable, φ_{kt}, with the MP shock.[19]

Table 8 shows the results of my cross-sectional regressions. Column (1) refers to baseline specification (13) when using FF1 as the measure of MP shock. The point estimate for $FF_t \times \mathcal{I}^h_{it}$ is both economically and statistically significant, suggesting that upon a 1–sd positive monetary policy shock, consumption for a participant household falls by 0.53 pp more than for a nonparticipant.[20] Column (2) shows results for a regression similar to (13) that excludes household-level controls. Column (3) shows results when extending the baseline specification to include the state-level participation interactive variable $\varphi_{kt} \times FF_t$. Either alternative presents estimates of the cross-sectional difference similar to that of the baseline. Column (4) shows results for baseline specification (13) when using FF4 as the measure of MP shock. In this case, the point estimate is larger than the one from Column (1) and statistically significant at 5%.

Appendix D.1 shows four robustness regressions. First, I run a regression similar to the baseline but with year fixed effects instead of time fixed effects. This allows me to include the MP shock FF_t as a regressor and show that consumption falls for both types of households. Second, I interact the participation dummy with an age variable and show that older participants show the strongest response in consumption. This is consistent with this group being more sensitive to fluctuations in the value of their retirement accounts. Third, I show that the effect of limited participation is robust to the introduction of a variable that captures the net value of housing (market value of the house net of mortgage). Fourth, I extend the baseline regression to the period Feb-1990 to Dec-2007 and include lagged consumption growth as an additional regressor. Due to data availability, I cannot construct the same consumption measure prior to 1996. Instead, I construct a reduced measure for the entire period Feb-1990 to Dec-2007, and results remain robust to this change. See Appendix B.2 for details on construction of this alternative measure of consumption.[21]

[19] In an alternative regression, I instead allow for a state-by-shock interactive control variable. Results are similar, so I only present the output for the first case.

[20] Results are also robust to inclusion of the state-level share of manufactures interacted with the MP shock. This serves as a control for state-level procyclicality. In all regressions, s.e. are clustered at the state level.

[21] As additional robustness check, I run event-study regressions using quarterly consumption variation at a monthly frequency for the average participant and the average nonparticipant and obtain results similar to those in the baseline case. I also find that results are economically significant (but not statistically significant) when using quarterly frequency time series of consumption for the average participant and nonparticipant. Either analysis is available upon request.

In Appendix D.2, I document the dynamic response of cross-sectional consumption to the contractionary MP shock by estimating a structural VAR, as in Gertler and Karadi (2015), and computing the impulse responses to a structural monetary shock. The method uses shocks to fed funds futures as instruments, therefore avoiding timing assumptions. The time series for participants' and nonparticipants' consumption are constructed by aggregating CEX household-level consumption data for the period 1984q1 to 2012q4. The analysis suggests that participants have a stronger and more persistent response to the shock than nonparticipants.

4.1.1. *Cross-sectional Regression in the Simulated Model*

In this section, I link the empirical estimates with the model counterpart. To this end, I run the same regression in the simulated model as in the data, and show that the point estimate of the interactive variable $FF_t \times \mathcal{I}_{it}^h$ is also economically significant. In the data, observations on consumption come from markets that differ over their level of participation (i.e., the fraction of participating households varies by year). Furthermore, for each year I have a significant number of different observations of consumption growth per type of household. In order to render the simulated dataset comparable to the empirical counterpart, I simulate economies that differ on the level of participation. These participation rates correspond to my construction from the PSID for the period 1996-2007. For each model economy, I run a simulation of $1,000$ periods and save data on consumption for each type of household and the realized MP shocks.[22] I then construct the variation in consumption at the household level and pool all observations. The specification for the model regression is similar to the empirical counterpart:

$$\Delta \ln C_{it} = \beta_0 + \beta_1 \mathcal{I}_{it}^h + \beta_2 FF_t \times \mathcal{I}_{it}^h + \gamma' X_{kt} + \epsilon_{it}, \tag{14}$$

where X_{kt} is a vector that controls for economy-level FE and its interaction with the MP shock.[23] The point estimate of the variable of interest, β_2, indicates that a 1–sd MP shock induces a fall in the participant's consumption that is 0.28 pp higher than that of a nonparticipant. This result confirms that the model is able to replicate the differential consumption response between a participant and a nonparticipant household. Note that this model estimate could potentially be higher if I assumed a higher IES for the participant relative to the nonparticipant. Although Guvenen (2009) focuses on TFP shocks, he shows that when moving from

[22] I simulate a long period in order to obtain the stochastic steady-state. This also allows me to obtain a large number of different observations for a participant and a nonparticipant, as I have in the data.

[23] I also run a regression substituting economy-level FE for the participation level and the results are the same. Also, note that since labor income is homogeneous across households (given the participation level), the effects of its variation is captured by the interactive variable.

heterogeneous to homogeneous IES, the relative volatility of consumption between a participant and a nonparticipant household falls significantly.

TABLE 9. Participant Excess Consumption Response: Model and Data

	Model	Data
Differential consumption response to a MP shock	-0.28	-0.53

Notes: The table presents the response of consumption (in pp) to a 1–sd contractionary MP shock. The first column shows the estimate of $\beta_2 \times sd(FF)$ from specification (14) on model-simulated data with OLS esimtation. The second column reports the empirical counterpart derived from column (3) of Table 8.

4.2. *Response of Aggregate Consumption*

The purpose of this section is to document any sort of general equilibrium effect of changes in the participation rate that may affect the transmission of monetary policy shocks to the economy. Recall the logic implied by the model: Higher participation implies that aggregate risk is shared among a larger pool of households so that, in equilibrium, average consumption falls by less. Capturing these effects is challenging since it requires well-identified changes in participation in a short period of time. Instead, my strategy is to try various approaches that exploit regional variation and time variation in participation rates, and observe whether empirical results are aligned with the model's prediction. As such, the following results should be taken as interesting insights rather than robust empirical evidence.

In the regional variation analysis, the source of variation is the participation rate at the US state level. To carry out this analysis, I merge the dataset used in the previous section with state-level participation rates constructed using data from the *Panel Study of Income Dynamics* (PSID). Appendix B.2 describes in detail my computation of participation rates at the state level from 1994 to 2007, and Appendix D.3.1 shows that there is large heterogeneity of participation rates across states. The assumption behind the next regression is that a US state is a closed economy, since this is the direct mapping with my model assumptions.[24]

[24]What I am ultimately after is for higher participation at the state level to be associated with smaller per capita exposure to equity. Any departure from perfectly integrated markets that has this feature will work—e.g., home bias in portfolios or local informational advantages (which could endogenously lead to home bias). Using data from the PSID, I find that there is a −20% correlation between participation rate and per capita equity holding value. This correlation was −45% in 2005.

For this regression, I sort states by their yearly level of participation. The variable of interest is $FF_t \times \mathcal{I}_{kt}^{HP}$, an interactive dummy that indicates differential effects of an MP shock on regions with high vs. low participation. The threshold is defined as the 20$^{\text{th}}$ percentile at a given year, and thus is time-varying. The dummy $\mathcal{I}_{kt}^{HP}$ takes a value of one if the participation rate for state k is above that year's threshold and zero otherwise. On average, the threshold is half a standard deviation below the respective year's mean. The regression specification is given by

$$\Delta \ln C_{it} = \alpha_t + \alpha_k + \beta_0 + \beta_1 \mathcal{I}_{kt}^{HP} + \beta_2 \mathcal{I}_{kt}^{HP} \times FF_t + \text{controls} + \epsilon_{it}, \tag{15}$$

where α_t are time FE and α_k are state FE. The control variables considered are labor income variation; household-level characteristics; state-level share of manufactures over total private production, interacted with FF_t, to control for a more procyclical output at the state level; state-by-year FE; region-by-year FE, where a region corresponds to the US Census regional classification of states; and region-by-time FE.

Table 10 shows the results of the regression. Column (1) has no controls except for state and time fixed effects. Column (2) adds labor income variation, household-level characteristics, and share of manufactures as controls. Column (3) also allows for state-by-year FE, alleviating endogeneity concerns. Column (4) has region-by-shock FE, and column (5) has region-by-time FE. The table shows that the point estimate for the variable of interest, $FF_t \times \mathcal{I}_{kt}^{HP}$, is statistically significant for all specifications. It is also economically significant: Upon a 1–sd MP shock, regions with high participation have between 0.50 and 0.66 percentage points milder fall in consumption than regions with low participation.

In Appendix D.3.1, I show the results of a similar regression but use one-year-lagged participation rates instead of contemporaneous. Point estimates are similar but less precise when the full set of controls is included. I also extend the benchmark regression by constructing time-varying quintiles of participation in substitute for the dichotomic threshold, and results still hold.

In Appendix D.4, I also carry out a time-variation analysis in which I compare the response of the economy to MP shocks in a period with low participation against a period with high participation. I use two methods to identify MP shocks. The first is a structural VAR estimation, as in Gertler and Karadi (2015), and the second is a traditional reduced-form VAR estimation, as in Christiano et al. (2005), which requires a Cholesky decomposition. In both cases, I compute the empirical impulse response of industrial production to a positive MP shock and find a milder response of output after the 1990s. For proper comparison, shocks are adjusted so that the policy rate rises by the same amount on impact in both samples. Although several factors might have contributed to this finding, it is reassuring that the model's predictions point in the same direction.

Table 10. Regression on the Role of Participation Rate

	(1)	(2)	(3)	(4)	(5)
I_{kt}^{HP}	-0.07	0.11	0.44	0.12	0.13
	(-0.29)	(0.34)	(0.94)	(0.39)	(0.29)
$FF_t \times I_{kt}^{HP}$	7.30**	8.42**	9.66**	7.67*	9.15*
	(2.23)	(2.04)	(2.20)	(1.87)	(1.94)
State FE	✓	✓	✓	✓	✓
Time FE	✓	✓	✓	✓	✓
Controls		✓	✓	✓	✓
State-by-Year			✓		
Region-by-FF_t				✓	
Region-by-Time					✓
N	185,115	185,115	185,115	185,115	185,115

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Notes: The dummy $\mathcal{I}_{kt}^{HP}$ takes a value of one if the participation rate for state k is above that year's threshold and zero otherwise. The threshold is defined as the 20$^{\text{th}}$ percentile over participation rates in a given year. FF_t is the MP shock. Controls include quarterly variation in real annual labor income, household-level characteristics, and state-level share of manufactures interacted with FF_t. Region corresponds to the US Census regional classification of states. Standard errors are clustered at the state level and t-statistics are shown in parentheses. See Appendix B.2 for data details.

5. Conclusion

In this paper, I examine the role of limited participation in equity markets for business cycle dynamics and asset prices. I do so by building a model of the US economy where only a fraction of households has access to equity markets. I calibrate the model to jointly match business cycle and asset pricing moments. In the model, participants are relatively more responsive to MP shocks due to their higher exposure to aggregate risk. I produce new empirical evidence that this is the case using micro-level data and well-identified monetary policy shocks.

My model also provides important insights on the effects of higher participation. As the fraction of households participating in equity markets increases, the same amount of aggregate risk is spread over a larger set of households, so that participants' per capita exposure to risk falls and their consumption becomes less volatile. In addition, since participants own firms, a less responsive consumption profile translates into milder fluctuations in investment and asset prices. These mechanisms imply that higher participation reduces the effectiveness of monetary policy but that the economy also becomes less volatile.

