Inelastic Asset Markets and Aggregate Demand

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Abstract

When does saving reduce aggregate demand, and when does it stimulate it, e.g. via investment? To study this question, we develop a general framework incorporating inelastic asset markets into a New-Keynesian (NK) model. The model suggests a new "sufficient statistic": The *demand pass-through* z_n of asset n is the share of \$1 of additional saving in asset n that ends up increasing aggregate demand for a given policy rate. In any model with perfectly elastic asset markets, $z_n = 0$, whereas models with inelastic asset markets naturally lead to $z_n > 0$. We show how accounting for $z_n > 0$ modifies the traditional Keynesian cross in two important ways. In theory, the two modifications can overturn the paradox of thrift, make redistribution contractionary, and austerity expansionary. We provide a quantitative evaluation of these effects in a heterogeneous-agent version of our model.

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1 Introduction

Suppose a household receives a stimulus check of \$1 and decides to spend 25¢, a typical number for a quarterly marginal propensity to consume (MPC). Most macroeconomic models today would say that this household, therefore, contributes an additional 25¢ to aggregate demand. In this paper, we ask: What happens to the remaining 75¢? Do they contribute anything to aggregate demand, too?

According to a traditional *(New-)Keynesian* perspective, the answer is no: Saving is whatever is not spent. An increase in saving does not raise investment. Instead, the asset market clears in general equilibrium by Walras' law: since the goods market clears, and all budget constraints hold, the asset market must clear as well.

However, this perspective seems flawed. What if the household is a successful entrepreneur that saves by investing in his or her business? Clearly, saving in *some* asset classes can stimulate investment, like it would according to the traditional *Wicksellian* perspective of saving and investment.

We propose a general framework that allows us to cleanly characterize when additional saving contributes to aggregate demand and when it does not. At the heart of our framework is a new sufficient statistic: The *demand pass-through* z_n for asset n precisely captures what share of new saving in asset n ultimately contributes to aggregate demand, by way of raising aggregate consumption or investment.

We show that $z_n = 0$ in a traditional New-Keynesian (NK) model, in which assets are perfectly substitutable, that is, asset markets are perfectly elastic.[1] In a model with inelastic asset markets, z_n is naturally positive, as additional saving can reduce expected returns even with a constant policy rate (short-term interest rate). Generally speaking, z_n is close to zero for assets n that are closely substitutable with the policy asset (short-term bonds), while z_n is larger for assets, such as public or private equity, that are less substitutable with the policy asset. In that way, our framework speaks to both, the Keynesian and the Wicksellian perspectives.

We derive a generalized Keynesian cross equation for date-0 output in our framework,

$$dY_0 = \frac{1}{1 - MPC - \sum_n z_n MPS_n} \left(\partial C + \sum_n z_n \partial A_n \right) \tag{1}$$

∂C is a generic demand shock, ∂A_n is a shock to net saving in asset n. Our demand pass-through enters in two places. First, the term $\sum_n z_n \partial A_n$ in parentheses captures the increase in aggregate demand that stems from a shock to saving in asset n. Such a shock could

[1] We build on the terminology of Gabaix and Koijen (2023).

come about, for example, as a result of fiscal stimulus, as in our introductory paragraph. Second, the term $\sum_n z_n MPS_n$ in the denominator shows that the economy behaves as if its "effective MPC" is greater: any given marginal income increase feeds back to demand not only via increased spending (MPC) but also via increased saving in positive-z_n assets.

These two new terms in (1) have important consequences for how business cycle shocks, monetary policy, and fiscal policy propagate, and allow us to shed new light on results from existing macro-finance models with inelastic asset markets. We run five experiments in the model:

a) The first policy we study is quantitative easing (QE), which simply corresponds to a positive shock to ∂A_n for the asset n being purchased. Clearly, QE has the largest "bang for the buck" precisely when purchasing the asset with the largest demand pass-through z_n. We show that this need not be long-term government bonds.

b) A paradox-of-thrift shock is one in which demand is reduced, $\partial C < 0$, and saving increased, $\partial A_n > 0$. Our Keynesian cross (1) shows that such a shock causes a milder recession if it emanates from households that buy high-z_n assets on the margin (such as public or private equity).

c) Redistribution from rich to poor can now potentially reduce aggregate demand, as now the difference in *(asset-market) adjusted MPCs* $MPC^i + \sum_n z_n MPS_n^i$ across households i matters, and not simply regular MPCs MPC^i. The savings adjustment $\sum_n z_n MPC_n^i$ is arguably greater for rich households than for poor.

d) Deficit-financed fiscal stimulus is generally more effective in this economy due to the higher adjusted MPC, compared to a model with elastic asset markets. However, if deficits are financed by issuing high-z_n assets, this reduces ∂A_n and thus fiscal multipliers.

e) Finally, we prove a neutrality result for monetary policy: We show that with log utility over consumption, and no wealth redistribution, inelastic asset markets do not change the effectiveness of monetary policy.