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Appendix A. Theoretical Framework: Further Details

A.1. *Full Set of Equilibrium Equations*

Aggregate Equations

$$\hat{Y}_t = g_{zt}^{1-\alpha}\hat{K}_t^{\alpha}L_t^{1-\alpha}$$

$$\hat{w}_t\Pi_{pt}g_{zt-1} = \hat{w}_{t-1}\Pi_{w,t}$$

$$\hat{d} = \hat{Y}_t - \hat{w}_tL_t - \hat{I}_t - \frac{\xi_p}{2}\left(\Pi_t - 1\right)^2\hat{Y}_t$$

$$\hat{K}_{t+1}g_{zt} = \left(1-\delta\right)\hat{K}_t + \upsilon_t\left(1 - \Phi\left(\frac{\hat{I}_t}{\hat{I}_{t-1}}g_{zt-1}\right)\right)\hat{I}_t$$

Household Equations

$$\lambda_{it} = \left(\hat{c}_{it} - \vartheta_0\frac{L_t^{1+\vartheta}}{1+\vartheta}\right)^{-\rho}$$

$$\hat{V}_{it} = \left\{\left(1-\beta\right)\left(\hat{c}_{it} - \vartheta_0\frac{L^{1+\vartheta}}{1+\vartheta}\right)^{1-\rho} + \beta g_{zt}^{1-\rho}\hat{R}_{Vit}^{\frac{1-\rho}{1-\gamma}}\right\}^{\frac{1}{1-\rho}}$$

$$\hat{R}_{Vit} = E_t\left(\hat{V}_{it+1}^{1-\gamma}\right)$$

$$\Lambda_{it,t+1} = \beta\frac{\hat{\lambda}_{it+1}}{\hat{\lambda}_{it}}g_{zt}^{-\rho}\left(\frac{\hat{V}_{it+1}}{\hat{R}_{Vit}^{\frac{1}{1-\gamma}}}\right)^{\rho-\gamma}$$

$$\hat{c}_{npt} = \frac{1}{\Pi_t}\frac{\hat{b}_t}{P_{t-1}}R_{t-1} + \hat{w}_tL_t + \hat{T}_t - \frac{\hat{b}_{t+1}}{P_t}e^{\epsilon_{zt}} - \frac{\xi_w}{2}L_t\left(\Pi_{wt}-1\right)^2$$

$$\frac{\theta_w}{\theta_w - 1}\vartheta_0L_t^{\vartheta} = \hat{w}_t + \frac{1}{\theta_w - 1}\xi_w\left(\Pi_{wt}-1\right)\Pi_{wt}$$

Intermediate Producers' Equations

$$\mathcal{Q}_{kt} = \mathbb{E}_t\hat{\Lambda}_{pt+1}\left\{\frac{\alpha}{1-\alpha}\hat{w}_{t+1}\frac{L_{t+1}}{\hat{K}_{t+1}} + \mathcal{Q}_{kt+1}\left(1-\delta\right)\right\}$$

$$1 = \upsilon_t\mathcal{Q}_{kt}\left[1 - \Phi\left(\frac{\hat{I}_t}{\hat{I}_{t-1}}g_{zt-1}\right) - \Phi'\left(\frac{\hat{I}_t}{\hat{I}_{t-1}}g_{zt-1}\right)\frac{\hat{I}_t}{\hat{I}_{t-1}}g_{zt-1}\right] + \mathbb{E}_t\hat{\Lambda}_{pt+1}\mathcal{Q}_{kt+1}\upsilon_{t+1}\Phi'\left(\frac{\hat{I}_{t+1}}{\hat{I}_t}g_{zt}\right)\left(\frac{\hat{I}_{t+1}}{\hat{I}_t}g_{zt}\right)^2$$

Retailers' Equations

$$\text{mc}_t = \frac{1}{1-\alpha} w_t \frac{L_t}{\bar{Y}_t}$$

$$\xi_p \left(\Pi_{pt} - 1\right) \hat{Y}_t \Pi_{pt} + (\theta - 1) \hat{Y}_t = \theta \text{mc}_{jt} \hat{Y}_t + \mathbb{E}_t \hat{\Lambda}_{pt,t+1} \xi_p \left(\Pi_{pt+1} - 1\right) \hat{Y}_{t+1} \Pi_{pt+1} g_{zt}$$

Euler Equations

$$\begin{aligned}
R_{bt} &= R_t + \psi \left(e^{\left(\frac{1-\varphi}{\varphi}\frac{\hat{b}_{t+1}}{P_t} - \bar{D}\right)} - 1 \right) \\
1 &= E_t \left[\hat{\Lambda}_{npt,t+1} \frac{R_{bt}}{\Pi_{t+1}} \right] \\
1 - \hat{\Psi}'_{Dt} &= E_t \left[\hat{\Lambda}_{pt,t+1} \frac{1}{\Pi_{t+1}} \left(R_{bt} \left(\hat{D}_{t+1}\right) + \frac{\hat{D}_{t+1}}{P_t} \psi e^{\left(\frac{\hat{D}_{t+1}}{P_t} - \bar{D}\right)} \right) \right] \\
\hat{Q}_{d,t} &= E_t \left[\Lambda_{pt,t+1} \left(\hat{Q}_{d,t+1} + \hat{d}_{t+1} \right) e^{\epsilon_{zt+1}} \right]
\end{aligned}$$

Taylor Rule

$$R_{b,t} = R_{b*} \left(\frac{R_{b,t-1}}{R_{b*}} \right)^{\mu_R} \left[\left(\frac{\Pi_t}{\Pi_*} \right)^{\phi_\pi} \left(\frac{\hat{Y}_t}{\hat{Y}_t^f} \right)^{\phi_y} \right]^{1-\mu_R} e^{\eta_{R,t}}$$

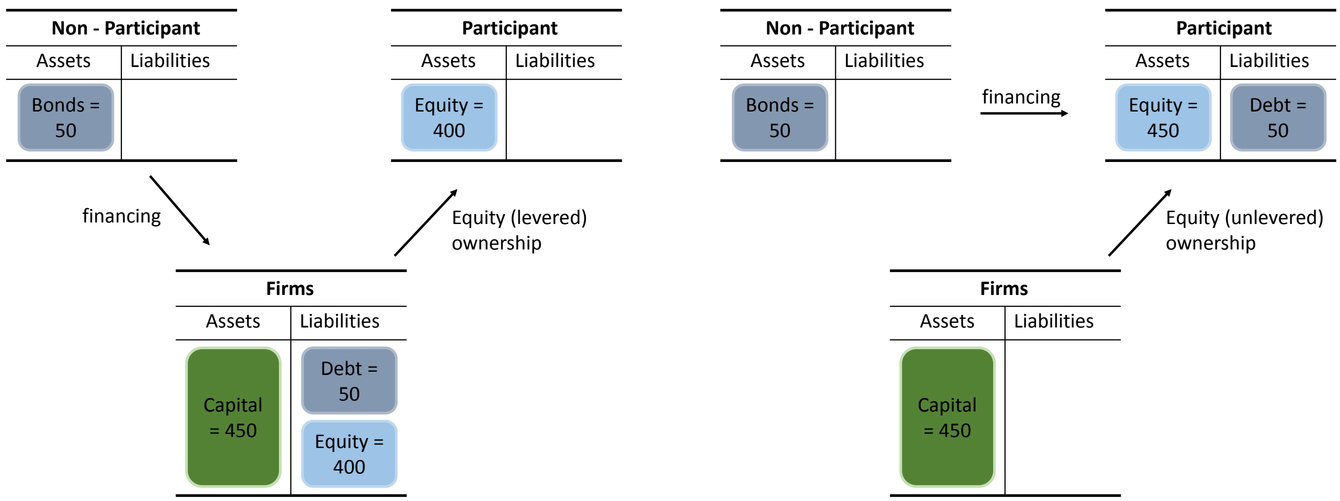
Market Clearing

$$\begin{aligned}
\hat{C}_t &= \varphi \hat{c}_{p,t} + (1-\varphi) \hat{c}_{np,t} \\
\hat{Y}_t &= \hat{C}_t + \hat{I}_t + \varphi \hat{\Psi} \left(\hat{D}_{t+1}\right) + \frac{\xi_w}{2} L_t \left(\Pi_{wt} - 1\right)^2 + \frac{\xi_p}{2} \hat{Y}_t \left(\Pi_{pt} - 1\right)^2 \\
\hat{T}_t &= (1-\varphi) \frac{\hat{b}_t}{P_{t-1}} \frac{1}{\Pi_t} \left[R_{bt-1} \left(\hat{D}_t\right) - R_{t-1} \right]
\end{aligned}$$

A.2. *Balance Sheets and Levered Equity*

In what follows, I elaborate on my model choice of unlevered firms and relative net financial wealth as a target. Appendix Figure A1a shows the balance sheet structure in an economy with levered claims. Nonparticipant households have net financial savings in risk-free bonds that are used by firms as a source of financing. Firms' net financial wealth or equity is given by their gross value of assets minus the debt incurred with nonparticipant households. Participant households' net financial savings consist of the value of the claim on firms. Appendix Figure A1b shows an equivalent structure in which firms are not levered, but participants are. Even though the leverage ratio of the participant differs across economies, the ratio of net financial wealth between a participant and a nonparticipant remains exactly the same.

FIGURE A1. Balance Sheets of Sectors in the Economy



(A) Levered Equity (B) Unlevered Equity

Even though the structure represented in Appendix Figure A1a is a better representation of reality, my model provides a clear mapping between that structure and the one I assume. In particular, I can link the leverage ratio to the ratio of net financial wealth, which would then be the proper target to summarize the economy's balance sheets. In the model, leverage is given by

$$\frac{D}{NFW} = \frac{(1-\varphi)b}{Q_d}.$$

Subtracting unity on both sides, and multiplying and dividing by $\frac{1-\varphi}{\varphi}$, I get

$$\frac{D}{NFW} - 1 = \frac{1-\varphi}{\varphi}\frac{Q_d - (1-\varphi)b}{(1-\varphi)b}\frac{\varphi}{1-\varphi}$$

$$\frac{D}{NFW} - 1 = \frac{\frac{Q_d}{\varphi} - \frac{(1-\varphi)}{\varphi}b}{b}\frac{\varphi}{1-\varphi}.$$

Therefore,

$$\frac{1-\varphi}{\varphi}\left[\frac{D}{NFW}-1\right]=\frac{NFW_p}{NFW_{np}},$$

where $NFW_p \equiv \frac{Q_d}{\varphi} - \frac{(1-\varphi)}{\varphi}b$ is the net financial wealth of an average participant household and $NFW_{np} \equiv b$ is that for an average nonparticipant household. I can directly compute these variables from the data provided by the SCF.

Appendix B. Description of Data Sources and Empirical Variables

B.1. *Data Sources*

In this section, I begin by describing the different datasets used in this paper and then detail how the relevant variables were computed.

Survey of Consumer Finances (SCF). This is a triennial cross-sectional survey for US households available since 1983, administered by the Federal Reserve Board. It contains detailed wealth information at the household level. I use it to construct the observed measure of participation in equity markets, and also to compute the relative net financial wealth ratio used as a target moment for the model.

Consumer Expenditure Survey (CEX). This is an annual rotating panel survey for US households administered by the Bureau of Labor Statistics, available in Stata format since 1984. Interviews are conducted on a monthly basis, but each household is interviewed every 3 months, up to five times. On each interview, a household provides information about consumption during the 3 months prior to the month of the current interview. On the fifth interview, households also provide information on wealth variables—in particular, whether they hold "stocks, bonds, mutual funds, and other such securities." I construct consumption, participation, and labor income variables from this database.

Panel Study of Income Dynamics (PSID).[25] This is a longitudinal household survey administered by the Institute for Social Research since 1968. The first time a wealth section was included on the survey was in 1984. This section was included every 5 years until 1999. Since then, wealth questions are asked every 2 years. This survey allows me to identify each household by its state of residence at the time of the interview.

[25]Panel Study of Income Dynamics, public use dataset. Produced and distributed by the Institute for Social Research, University of Michigan, Ann Arbor, MI (year data were downloaded).

Other sources. Consumption and investment are obtained from NIPA Table 1.1.6. The price deflator for nondurables is gathered from NIPA Table 1.1.9. Data on the nonfinancial corporate sector (NFCS) are from NIPA Table 1.14 and the debt to net worth ratio is taken from FRED series NCBCMDPNWMV. The risk-free rate and return on equity are obtained from the CRSP.[26]

B.2. *Empirical Variables*

Consumption of nondurables. In the CEX, consumption is divided between the fraction that occurred during the quarter prior to the month of the interview (pq), and the fraction that occured during the current quarter (cq). For instance, in an interview carried out on May, "pq" has consumption for February and March, while "cq" has that for April. This facilitates calendar aggregation. However, on the regressions I use the sum of the two (pq+cq), since I do not make any calendar aggregation. I focus on nondurables consumption, defined as food, alcohol and beverages, apparel, gas and oil, public transportation, maintenance and repairs, vehicle rental, personal care, reading, tobacco, cash contributions, and miscellanea.[27] The latter two were included because they contain nondurable items, and regression results are robust to their exclusion. I then construct real consumption using the price index for nondurables. Each household provides information five times at most. This means that I have at most four observations of quarterly variation of consumption per household, so I cannot run a regression with household-level fixed characteristics. Each quarterly variation in consumption (up to the month prior to the interview) is a data point for the regression. There is a different set of households in each month, which allows for a significant number of observations. In the paper, I also use a reduced version of nondurables that allows me to obtain panel data on consumption starting from 1984. This measure is similar to the benchmark one, but excludes maintenance and repairs, vehicle rental, and miscellanea. This reduced version of consumption is used to compute the relative volatility of consumption between a participant and a nonparticipant presented in Tables 4 and 7. It is also used for the regression shown in Appendix Table D4.

Net value of housing. One of the robustness regressions requires computation of the net value of housing. This is a household's total market value of property ("propvalx") minus the principal balance outstanding on mortgages ("qblncm1x," "qblncm2x," "qblncm3x").

[26] Center for Research in Security Prices, CRSP US Stock Database, Wharton Research Data Services, http://www.whartonwrds.com/datasets/crsp/.

[27] Cash contributions include items such as alimony, child support, and contributions to charities. Miscellanea includes, e.g., membership fees.

Measures of Participation. The SCF provides the right set of variables to construct a measure of participation in equity markets. The summary variable is "equity" and includes directly held stocks, stock mutual funds, IRAs/Keoghs invested in stock, other managed assets with equity interest, thrift-type retirement accounts invested in stock, and savings accounts classified as 529 or other accounts that may be invested in stocks. The summary variable "equity" is available starting in 1989. I consider a household to be a participant if it has a positive (and nonmissing) value for that variable. The resulting participation rate appears in Appendix Figure B3. For 1983 and 1986, the SCF database is of lesser quality for this purpose, since it contains the variable "stocks and mutual funds" or "IRA and Keogh accounts," but there is no clear way to construct overall equity holdings for that period. Therefore, I constructed a version of participation using "stocks and mutual funds" and a broader one that uses both[28]. The average participation rate for 1983-1989 is 23.3% when I use the narrow version, and 32.1% when I use the broader version. Note that retirement accounts became popular in the 1990s. For comparison, I estimate participation from PSID data for 1984 to be 24.8%[29].

For the classification of a participant household, I use financial variables provided by the CEX. I build two alternative measures, both based on the CEX's asset classification: securities, such as "stocks, mutual funds, private bonds, government bonds or Treasury notes". This is the closest variable to equity that the CEX provides for the 1990s and 2000s. In the narrow version, I consider a household to be a participant if it satisfies any of the following three conditions: (i) declares having the same amount as the "last day of (last month, one year ago)" [compsec=1] and it also has positive (and nonmissing) amounts of the variable "on the last day of (last month)" (secestx>0); (ii) the amount has decreased [compsec=3]; or (iii) the amount has increased [compsec=2]. For the broad version, I also observe whether the household reports a positive selling [sellsecx] or buying [purssecx] price for the security during the past 12 months. These two constructions provide very similar participation rates, so I perform all of my analysis using the broader version.

To obtain a more accurate measure of the state-level participation rate than that from the CEX, I construct a measure based on the PSID. This variable is used for the state-level variation analysis detailed in Section 4.2 of the paper. The PSID dataset allows me to construct a state-level measure of participation every 2 years for the period 1999-2007, and then also for the year

[28] The data published for 1986 can also be used to construct 1983 measures. The FRB offers the respective weights to do so: "FRB 1986 WEIGHT #2" [C1014] and "FRB 1983/86 WEIGHT #1" [C1015].

[29] This figure is slightly below the 27.6% estimated by Mankiw and Zeldes (1991), since they have a sample that is almost half the size I used.

1994. For each state, I linearly interpolate the participation rate to get a yearly frequency time series. My classification of a participant household using PSID data is similar to the one using SCF data. In particular, I identify a household as a participant if she "owns a non-IRA stock" or if she owns an "IRA/Private annuity" that is "mostly stocks" or "split" between stocks and "interest earning." I then link each household to her state of current residence, and use population weights to compute participation by state and year. Appendix Figure B4a shows that when compared with the SCF, participation rates at the national level differ in level but the dynamics are similar for this period.[30] For the year 1994, I would only be able to compute participation rates using the variable "owns a non-IRA stock." Since this would give me a lower level of participation, I instead use this as a measure of cross-sectional dispersion across states and adjust the mean based on the variation between 1999 and 1994 observed in the SCF.

Monetary policy shocks. My measure of monetary policy shocks is based on the time series provided by Gertler and Karadi (2015). As is standard in the literature, these shocks are based on changes in fed funds futures measured within a 30-minute window around FOMC announcements; see, for example, Gürkaynak, Sack, and Swanson (2005) and Nakamura and Steinsson (2018). The authors then aggregate these shocks to monthly frequency, using weights that account for the relevance each shock has within a month. Furthermore, the authors provide two possible measures of shocks, based on different futures contracts. The first, FF1, is the surprise in the current month's federal funds futures. The second, FF4, is the surprise in the 3-month-ahead monthly fed funds futures.

My empirical analysis using micro-level data, detailed in Sections 4.1 and 4.2 of the paper, is based on the FF1 measure.[31] Since my dependent variable is the quarterly variation in consumption, I aggregate the FF1 monthly shock to a quarterly shock, using weights proportional to the influence each shock could have on that quarter's consumption growth. For example, for the 3 months ending in March, the January shock has a weight of unity, the February shock has weight of 2/3 and the March shock has a weight of 1/3. Results are robust to unweighted shocks, and are available upon request.

Relative Net Financial Wealth. The data source is the SCF. For the period 1989-2016, I define net financial wealth (NFW) for a household as my construction of financial assets minus financial liabilities. Financial assets are taken as defined by the SCF, ranging from bank

[30]The average participation rate for the 1999-2007 period is 36% according to my construction from the PSID, compared to 52% on my construction from the SCF.

[31]Results are robust to using the FF4 measure and are available upon request.

deposits to managed accounts and excluding business ownership. I define financial liabilities as the sum of credit card balances after the last payment [CCBAL], installment loans [INSTALL], other lines of credit [OTHLOC], and other debt [ODEBT]. Note that assets and liabilities exclude housing and mortgages, respectively. Using the classification of participant household, I then construct the ratio of average NFW for a participant over the average NFW for a nonparticipant. Averages are constructed using the population weights. For the period 1983-1986, I follow a similar logic, although names and partial composition of the variables have changed. Financial assets are "Total paper assets" [c1445, c1446] and financial liabilities are "Total other debt" [c1453, c1454]. The participant's leverage ratio in Table 5 is computed as $(\xi \times Equity_p + Debt_p)/NFW_p$, where ξ is the debt to net worth ratio of the NFCS (see *Other sources*), and $Equity_p$, $Debt_p$, and NFW_p are equity, financial liabilitites, and net financial wealth of the average participant, respectively.

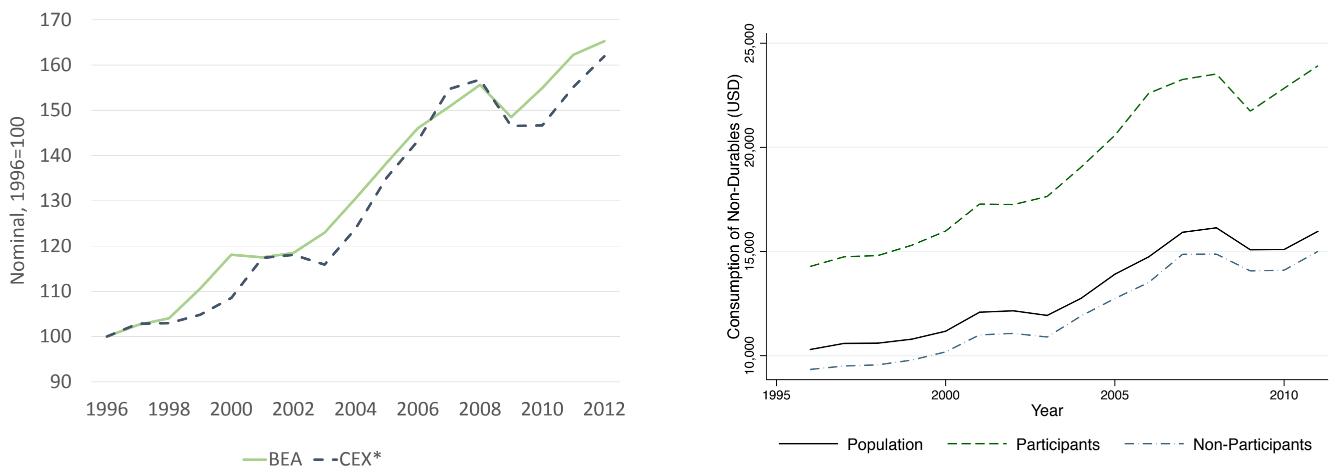
Target moments. All targrted moments are computed for 1970-1980. I define output to be the sum of consumption and investment. The former is personal consumption expenditure and the latter is fixed capital formation, both obtained from NIPA tables. Investment is only available quarterly in levels since Mar-02, so I merge that series with a real index of fixed capital formation, also from NIPA tables. I compute the average quarterly ratio as a target. I also apply the Hodrick-Prescott filter (smoothing = 1,600) to obtain the cyclical components, and compute the volatility of output and relative volatility of investment. For equity premia, I obtain value-weighted monthly returns from the CRSP (vwretd) and monthly returns from the 90-day T-bill (t90ret). I compute the difference in these two series each month, accummulate for the last 12 months, and take the data in December of each year. I then take the average for every December for 1970-1989. The correlation between earnings and output is computed using earnings from the nonfinancial corporate sector. Earnings are the sum of profits after tax (W328RC) and taxes and interest (B465RC + W325RC + B471RC + W327RC) from NIPA tables. I use the implicit deflator for the NVA of the nonfinancial corporate sector to deflate the series, and then compute their HP cycles. I then compute the (quarterly) correlation between the cycle of earnings and the cycle of output (as computed above). Equity payouts from the nonfinancial corporate sector are constructed as in Greenwald, Lettau, and Ludvigson (2019). These are net dividends plus net equity repurchases as obtained from the Flow of Funds ($FA103164103 - FA106121075$). This series is deflated, and I take use log HP cycle to compute the relative volatility.

B.3. *Time Series for the Empirical Analysis*

B.3.1. *Time Series for Consumption*

In Appendix Figure B1a, I compare my construction of nominal consumption of nondurables using CEX data with that provided by the BEA. The figure shows that the evolution between the two variables is similar, even if the levels may differ.[32] Appendix Figure B1b shows consumption for an average participant household vs. a nonparticipant.

FIGURE B1. Consumption of Nondurables (Nominal)



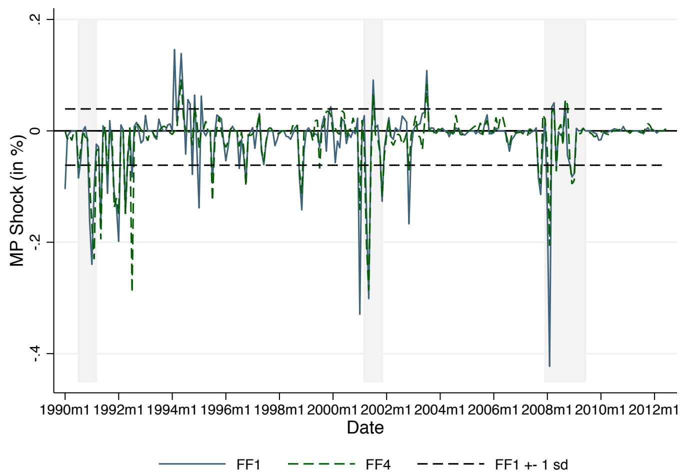
(A) CEX vs. BEA (B) Participant vs. NonParticipant

Notes: The left panel compares my construction of nominal nondurable consumption—based on the CEX—with the one provided by the BEA. See Appendix B.1 for a description of data sources. The right panel compares consumption between participant and nonparticipant households. See Appendix B.2 for details.