After proving these results in our general framework, we turn to a quantitative version of the model. The quantitative model is fully dynamic, allows for heterogeneous agents in the tradition of Bewley, Aiyagari, and Huggett, and works with three assets: a policy asset (short-term bonds), long-term bonds, and stocks. We calibrate this model to match evidence on intertemporal MPCs, and match evidence that helps pin down the demand

pass-throughs z_n. We then use this model to revisit these experiments from our general framework.

Our results suggest that QE is, in fact, more powerful when buying equities instead of long-term bonds. This finding mainly follows from matching the evidence in Gabaix and Koijen (2023) on the low price elasticity of the demand for stocks, and holds despite our model featuring low MPCs out of stock market gains (as in Chodorow-Reich, Nenov and Simsek 2019).

Further, we find that paradox-of-thrift recessions are indeed milder and more transitory if rich households are pulling back their spending (as during the Covid recession) compared to poor households (as during the Great Recession). Redistribution from rich to poor is still expansionary, though less so than previously thought. Fiscal stimulus is, in fact, significantly more powerful than before when financed by issuing short-term debt, while monetary policy is just as effective.

Literature. Our paper connects to several strands of literature at the intersection between macroeconomics and finance.

Closest to us are several papers that study monetary policy transmission. Kekre and Lenel (2019) show how monetary policy induces redistribution to savers with a high marginal propensity to take risk (MPR), which amplifies the effectiveness monetary policy. Our Proposition 7 confirms this finding, and shows that this logic relies on the savers saving in assets with high demand pass-through $\mathbf{z}$. Kekre, Lenel and Mainardi (2022) study a similar mechanism in a model with short-term and long-term bonds. In Bernanke, Gertler and Gilchrist (1999), monetary policy redistributes towards entrepreneurs. The entrepreneurs invest in capital, an asset with a z of 1, amplifying monetary policy.

However, not all papers have found amplification of monetary policy. The model in Kaplan, Moll and Violante (2018) has two assets, a liquid (policy) asset and an illiquid asset (capital). Households save in both and cannot perfectly intermediate between the two accounts. Since there is no additional financial intermediation, this gives rise to an inelastic market for capital. Firms only have access to the illiquid asset. In response to monetary easing, firms are forced to invest more to cover rising aggregate demand, which, interpreting firms as agents in our framework, effectively gives them a negative income elasticity. Therefore, monetary policy redistributes away from agents with a high marginal propensity to save in the illiquid account, pushing up the illiquid return and dampening monetary policy.

Luetticke (2021) also studies a two-asset heterogeneous-agent model. It introduces the concept of "marginal propensities to invest" (MPI), identical to our MPS_n in his applica-

tion for asset n being the illiquid asset. Luetticke (2021) conjectures that agents with high MPI may contribute more to aggregate demand via investment, though he does not formally characterize this mechanism, as we do in this paper. Closest to use in the space of heterogeneous-agent models is Chiang and Zoch (2023). This paper studies QE and tax cuts in a model much like Kaplan et al. (2018), except that it allows for frictional financial intermediation. The paper derives a Keynesian cross like equation, similar to ours. Frictional financial intermediation reduces the power of QE, e.g. relative to Cui and Sterk (2018). Chiang and Zoch (2023) compare this to tax cuts.

There has been a renewed interest in models with inelastic (or segmented) asset markets over the last few years, led by, among others, Gabaix and Maggiori (2015), Itskhoki and Mukhin (2017), and, in particular, Gabaix and Koijen (2023). On the empirical side, this is closely connected to the literature around the demand system based approach to asset pricing (Koijen and Yogo 2018).

2 Analytical framework

Our economy is an infinite-horizon economy, with periods $t = 0, 1, 2, \ldots$. The economy is populated by a continuum of households of a discrete set of types $i = 1, \ldots, I$. The main period of interest is $t = 0$, which we interpret as the short run. In period $t = 0$, households trade assets, invest in capital, work, and consume. There is aggregate uncertainty, which is resolved once and for all at date $t = 1$. A state $s \in \mathcal{S}$ is realized at the beginning of date $t = 1$ with probability π_s, and conditional on s the continuation economy from date $t = 1$ onward is deterministic. Figure 1 illustrates the setup of the model.