[32]The BLS shows that for the period 1992 to 2005, nondurables from the CEX are between 61% and 69% of that provided by the BEA. See https://www.bls.gov/cex/twoyear/200405/csxpce.pdf.

B.3.2. *Time Series for Monetary Policy Shocks*

FIGURE B2. Monetary Policy Shocks - Monthly



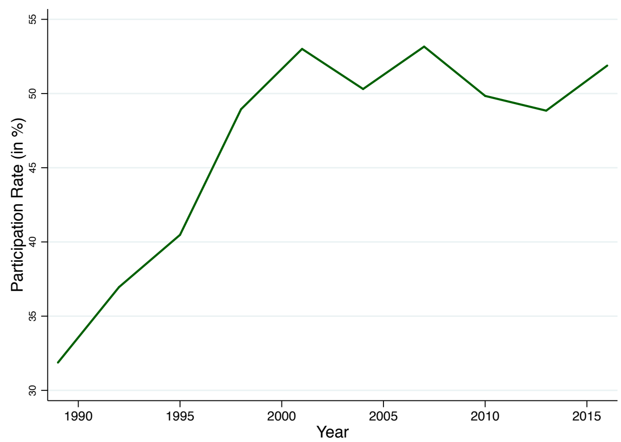
Notes: This figure shows the monthly time series for MP shocks obtained from Gertler and Karadi (2015). The gray areas are periods of recession. The dashed lines represent the mean $\pm 1sd$. FF1 refers to the surprise in the current federal funds futures rate, while FF4 is the surprise in the 3-month ahead-futures rate.

Appendix Figure B2 has the MP shocks at a monthly frequency, as constructed by Gertler and Karadi (2015). The gray areas are periods of recession. Dashed lines represent the mean $\pm 1sd$. FF1 refers to the surprise in the current federal funds futures rate, while FF4 is the surprise in the 3-month-ahead futures rate. Their correlation is 78.5%, with FF1 usually being of bigger magnitude.

B.3.3. *Time Series of Participation in Equity Markets*

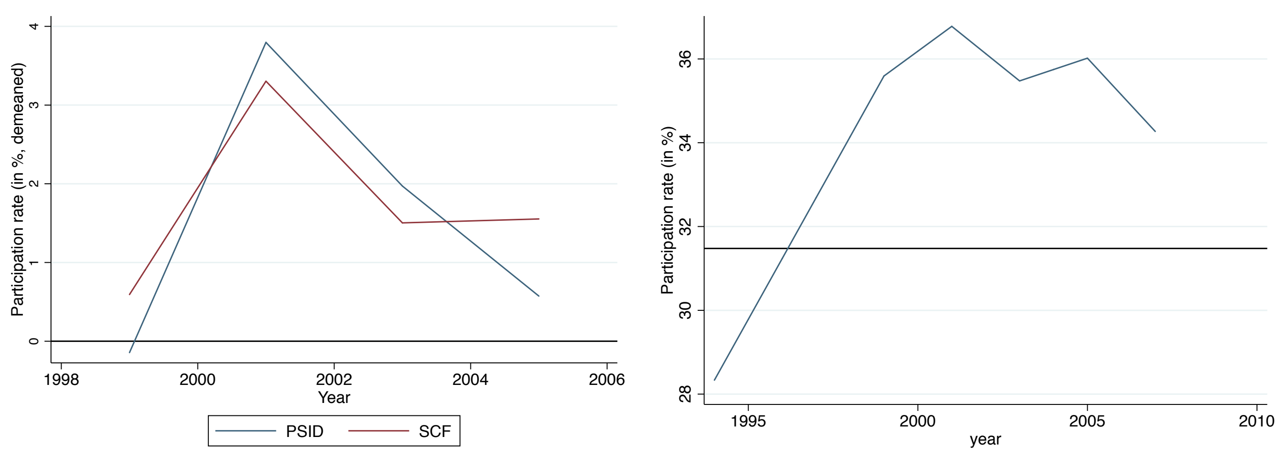
Appendix B.2 explains in detail the construction of the different measures for participation in equity markets. In what follows, I present the results of these estimates. Appendix Figure B3 shows participation rates using data from the SCF. The effects of the popularization of the 401K/IRA accounts are evident during the 1990s, with a posterior convergence during the 2000s.

Figure B3. Participation rate in the US (SCF)



Notes: This figure shows the fraction of US households with equity holdings (direct or indirect). Source: SCF. See Appendix B.2 for details.

Figure B4. Participation Rate Based on the PSID



(A) SCF vs. PSID

(B) Participation Rate PSID

Notes: The left panel compares the participation rate constructed from the SCF with that from the PSID. Variables are demeaned. The right panel shows the participation rate constructed using PSID data. The variation between 1994 and 1999 was imputed using data from the SCF. See Appendix B.2 for details.

Appendix Figure B4 shows the participation rate constructed from PSID data. The left panel compares the (demeaned) construction from the PSID withat that of SCF. The dynamics are similar, so I used SCF dynamics between 1994 and 1999 to extrapolate the average participation rate for the PSID for 1994. Results are shown in the right panel.

Appendix C. Quantitative Analysis and Robustness

C.1. *Decomposition of the Price of Equity*

I follow the decomposition by Campbell and Shiller (1988), in which current return on equity responds to variations in future cash flows, real rates, and excess returns. From the definition of return on equity $R_{dt+1} = (Q_{dt+1} + D_{t+1}/Q_{dt})$, we can approximate log return (r_{dt}) as

$$r_{dt+1} = k_0 + \rho q_{dt+1} - q_{dt} + (1-\rho)\ln d_{t+1},$$

where $q_{dt} = \ln Q_{dt}$, and $\rho \equiv 1/(1+\exp(\bar{d} - \bar{q}_d))$ and $k_0 \equiv -\ln\rho + (1-\rho)\ln(1/\rho - 1)$, with $\bar{d}$ and $\bar{q}_d$ being time averages. After some algebraic manipulation we can obtain an equation that links changes in expected excess returns with future cash flows, future real rates, and future excess returns

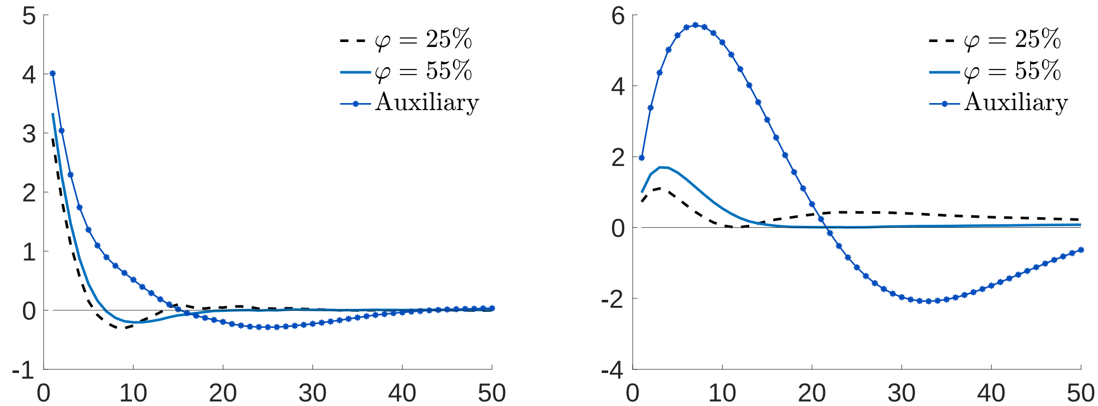
$$\underbrace{e^r_{t+1} - E_t e^r_{t+1}}_{=\tilde{e}_{t+1}} = (E_{t+1} - E_t)\left\{\underbrace{\sum_{j=0}^{\infty}\rho^j \Delta d_{t+1+j}}_{=\tilde{e}_{d,t+1}} - \underbrace{\sum_{j=0}^{\infty}\rho^j r_{t+1+j}}_{=\tilde{e}_{r,t+1}} - \underbrace{\sum_{j=0}^{\infty}\rho^j e_{t+1+j}}_{=\tilde{e}_{e,t+1}}\right\} \tag{16}$$

so that $\tilde{e}_{t+1} = \tilde{e}_{d,t+1} - \tilde{e}_{r,t+1} - \tilde{e}_{e,t+1}$. To make the analysis comparable to previous empirical work, I follow Campbell and Ammer (1993) and compute the expectations by means of a VAR(p). Table 6 presents the implied unconditional variance decomposition, for both the model and the data. For the empirical decomposition, I focus on the period 1970Q1-1989Q4. The variables included in the VAR(4) are the equity excess returns; the real return of a 90-day T-bill; the log of dividend-price ratio; the relative bill (90-day T-bill minus its 12-month-lagged moving average); and the 10-year Treasury spread against a 30-day T-bill. For the model counterpart, I also estimate a VAR that includes excess returns, the real rate, and the log of the dividend-price ratio.[33] As has been found in the empirical asset pricing literature, the majority of the variation in current excess returns is explained by fluctuations in future excess returns.

[33] Due to the high persistence in the model, I added 50 lags to the VAR.

C.2. *Partial Equilibrium Effects of Higher Participation*

FIGURE C1. Partial Equilibrium Effects over Investment



(A) Effective Tobin's marginal Q (in %) (B) Investment (in %)

Notes: The figure compares the response of Tobin's marginal Q and investment to a 1–sd expansionary MEI shock under different scenarios. The dashed black line is under low participation ($\varphi = 25\%$) and the solid blue line is under high participation ($\varphi = 55\%$). The blue dotted line is a construction in which an auxiliary participant is subject to the equilibrium prices under low participation but has the exposure to equity (and leverage) a participant would have under high participation. Using the implied auxiliary SDF, I construct a new Tobin's marginal Q and investment using equations (4) and (5). Units are percentage deviation from the ergodic steady-state.

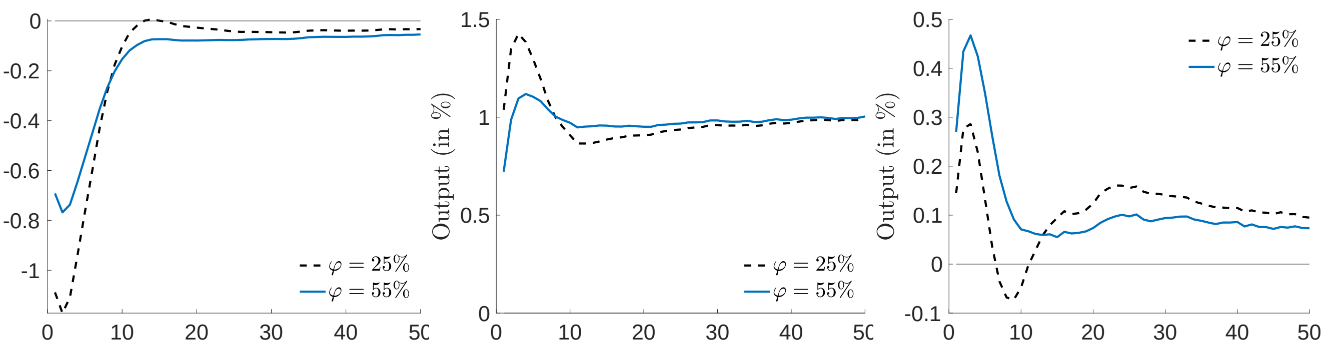
As in Section 3.3.2, I quantify the direct effects of higher participation by constructing a case in which an auxiliary participant faces equilibrium prices under low participation, but has the levered exposure to equity a participant would have under high participation. That is, for the auxiliary agent, I set $\varphi = 55\%$ in both the budget constraint and the Euler for bonds. Thus, consumption and borrowing are endogenously chosen by the auxiliary participant, while all other variables take the equilibrium path observed under low participation.

Appendix Figure C1 shows the response of Tobin's marginal Q and firms' investment to a positive 1–sd MEI shock when considering the SDF of the auxiliary agent (dotted blue line). It contrasts the responses with the cases of low (dashed black) and high (solid blue) participation. The left panel shows that the direct effect on Tobin's marginal Q is large. Milder crowding out effects and lower leverage imply that the negative impact on the auxiliary agent's consumption and SDF are lower, so that Tobin's marginal Q increases by more. As a result, the right panel of Appendix Figure C1 shows that investment increases by significantly more in the auxiliary case.

When comparing the dotted blue line with the solid blue line, we observe that the amplification effect is mitigated. This is because of general equilibrium adjustments when going from low to high participation.

C.3. *Heterogeneous IES*

FIGURE C2. Output Response under Heterogeneous IES



(A) Monetary Policy Shock (B) Productivity Shock (C) Investment Shock

Notes: This figure shows the response of output (in %) to a 1–sd shock for each type of shock in the model. The dashed black line shows the response under low participation ($\varphi = 25\%$) and the solid blue line under high participation ($\varphi = 55\%$).

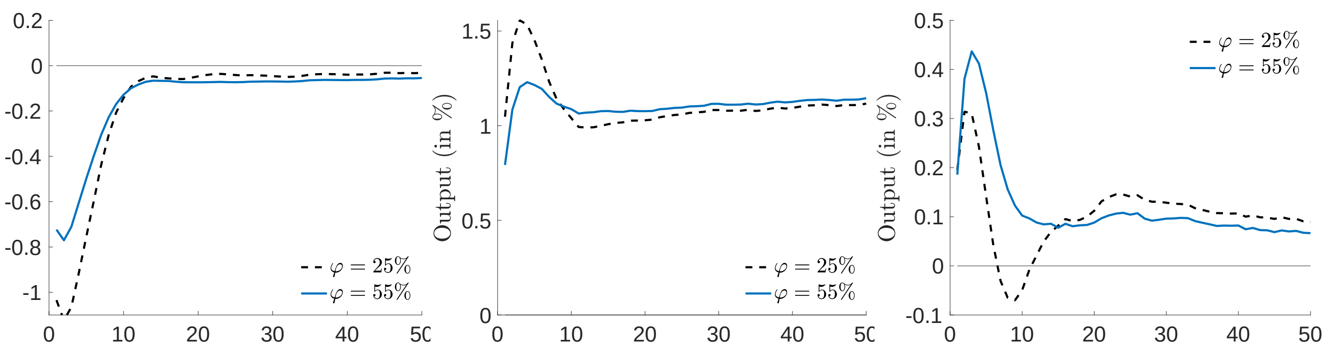
In the baseline model, I assume homogeneous IES across household types to avoid changes in aggregate IES as participation rises. However, empirical work by Vissing-Jorgensen (2002) suggests that nonparticipants have a lower IES than participants. In this appendix, I account for this heterogeneity while avoiding changes in the economy-wide average IES as participation rises. In the low-participation economy, I assume the IES is 0.3 for the participant and 0.1 for the nonparticipant; see Guvenen (2009). To keep the average IES in the model fixed, I adjust the participant's IES in tandem with the rise in the participation rate. Appendix Figure C2 shows that for reasonable parameter values, MP and TFP shocks are dampened with higher participation, while MEI shocks are amplified. In this case, the crowding out effects for the MEI shocks are milder.

C.4. *Time-Varying Participation and Heterogeneous Risk Aversion*

There are several reasons why endogenous participation may matter. Chief among these are (i) it can change the average risk aversion across participants, and (ii) it can affect participants' levered exposure to aggregate risk. In what follows, I address these concerns separately, with model modifications that do not diver much from the baseline model. Building a full-blown model of endogenous participation would indeed be valuable, but it would also go beyond the scope of this paper and significantly increase the complexity of the model; I am interested in the effects of the stark rise in participation observed during the 1990s rather than the significantly milder cyclical fluctuations. To put these variations into perspective, the rise in participation during the 1990s was of around 25 pp, while the standard deviation during the 1998-2016 period was only 1.8%.

C.4.1. *Heterogeneous Risk Aversion*

FIGURE C3. Output Response under Heterogeneous Risk Aversion



(A) Monetary Policy Shock (B) Productivity Shock (C) Investment Shock

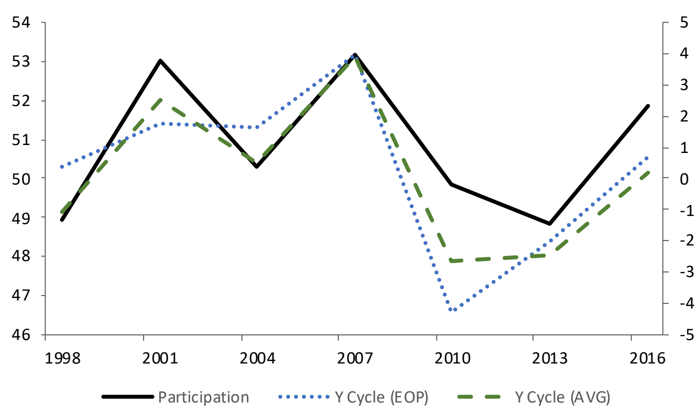
Notes: This figure shows the response of output (in %) to a 1–sd shock for each type of shock in the model. The dashed black line shows the response under low participation ($\varphi = 25\%$) and the solid blue line under high participation ($\varphi = 55\%$).

There are at least three reasons why participation in equity markets might have increased: lower volatility in stock market returns, a change in risk aversion from a fraction of nonparticipants, or a reduction in the costs of accessing equity markets (see Favilukis (2013)). Any of these cases would induce a rise in the risk aversion of the average participant household, and provide an opposing force to the effect of a lower levered exposure to equity. To account for this scenario, I solve an alternative model in which participants have lower risk aversion than nonparticipants. I recalibrate the model under low participation to match the same set of moments as in the benchmark, and run the same impulse response analysis on output as in previous sections. As I raise participation, I increase the risk aversion of the average participant household so that the average risk aversion in the economy stays constant. In particular, I set the average risk aversion to $\gamma = 12$ and that of the nonparticipant to be $\gamma_{np} = 15$, and obtain the participant's risk aversion as the residual $\gamma_p = (\gamma - (1-\varphi)\gamma_{np})\frac{1}{\varphi}$. Appendix Figure C3 presents the response of output to the three types of shocks. For reasonable parameter values, I observe no significant quantitative differences in my model predictions. Monetary policy shocks and productivity shocks are still dampened with higher participation, while MEI shocks are amplified.

C.4.2. *Procyclical Participation Rate*

Next, I address the concern related to the existence of a state-dependent participation rate. Appendix Figure C4 contrasts the fluctuations in participation rates with the cyclical component of output for the period 1998-2016. Since the participation rate is measured using data from the SCF, each data point corresponds to a 3-year period. Output cycle was constructed using the HP filter for annual data ($\lambda = 100$)—see Appendix B.2 for details—and I then considered two possibilities for aggregation to 3-year periods: average and end-of-period. The solid black line shows the participation rate (in %, left axis), computed from the SCF; the dashed green line shows the average HP cycle of output (in %, right axis) for each 3-year period; and the dotted blue line shows the HP cycle of output (in %, right axis) at the end of the 3-year period.

Figure C4. Procyclicality of Participation Rate



Notes: This figure shows the participation rate (left axis, in %) and the cyclical component of output (right axis, in %). Output cycle was constructed using the HP filter for annual data ($\lambda = 100$). Data are presented every 3 years. *Y cycle (EOP)* refers to output at the end of each 3-year period. *Y Cycle (AVG)* refers to the average of each 3-year period. See Appendix B.2 for details.

Appendix Figure C4 shows that the participation rate is indeed procyclical, with the covariance between participation rate and output cycle ranging between 2.9 and 3.4, depending on the time series for the output cycle. Another important observation is that the cyclical fluctuations are orders of magnitude smaller than the variation observed during the 1990s: While the participation rate rose by 25 pp during that period, its standard deviation during the 1998-2016 period—i.e., after stabilizing following the structural break—was only 1.8%. Nonetheless, allowing for a time-varying participation rate still provides a valid robustness check for the model.

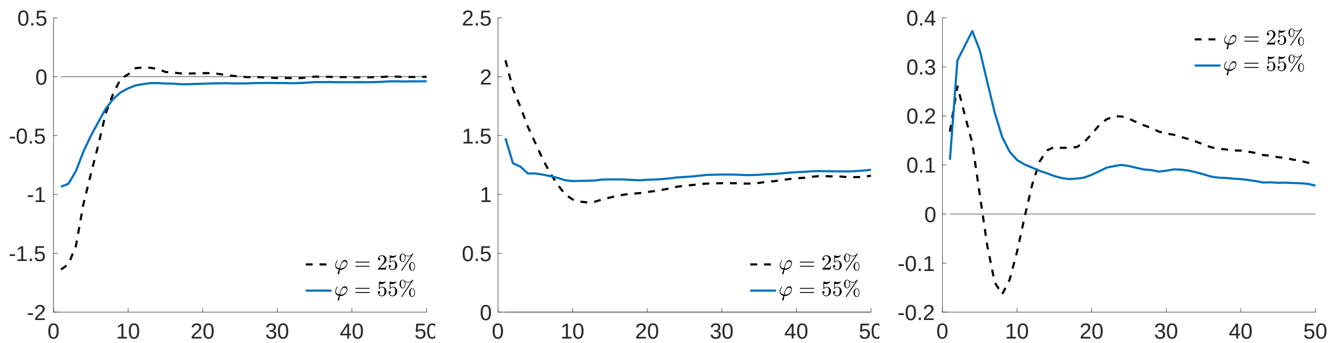
Table C1. Calibration of Participation Rate

	Parameter		Moment			
			Target		Model	
	ϕ_0	ϕ_1	$\mathbb{E}[\varphi_t]$	$\text{cov}(Y_t, \varphi_t)$	$\mathbb{E}[\varphi_t]$	$\text{cov}(Y_t, \varphi_t)$
Low φ	0.11	0.99	25.0%	2.90	25.3%	2.94
High φ	0.23	1.05	55.0%	2.90	55.8%	2.92

Notes: This table shows the calibrated parameters for the time-varying participation rate, as well as the targeted and simulated moments. *Low* φ refers to the period of low participation and *High* φ to the period of high participation. Y_t corresponds to the HP cycle of output and φ_t to the participation rate. See text for details.

To do this without significantly complicating the model, I now assume that the fraction of participants evolves according to $\varphi_t = \phi_0 \left(Y_t/Z_{t-1}\right)^{\phi_1}$, with $\phi_0, \phi_1 > 0$. This reduced-form assumption for the participation rate captures more complex participation decisions that may arise due to differential consumption needs across participants, or heterogeneity in investment technologies across participants such as information frictions. The new parameter ϕ_0 is set to match the average participation rate in each subperiod—i.e., 25% and 55%. In order to focus on the effect of higher participation, I assume that ϕ_1 did not vary in tandem with ϕ_0. I calibrate ϕ_1 to match the covariance between the participation rate and the cyclical component of output for the period 1998-2016. Since the objective of the exercise is to determine whether the main results hold in an alternative economy whose only diference with the baseline is a procyclical participation rate, I kept all other model parameters fixed at their baseline values as presented in Table 1 and Table 2. Appendix Table C1 shows the calibrated values for ϕ_0 and ϕ_1, as well as the targeted and simulated moments.

Figure C5. Output Response under Procyclical Participation Rate



(A) Monetary Policy Shock (B) Productivity Shock (C) Investment Shock

Notes: This figure shows the response of output (in %) to a 1–sd shock for each type of shock in the model. The dashed black line shows the response under low participation ($\varphi = 25\%$) and the solid blue line under high participation ($\varphi = 55\%$).

Appendix Figure C5 shows the response of output to a 1–sd shock for each type of shock considered in the baseline model. Results are still in line with those in Section 3.3—that is, monetary policy and productivity shocks are dampened with higher participation, while investment shocks are amplified.

C.5. *Active and Passive Participants*

This appendix is motivated by the fact that in the data, a large fraction of participants only have indirect holdings of equity. In 1989, 53% of participants had direct holdings of stocks. The rest invested in equity only through 401K/IRA accounts, mutual funds, or other types of investment funds. The fraction of direct holders then decreased to 40% in 2001. Based on these facts, I extend the baseline model to allow for active participants—i.e., direct holders—and passive participants—i.e., indirect holders. The latter are households that do not actively reoptimze the composition of their portfolio.[34]

In the model, a measure $1-\phi$ of participants are passive and ϕ are active. A fixed fraction ψ of the passive participant's savings, s_{it}, is invested in equity and the rest is invested in bonds.