We first formulate household behavior for a fixed $\beta < 1$ and then consider the analytically convenient limit $\beta \nearrow 1$.[2]

2.1 Assets and the long-run continuation problem

There are $N + 1$ date-0 assets, indexed by $n = 0, \ldots, N$. Asset n has date-0 price $q_n \equiv (1 + r_n)^{-1}$ and pays y_{ns} units of date-1 financial wealth in state s, with payoffs normalized so that $\sum_{s \in \mathcal{S}} \pi_s y_{ns} = 1$. We call asset 0 the *policy asset;* its return r_0 is set by monetary policy, as we specify further below. The remaining returns $r_1, \ldots, r_N$ are equilibrium objects.

Once state s is realized, household i enters the long run with financial wealth a^i_{1s} and

[2]See Woodford (2021), GLSW (2021), our Tariff paper for recent papers that have worked with this limit. Since β is close to 1 in typical calibrations, this limit is quantitatively typically not very consequential. Our quantitative model in section 5 will not impose the limit.

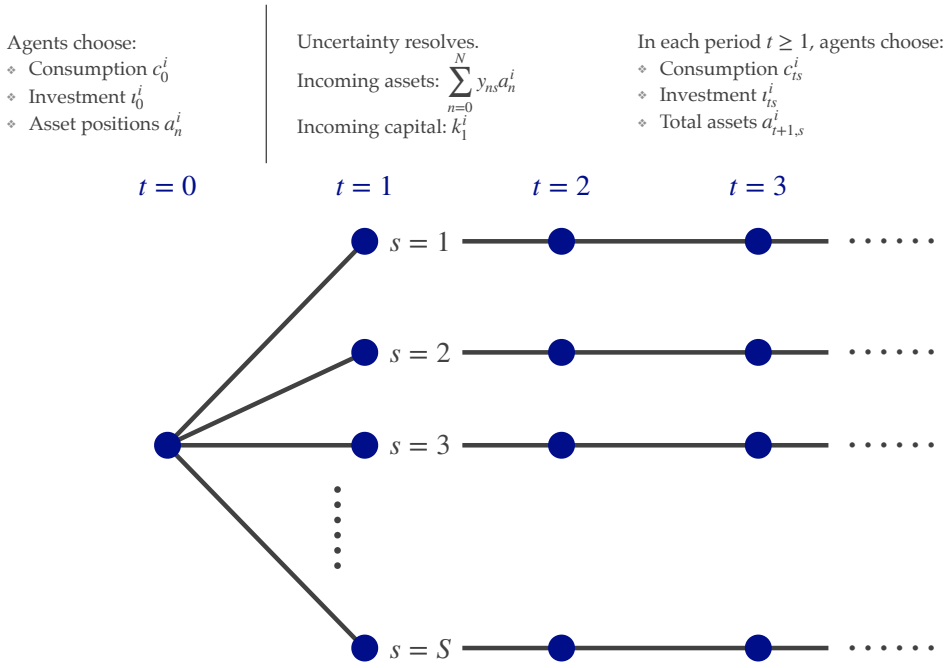


Figure 1: Overview of the analytical framework

physical capital k_1^i. Let

$$\mathcal{P}_s^i \equiv \left\{ r_{ts}, w_{ts}, R_{ts}, \tau_{ts}^i \right\}_{t \geq 1}$$

denote the state-contingent continuation prices and transfers faced by household i. For $\beta < 1$, its continuation value is

$$\mathcal{U}_i \left(a_{1s}^i, k_1^i; \mathcal{P}_s^i \right) = \max_{\{c_{ts}^i, a_{t+1,s}^i, \iota_{ts}^i, k_{t+1,s}^i\}_{t \geq 1}} \sum_{t=1}^{\infty} \beta^{t-1} \left[u_i(c_{ts}^i) - u_i(c^i) \right] \tag{2}$$

subject to

$$c_{ts}^i + q_{ts} a_{t+1,s}^i + \iota_{ts}^i = a_{ts}^i + w_{ts} + R_{ts} k_{ts}^i + \tau_{ts}^i, \tag{3}$$

$$k_{t+1,s}^i = (1 - \delta) k_{ts}^i + \iota_{ts}^i, \tag{4}$$

where $q_{ts} \equiv (1 + r_{ts})^{-1}$, together with the usual no-Ponzi and transversality conditions. We subtract the utility of steady-state consumption c^i, which we introduce below, as a normalization. It does not affect choices but helps with the limit $\beta \nearrow 1$ (see Woodford, 2021). Whenever both one-period financial saving and physical investment are interior in