[34]Although a household could still be an active trader even when only having indirect holdings of stocks—e.g., the mutual fund is the active trader—the spirit of this section is to provide a lower bound for the mechanisms in the model by assuming that the entirety of this type of participants is passive.

The problem of the passive participant is

$$\begin{aligned} V_{it} =& \max_{c_{it}, s_{it}} \left\{ (1-\beta) \left(c_{it} - z_{t-1} \vartheta_0 \frac{l_{it}^{1+\vartheta}}{1+\vartheta} \right)^{1-\rho} + \beta R_t \left(V_{it+1} \right)^{\frac{1-\rho}{1-\gamma}} \right\}^{\frac{1}{1-\rho}} \\ \text{s.t. } & c_{it} + \Phi_t \left(W_{it} \right) + s_{it} = \frac{1}{P_t} W_{it} l_{it} + T_{it} + s_{it-1} \left[\psi R_{dt} + (1-\psi) \frac{R_{t-1}}{\Pi_t} \right] \\ l_{i,t} =& \left(\frac{W_{it}}{W_t} \right)^{-\theta_w} L_t^d. \end{aligned}$$

The Euler equation for the passive participant reads

$$1 = E_t \left[\Lambda_{i,t+1} \left(\psi R_{dt+1} + (1-\psi) \frac{R_t}{\Pi_{t+1}} \right) \right].$$

The problems for the active participant and the nonparticipant are the same as in the baseline model, and so are their optimality conditions. As a result, the active participant is the marginal investor pricing equity. Note that by market clearing, the active participant has to hold $\theta_{t+1} = \frac{1}{\varphi\phi} - \frac{1-\phi}{\phi}\psi\frac{s_t}{Q_{dt}}$. On the production side, the problem of the firms is the same as in the baseline model, except that now the stochastic discount factor is given by the average

$$\Lambda_{t+1} \equiv \phi \Lambda_{ap,t+1} + (1-\phi) \Lambda_{pp,t+1}.$$

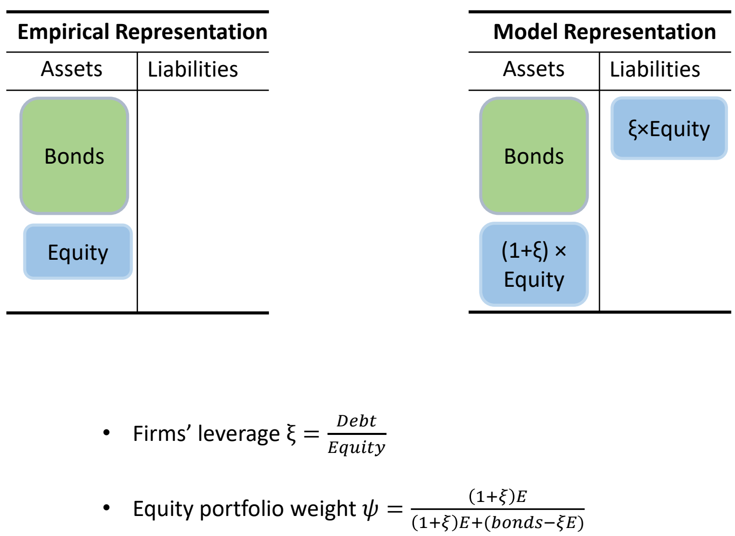
This extension of the model introduces three new parameters that I calibrate to match data moments. The first parameter is the steady-state level of savings for the passive participant. I choose this parameter to match the relative NFW between the average passive participant and the average nonparticipant household. Using data from the SCF, I find this moment to be 3.1 in 1989. The second parameter to calibrate is the measure of active participants ϕ, which is set to match the fraction of total participants that have direct holdings of equity. Appendix Table C2 presents this fraction for 1989 and 2001, as computed from the SCF. The first two rows show the fraction of households that have direct holdings of equity (active) and those that have only indirect (passive) over the total number of households. The third row shows the fraction of households with direct holdings over all participant households. Based on this table, I choose $\phi = 0.55$ when participation is low and $\phi = 0.40$ when participation is high.

Table C2. Fraction of Participants with Direct Holdings of Equity

Measure	1989	2001
Active / Total	16.9%	21.3%
Passive / Total	14.9%	31.7%
Active / Participants	52.9%	40.2%

Notes: *Active* refers to participant households that have direct holdings of equity; *Passive* refers to those that only have indirect holdings of equity; *Total* refers to the total population of US households. See Appendices B.1 and B.2 for details.

Figure C6. Portfolio of the Passive Participant



The third parameter to calibrate is the fixed share in equity ψ. Since equity is levered in the data, I provide a simple way to link the balance sheet of the passive participant in the data and in the model, as represented in Appendix Figure C6. The left side of the figure computes the balance sheet of the passive participant using the SCF, where "Bonds" refers to savings in net financial assets other than equity. To disentangle assets from liabilities in equity holdings, I compute the leverage ratio ξ for the nonfinancial corporate sector. That way, the empirical balance sheet under the model representation (unlevered equity) has equity holdings equal to $(1+\xi) \times Equity$ and net (positive) bond holdings of $Bonds - \xi \times Equity$. This computation yields a share of equity $\psi = (1+\xi) \times Equity/NFW \approx 0.4$ in 1989. The model is also calibrated to match the same set of moments as in the baseline model. Appendix Table C3 shows the entire set of calibrated moments for this model extension.

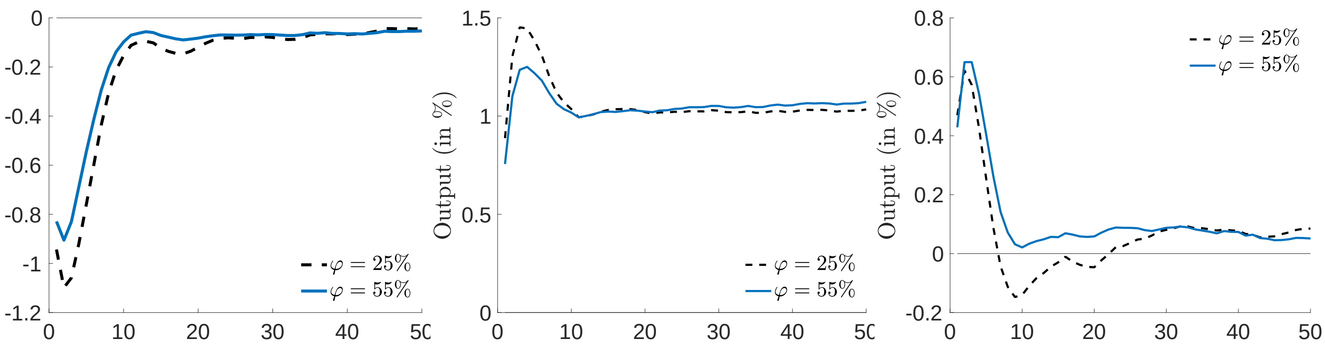
Table C3. Target Moments: Model vs. Data

Target	**Model**	**Data**
Business cycles		
Output volatility	2.1	2.2
Investment over output	0.19	0.17
Relative volatility investment	2.6	2.8
Correlation output and gross profits	67	72
Asset prices		
Equity premium	3.6	4.0
Real risk-free rate	2.2	2.0
Equity price elasticity	-3.0	-3.5
Relative volatility equity payouts	15.5	15.0
Cross-section		
Relative NFW average participant vs. non-participant	12.4	12.0
Relative NFW passive participant vs. non-participant	3.6	4.0

Notes: This table shows the set of data moments targeted in the calibration and their model counterparts. See Appendix B.2 for details.

With the calibrated model in hand, I analyze whether the effects of higher participation on the economy's response to the three types of shocks hold. Appendix Figure C7 shows that it is still the case that monetary policy and productivity shocks are *dampened* with higher participation, while investment shocks are *amplified*.

Figure C7. Output Response with Passive Participants



(a) Monetary Policy Shock (b) Productivity Shock (c) Investment Shock

Notes: This figure shows the response of output (in %) to a 1–sd shock for each type of shock in the model. The dashed black line shows the response under low participation ($\varphi = 25\%$) and the solid blue line under high participation ($\varphi = 55\%$).

Appendix D. Empirical Analysis and Robustness

D.1. *Robustness Cross-sectional Regressions*

Table D1. Robustness: Year Fixed Effects

	(1)	(2)
FF_t	-7.99***	-2.59
	(-4.01)	(-0.93)
I^h_{it}	3.52***	3.32***
	(15.03)	(14.44)
$FF_t \times I^h_{it}$	-7.59*	-7.92**
	(-1.98)	(-2.05)
State FE	✓	✓
Year FE		✓
N	185,115	185,115

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Notes: The dependent variable is quarterly consumption growth (in pp) for a household i. FF_t refers to the MP shock and I^h_{it} is a dummy that takes a value of one if the household is a participant. The interactive variable $FF_t \times I^h_{it}$ captures excess response from the participant relative to the nonparticipant. All regressions control for seasonality. In the second column I also control for year FE. Standard errors are clustered at the state level and t-statistics are shown in parentheses.

In this section, I perform four robustness checks on the baseline cross-sectional regression. I start by running a simpler regression in which, instead of time fixed effects, I introduce year fixed effects to corroborate that the MP shock is contractionary for both types of households. The specification for the regression is

$$\Delta \ln C_{it} = \beta_0 + \beta_1 FF_t + \beta_2 \mathcal{I}^h_{it} + \beta_3 \mathcal{I}^h_{it} \times FF_t + \alpha_k + \mathrm{YR}_t + \mathrm{Seas}_t + \epsilon_{it}, \tag{17}$$

where α_k refers to state FE, YR_t to year FE, and Seas_t to seasonal dummies.

The model predicts that both β_1 and β_3 should be negative, meaning that both types of households' consumption fall upon a contractionary MP shock, but the participant's falls by more. The first column of Appendix Table D1 shows the results of the regression without year FE, while the second column includes year FE. In effect, in both specifications β_1 and β_3 are negative as predicted by the model. Allowing for year FE, however, yields a smaller (in absolute value) and nonsignificant point estimate for β_1. Interestingly, estimates for β_3 are not affected. The second column suggests that consumption falls by 0.18 pp for the nonparticipant and by 0.72 pp for the participant.

My model predicts that households with higher net present value of equity will react relatively more to an MP shock. In the data, these tend to be older rather than younger households. Although my model does not distinguish between young and old households, evaluating to what extent my model can relate to the data on this dimension would still constitute a valid robustness check. If my model mechanisms are—to a certain extent—invariant to age, I would expect older participants to respond more than younger ones. To observe whether this is the case, I expand specification (17) by introducing the interactive variable $\mathcal{I}_{it}^h \times Age_{it} \times FF_t$ as follows:

$$\Delta \ln C_{it} = \beta_0 + \beta_1 FF_t + \beta_2 \mathcal{I}_{it}^h + \beta_3 Age_{it} + \Gamma' \mathcal{I}_{it}^h \times Age_{it} \times FF_t + \alpha_k + \mathrm{YR}_t + \mathrm{Seas}_t + \epsilon_{it}.$$

The dummy variable Age_{it} takes a value of unity if the head of household is 55 years or older, while the dummy variable $\mathcal{I}_{it}^h$ equals one if the household is a participant, either being zero otherwise.[35] Therefore, the point of comparison in the empirical model is a young nonparticipant. Again, my model does not explicitly consider young vs. old nonparticipants, but to the extent that older participants have higher exposure to equity than younger, its mechanisms would suggest that older participants react more.

Appendix Table D2 shows the results. Point estimates suggest that households' response can be ordered as follows, from low to high: young NP, old NP, young P, and old P, where *P* refers to participant and *NP* to nonparticipant. One reason old NP may react more than young NP is that my measure of participation is imperfect, being defined as those holding "stocks, bonds, mutual funds, and other such securities." Retirement accounts and 401Ks are not included, so some households classified as nonparticipants may actually be participants. Given that caveat, the main takeaway of this regression is that old participants' consumption reacts by 1.4 pp more than young nonparticipants' and by 0.6 pp more than young participants'.

[35]In the sample, I drop households younger than 30 years old.

TABLE D2. Robustness: Participation and Age

	(1)
FF_t	1.95
	(0.59)
I^h_{it}	2.90***
	(10.93)
Age_{it}	0.64**
	(2.38)
$I^h_{it} \times Age_{it} \times FF_t$	
NP Old φ_k $[0 \times 1]$	-9.45*
	(-1.98)
P Young φ_k $[1 \times 0]$	-11.43*
	(-1.97)
P Old φ_k $[1 \times 1]$	-20.61***
	(-3.57)
N	156,225

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Notes: The dependent variable is quarterly consumption growth (in pp) for a household i. FF_t refers to the MP shock and I^h_{it} is a dummy that takes a value of one if the household is a participant. Age_{it} is a dummy that takes a value one if the head of household is older than 55 years and 0 otherwise. Observations with age less than 30 are dropped. The regression controls for state FE, year FE, and seasonality. Standard errors are clustered at the state level and t-statistics are shown in parentheses.

A feasible concern is that my benchmark cross-sectional results are actually driven by the effects of an MP shock on the net value of housing. To the extent that equity-wealthier households are also more exposed to housing, their stronger response may be driven by fluctuations in house prices and mortgage values. To alleviate this concern, I compute the net value of housing as the market value of the property a household has net of the outstanding balance of the mortgage—see Appendix B.2 for details—and construct a categorical variable, NH_{it}, with four groups. The first is defined by households with negative net value of housing. To define the second and third groups, I compute the median of the housing measure, conditional on this variable being positive and nonmissing. The second group is then composed of households with positive net value of housing but below the median, and the third is for households with values above the median. Given that there are several missing values on the net value of housing, I allow for a fourth category to incorporate them in the regression and avoid losing data points.

With this categorical variable in hand, I also construct the interactive variable $NH_{it} \times FF_t$ and introduce it to extend specification (17) as follows:

$$\Delta \ln C_{it} = \beta_0 + \beta_1 \mathcal{I}^h_{it} + \beta_2 FF_t + \beta_3 \mathcal{I}^h_{it} \times FF_t + \Gamma_1' NH_{it} + \Gamma_2' NH_{it} \times FF_t + \alpha_k + \mathrm{YR}_t + \mathrm{Seas}_t + \epsilon_{it}.$$

Appendix Table D3 shows the results. The point estimates of this interactive variable suggest that households with higher net value of housing react more to a MP shock, but these estimates are not statisticaly significant. Importantly, the point estimate related to $\mathcal{I}^h_{it} \times FF_t$ is very close to that of the baseline specification (13) and of the alternative specification (17), suggesting that limited participation in equity markets is an important factor driving households' consumption response.

I also show that results are robust to extending the initial period of baseline regression (13) to Feb-1990, as well as to the inclusion of lagged consumption growth, $\Delta \ln C_{i,t-3}$, as a control. Due to data availability, the composition of consumption for this extended regression is a subset of the one used in the baseline regression; see Appendix B.2 for details. Appendix Table D4 shows the result. Column (1) only includes state FE and year FE as controls; Column (2) adds the same set of controls as in the baseline regression, represented in Column (1) of Table 8; see Section 4.1 for details. Column (3) also interacts state-level FE with FF_t, and Column (4) adds lagged consumption growth as a control.[36] All four specifications sustain the finding that a participant's consumption reacts by around 0.5 pp more than that of a nonparticipant's to a 1–s.d. MP shock.

[36] A high fraction of households have missing values for lagged consumption growth. To avoid losing datapoints, I incorporate a dummy for those households that do not report lagged consumption. Thus, the term added to the regression is $\mathcal{I}^c_{it} + \mathcal{I}^c_{it} \times \Delta \ln C_{i,t-3}$, where $\mathcal{I}^c_{it}$ equals one if the household reports lagged consumption growth and zero otherwise, and $\Delta \ln C_{i,t-3}$ is the household's consumption growth in the previous quarter.

Table D3. Robustness: Net Value of Housing

	(1)
FF_t	-1.05
	(-0.16)
I^h_{it}	3.23***
	(14.38)
$NH_{it} = \text{low}$	-1.22**
	(-2.23)
$NH_{it} = \text{high}$	-0.96**
	(-2.35)
$NH_{it} = .$	-1.56***
	(-2.94)
$I^h_{it} \times FF_t$	-7.39*
	(-1.91)
$NH_{it} = \text{low} \times FF_t$	-0.39
	(-0.06)
$NH_{it} = \text{high} \times FF_t$	-4.96
	(-0.73)
$NH_{it} = . \times FF_t$	-1.45
	(-0.23)
N	185,115

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Notes: The dependent variable is quarterly consumption growth (in pp) for a household i. FF_t refers to the MP shock and I^h_{it} is a dummy that takes value of one if the household is a participant. NH_{it} is a categorical variable based on a household's net value of housing. There are four categories: high, low, negative and missing value—see text for details. The table presents the comparison with respect to negative net value of housing. This categorical variable is interacted with FF_t to observe differences in consumption response to a MP shock. The regression controls for state and year FE. Standard errors are clustered at the state level and t-statistics are shown in parentheses.

TABLE D4. Robustness: Extension of Sample to 1990-2007

	(1)	(2)	(3)	(4)
I^h_{it}	3.69***	2.90***	2.90***	3.19***
	(18.43)	(13.23)	(13.22)	(14.32)
$FF_t \times I^h_{it}$	-6.93*	-7.16*	-7.28*	-7.01*
	(-1.86)	(-1.92)	(-1.93)	(-1.76)
State FE	✓	✓	✓	✓
Time FE	✓	✓	✓	✓
HH Controls		✓	✓	✓
State$\times FF_t$ FE			✓	✓
$\Delta\ln C_{i,t-3}$				✓
N	230,074	230,074	230,074	230,074

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Notes: The dependent variable is quarterly consumption growth (in pp) for a household i. Consumption is a reduced version of the one used for the baseline regression; see Appendix B.2 for details. FF_t refers to the MP shock, and I^h_{it} is a dummy that takes a value of one if the household is a participant. The interactive variable $FF_t \times I^h_{it}$ captures excess response from the participant relative to the nonparticipant. Column (1) has only I^h_{it} and $FF_t \times I^h_{it}$ as regressors. Column (2) adds the same controls as in the baseline regression; see Section 4.1 for details. Column (3) also interacts state-level FE with FF_t, and Column (4) adds lagged consumption growth ($\Delta\ln C_{i,t-3}$) as a regressor. Standard errors are clustered at the state level, and t-statistics are shown in parentheses.

D.2. *Structural VAR: Cross-sectional Response to Contractionary MP Shock*

In this section, I analyze the dynamic response of cross-sectional consumption to a contractionary MP shock. I estimate a structural VAR as in Mertens and Ravn (2013) and Gertler and Karadi (2015), and compute impulse responses to a positive structural MP shock. The analysis begins by defining

$$\text{structural VAR:} \quad AY_t = \sum_{j=1}^{p} C_j Y_{t-j} + \epsilon_t$$

$$\text{reduced form:} \quad Y_t = \sum_{j=1}^{p} B_j Y_{t-j} + u_t,$$

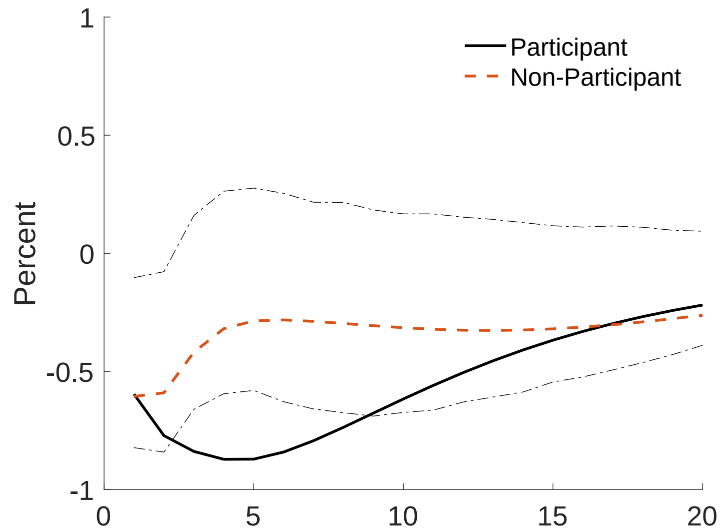
where $u_t = S\epsilon_t$, $S = A^{-1}$ and $B_j = A^{-1}C_j$, with $E[\epsilon_t\epsilon_t'] = I$ and $E[u_t u_t'] = E[SS'] = \Sigma$. Let $Y^p_t \in Y$ denote the monetary policy indicator—that is, the variable in the structural representation that has exogenous variation induced by the structural monetary shock $\epsilon_t^p \in \epsilon_t$. Let s be the column in S corresponding to the impact on reduced-form residuals u_t of the structural shock ϵ_t^p. Since we are only interested in the effects of monetary policy shocks, we only need to identify s on the structural VAR. We do so by using surprises to the fed funds futures as external instruments for the identification.[37] This procedure was developed by Mertens and Ravn (2013) and consists of two broad steps. First, we estimate the reduced-form VAR and get $\hat{u}_t$. Then, we use this residual and the instruments to identify s. Briefly, we do so by running a regression of the VAR residuals onto the instruments. The benefit of this method is that it allows us to identify the effects of an MP shock on a set of variables without imposing timing restrictions. Samples between the two steps need not be the same, which matters since the series for fed funds futures is only available from the early 1990s onward.

The baseline VAR in Gertler and Karadi (2015) includes the 1-year Treasury yield, CPI (in logs), industrial production (in logs) and excess bond premium. I extend this set of variables to include the consumption of participants and nonparticipants, where I measure each variable as the population–weighted average consumption for each type of household using CEX data. The policy indicator is the 1-year Treasury yield. The quarterly VAR has two lags and is estimated for the period 1984q1-2012q4. The identification regression uses data for the period 1991q1-2007q4.[38]

[37]Since variables are at quarterly frequency, I use the 3-month-ahead fed funds future (FF4), which captures revisions in market expectations for monetary policy for up to 3 months. This is also the preferred instrument in Gertler and Karadi (2015). Results are similar when considering Romer and Romer (2004) narrative approach as instruments; results are available upon request.

[38]I end the identification sample in 2007q4 due to the existence of the zero lower bound, but results are robust to extending the sample up to 2012q4.

Figure D1. Cross-sectional Response to a Structural MP Shock



Notes: This figure shows the consumption response of participants and nonparticipants to a positive 1–sd structural MP shock. See text for details on the VAR. The solid black line represents the response of participants' consumption in percentage points. The dashed red line shows the response of nonparticipants. The dotted black lines denote the 90% confidence interval for the response of nonparticipant constructed using wild bootstrap. The robust F-statistic from the instrument regression is 18.19—above the 10 threshold suggested by Stock et al. (2002) to be confident that a weak instrument problem is not present.

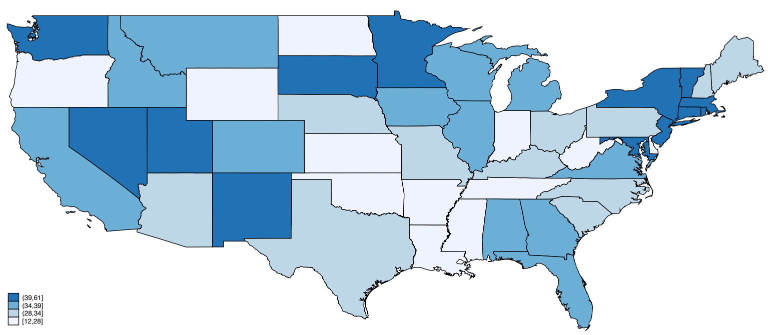
Appendix Figure D1 shows the consumption response of participants and nonparticipants to a positive 1–sd structural MP shock. The solid black line represents the response of participants' consumption in percentage points. The dashed red line shows the response of nonparticipants. The dotted black lines denote the 90% confidence interval for the response of nonparticipant, constructed using wild bootstrap. Aside from being contractionary for both types of households, point estimates suggest that participants' response is stronger and more persistent than that of nonparticipants.

D.3. *Empirical Analysis: Aggregate Effects of Higher Participation*

In this appendix, I further analyze the effects of higher participation on the response of aggregate consumption and output to MP shocks. As stated in Section 4.2, providing evidence on these effects is challenging since it requires clear identification of changes in participation in a short period of time. Instead, I present suggestive evidence by exploiting regional variation and time variation in participation rates. I first provide a robustness analysis of the cross-sectional variation study and then shift to a time-variation approach.

D.3.1. *State-level Variation in Participation*

Figure D2. Heterogeneity in Participation Rates



Notes: Average participation rate by state for the period 1994-2007. Data source: PSID.

Table D5. Descriptive Statistics of Participation Rates

Moment	**Value**
Mean	34.1%
Median	33.6%
S.D.	13.4%
15th percentile	22.4%
25th percentile	26.7%
75th percentile	40.8%
85th percentile	45.7%
Skewness	0.6
Kurtosis	4.7

Notes: Moments constructed from participation rate by state for the period 1994-2007. Data source: PSID.

Since I consider regional variation in participation at the state level, I begin by showing that there is significant heterogeneity in participation rates across states. Appendix Figure D2 displays the state-level average participation rate for the period 1994-2007 using data from the PSID—see Appendix B.2 for details—and Appendix Table D5 shows some descriptive statistics. We observe that there are no clear geographical patterns and that there is significant variation in participation.

Results from Section 4.2 suggest that regions with higher participation exhibit a milder response to MP shocks than regions with lower participation. As a robustness exercise for specification (15), I now use an indicator for participation at the state level for the year prior to the one in which the monetary policy shock took place. The regression is similar to the baseline one,

$$\Delta \ln C_{it} = \alpha_t + \alpha_k + \beta_1 FF_t + \beta_2 \mathcal{I}_{kt}^{HP,-1} + \beta_3 \mathcal{I}_{k,t}^{HP,-1} \times FF_t + \text{controls} + \epsilon_{it},$$

where $\mathcal{I}_{k,t}^{HP,-1}$ equals one if the state had a participation rate above the 20$^{\text{th}}$ percentile 1 year before the monetary policy shock took place. Controls include labor income variation, household-level characteristics, and state-level share of manufactures. Column (1) of Appendix Table D6 shows the results when only controlling for state FE and time FE. The point estimate for β_3 is statistically significant at 5%, and slighty below the baseline estimate presented in Column (1) of Table 10. It implies that states with high participation have a 0.38 pp milder fall in consumption than states with low participation. Column (2) of Appendix Table D6 shows that while still economically significant, the point estimate loses its statistical significance when the set of controls is included.

As an additional robustness exercise, I extend specification (15) to allow for quintile groups of participation rather than having a 20$^{\text{th}}$ percentile benchmark. These new dummy variables—one per quintile group—are also interacted with the MP shock. Appendix Figure D3 shows the estimated interaction for each quintile group. By construction, point estimates are comparisons with respect to the lowest quintile, so we should expect all estimated coefficients to be positive. The red lines on the figure depict the 90% confidence interval for that particular regressor. Indeed, the estimates for all groups are positive, but only those for quintiles two and three are statistically significant at 10%. The top two quintiles are not significantly different from zero, nor statistically different from the previous two quintile group estimates.

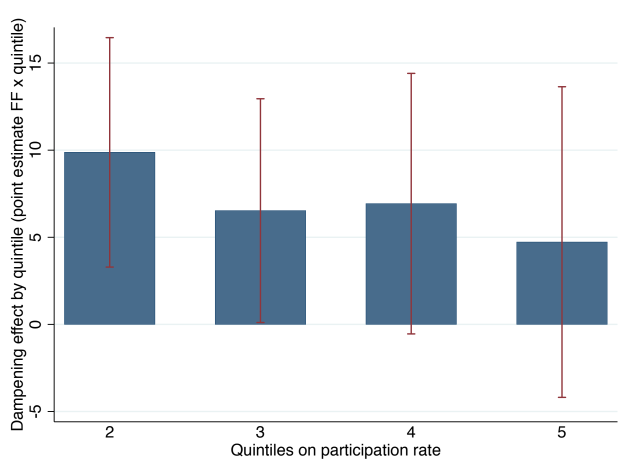
Table D6. Auxiliary Regression on the Role of Participation Rate

	(1)	(2)
$I_{k,t}^{HP,-1}$	-0.28	0.08
	(-0.34)	(0.09)
$FF_t \times I_{k,t}^{HP,-1}$	6.07**	7.29
	(1.85)	(1.66)
State FE	✓	✓
Time FE	✓	✓
Controls		✓
N	185,115	185,115

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Notes: $\mathcal{I}_{kt}^{HP,-1}$ is a dummy variable that takes value one when state k's last year's participation was above the 20$^{\text{th}}$ percentile of state-level participation rates for that year. Controls are household-level characteristics, quarterly change in real annual labor income, and state-level share of manufactures interacted with the MP shock. Standard errors are clustered at the state level and t-statistics are shown in parentheses. See Appendix B.2 for data details.

Figure D3. Response by Percentile Group



Notes: This figure shows an extension to specification (15), in which yearly quintile groups of participation are considered instead of I_t^{HP}. Comparison is with respect to the lowest quintile. The bars show the point estimates of the interaction of each quintile-dummy with the MP shock. The red lines depict the 90% confidence interval. A positive point estimate implies a milder response to the shock for states that belong to that quintile group.

D.4. *VAR Estimations on MP Shocks*

This section details the time-variation analysis described in Section 4.2. I compare the response of the economy to MP shocks in a period with low participation with a period with high participation. I follow two approaches to identify MP shocks in a VAR framework. The first is instrumented identification, as in Gertler and Karadi (2015), and the second is the standard Cholesky identification, as in Christiano, Eichenbaum, and Evans (2005). Under both approaches, I use a similar set of variables as those used in Gertler and Karadi (2015): (log) industrial production (IP), (log) consumer price index (CPI), effective federal funds rate (EFFR), and corporate bond spreads (EBP).

For ease of exposition, I again present the VAR specification as detailed in Appendix D.2:

$$\text{structural VAR:} \quad AY_t = \sum_{j=1}^{p} C_j Y_{t-j} + \epsilon_t$$

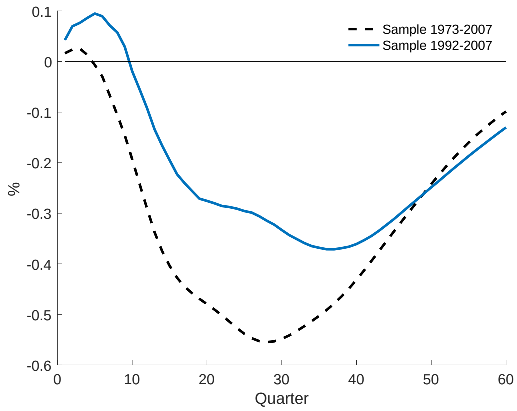
$$\text{reduced form:} \quad Y_t = \sum_{j=1}^{p} B_j Y_{t-j} + u_t,$$

where $u_t = S\epsilon_t$, $S = A^{-1}$ and $B_j = A^{-1}C_j$, with $E[\epsilon_t \epsilon_t'] = I$ and $E[u_t u_t'] = E[SS'] = \Sigma$. In this section, I aim to capture differences in the periods before and after the rise in participation rates. My hypothesis is that either A or $\{C_j\}_{j=1}^p$ underwent some changes with higher participation. To the extent that this is true, it should have implications for S or $\{B_j\}_{j=1}^p$.

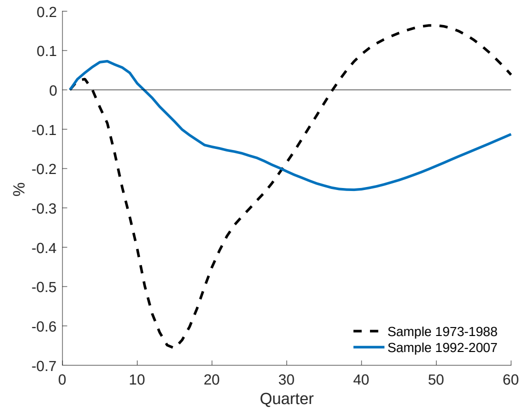
For the instrumented VAR approach, my strategy is to compare the impulse response of industrial production to a policy shock, ϵ_t^p, in a model estimated from a broad sample (Jan-73 to Dec-07) with a model estimated from a narrow sample (Jan-92 to Dec-07).[39] In both cases, the identification regression uses data for the period 1992q1-2007q4. If the rise in participation generated any structural changes in the US economy that affected either A or $\{C_j\}_{j=1}^p$, these should be captured in the reduced-form VAR estimations. Of course, there could have been many other reasons for these matrices to change, but it is reassuring if model predictions are aligned with data.

[39] I deliberatly stop the sample at Dec-07 to avoid dealing with the Great Recession and the zero lower bound problem. In addition, since I allow for 12 lags on the VAR, there are a sizable number of coefficients to estimate. Thus, I need a large number of observations, which prevents me from starting much further in time than Jan-92.

FIGURE D4. Response of Industrial Production to a Positive MP Shock



(A) Instrumented Identification



(B) Cholesky Identification

Notes: This figure shows the response of output to a positive MP shock under two identification methods. Panel (A) shows the response when instrumenting the VAR to identify shocks. It compares the response when using the full 1973q1-2007q4 sample (dashed black line) with the narrower 1992q1-2007q4 sample (solid blue line). Panel (B) shows the response when making timing assumptions for identification. It compares the response when using the 1973q1-1988q4 sample (dashed black line) with the 1992q1-2007q4 sample (solid blue line). See text for details.

Appendix Figure D4a shows the response of IP to a policy shock chosen so that the EFFR rises by 0.4% on impact in both samples.[40] In line with the quantitative model, the figure shows that the impulse response is milder for the post-1990s sample. These results are robust to reasonable sample variation.

Next, I perform a similar analysis but use a Cholesky decomposition rather than the instrumented identification, with the following decreasing order of exogeneity: CPI, IP, EFFR and EBP. In contrast to the instrumented VAR, this method allows for full estimations over non-overlapping samples. To obtain the same number of observations, I choose Jan-73 to Dec-88 as the low-participation sample and Jan-92 to Dec-07 as the high-participation sample. Once again, shocks are chosen so that the EFFR increases by the same amount on impact in each sample. Results presented in Appendix Figure D4b also suggest a relatively milder response of industrial production for the high-participation sample.

[40]This corresponds to the response of EFFR in the broad sample for a 1–sd structural shock.

D.5. *Forecasting Excess Returns*

TABLE D7. Regression on Excess Returns

	Estimation
D_t/Q_{dt}	4.99***
	(3.41)
C_t/Y_t	1.47*
	(1.98)
N	71

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: This table shows the results of regressing excess returns on equity onto the price-dividend (D_t/Q_{dt}) and the consumption-to-output (C_t/Y_t) lagged ratios. Data are in yearly frequency for the period 1947-2018. Realized excess returns are the CRSP value-weighted return, including distributions minus the 30-day Treasury bill return. The dividend-price ratio is constructed exactly as described on Appendix A.2. of Cochrane (2011). The consumption-to-output ratio is computed using nominal consumption and GDP from the BEA.

In order to compute required excess returns in the data, I follow Cochrane (2011) and Hall (2017) and run a regression of annual excess returns on the dividend-price ratio and the consumption-to-GDP ratio for the period 1947-2018. Financial variables for the regression are obtained from Wharton Research Data Services (WRDS). The time frequency for the regression is yearly. The series of realized excess returns $R^e_{t,t+1}$ is constructed as the CRSP value-weighted return including distributions (vwretd) less the 30-day Treasury bill return (t30ret). The dividend-price ratio $\frac{D_t}{Q_{dt}}$ is constructed exactly as described in Appendix A.2. of Cochrane (2011). The consumption-to-output ratio is computed using nominal consumption and GDP from the BEA. The regression used to forecast excess returns is specified as

$$R^e_{t,t+1} = \beta_0 + \beta_1 \frac{D_t}{Q_{dt}} + \beta_2 \frac{C_t}{Y_t} + \epsilon_{it+1},$$

and I run it for the period 1947-2018. Appendix Table D7 shows results of the point estimates. In particular, the coefficient associated with $\frac{D_t}{Q_{dt}}$ is close to the estimated 3.8 of Cochrane (2011) for the period 1947-2009. When comparing the predicted values for 1970-1989 with 2000-2018, I find that the implied required returns fell by 17%.