the long run, household optimality implies the no-arbitrage relation

$$r_{ts} = R_{ts} - \delta.$$

2.2 Date-0 household problem

Household i has population weight μ^i, initial holdings α_n^i of asset n, and predetermined physical capital k_0^i. At date 0 it chooses consumption c_0^i, labor l_0^i, portfolio holdings $\{a_n^i\}_{n=0}^N$, and physical investment ι_0^i. Its date-1 capital is

$$k_1^i = (1-\delta)k_0^i + \iota_0^i,$$

and the date-1 financial wealth delivered by its date-0 portfolio in state s is

$$\overline{a}_{1s}^i \equiv \sum_{n=0}^N y_{ns} a_n^i.$$

The date-0 problem is

$$\max_{c_0^i, l_0^i, \{a_n^i\}, \iota_0^i} u_i(c_0^i) - v_i(l_0^i) + h_i\left(\{a_n^i\}_{n=0}^N, k_1^i; \{\mathcal{P}_s^i\}_{s\in\mathcal{S}}\right) \tag{5}$$

subject to

$$c_0^i + \sum_{n=0}^N q_n a_n^i + \iota_0^i \leq w_0 l_0^i + R_0 k_0^i + \sum_{n=0}^N q_n \alpha_n^i + \tau_0^i. \tag{6}$$

The continuation aggregator h_i is deliberately general. A convenient representation is

$$h_i\left(\{a_n^i\}, k_1^i; \{\mathcal{P}_s^i\}_s\right) = \mathcal{H}_i\left(\{a_n^i\}, k_1^i, \mathbb{E}_s \mathcal{V}_i\left(\{a_n^i\}, k_1^i, \mathcal{U}_i\left(\overline{a}_{1s}^i, k_1^i; \mathcal{P}_s^i\right)\right)\right). \tag{7}$$

This nests expected utility as a special case, but also allows nonseparabilities between date-0 choices and long-run utility, recursive preferences, portfolio frictions, heterogeneous beliefs, and idiosyncratic risk inside the continuation value. The object h_i is not itself random at date 0; uncertainty enters through the distribution of s and through the state-contingent continuation values. The main restriction in 7 is that future prices $\mathcal{P}_s^i$ only enter through continuation utility $\mathcal{U}_i\left(\overline{a}_{1s}^i, k_1^i; \mathcal{P}_s^i\right)$.

2.3 Production and nominal rigidity

Output is produced with physical capital and labor according to

$$Y_t = A_t K_t^{\alpha} L_t^{1-\alpha}. \tag{8}$$

In the long run, after state s has been realized, factor prices are flexible and satisfy

$$R_{ts} = \alpha A_{ts} \left(\frac{L_{ts}}{K_{ts}} \right)^{1-\alpha}, \qquad w_{ts} = (1-\alpha) A_{ts} \left(\frac{K_{ts}}{L_{ts}} \right)^{\alpha}. \tag{9}$$

Aggregate capital is

$$K_{ts} = \sum_{i=1}^{I} \mu^i k_{ts}^i.$$

At date 0, the capital stock K_0 is predetermined. A nominal wage rigidity makes aggregate output Y_0 demand determined. Conditional on a value of Y_0, firms hire the labor needed to produce it,

$$L_0 = \left(\frac{Y_0}{A_0 K_0^{\alpha}} \right)^{\frac{1}{1-\alpha}}. \tag{10}$$

Factor payments are then

$$R_0 K_0 = \alpha Y_0, \qquad w_0 L_0 = (1-\alpha) Y_0. \tag{11}$$

We assume that the union allocation of labor and the ownership of predetermined capital imply that household i receives a fixed share of date-0 factor income,

$$w_0 l_0^i + R_0 k_0^i = \eta^i Y_0, \qquad \sum_{i=1}^{I} \mu^i \eta^i = 1. \tag{12}$$

Equivalently, $\eta^i = (1-\alpha)\eta_L^i + \alpha \eta_K^i$ for household-specific labor and capital income shares η_L^i and η_K^i.

Let$x_n^i \equiv a_n^i - \alpha_n^i$ denote net purchases of asset n. Since date-0 labor is allocated by the union once aggregate demand is known, the labor-disutility term can be suppressed in the marginal asset-market calculations. The date-0 household problem can then be summarized by the reduced budget constraint

$$c_0^i + \sum_{n=0}^{N} q_n x_n^i + \iota_0^i \leq \eta^i Y_0 + \tau_0^i, \tag{13}$$

and by the continuation term

$$h_i\left(\{\alpha_n^i + x_n^i\}_{n=0}^N, (1-\delta)k_0^i + \iota_0^i; \{\mathcal{P}_s^i\}_{s\in\mathcal{S}}\right).$$

2.4 Government and monetary policy

At date 0, the fiscal authority chooses government purchases G_0, household transfers $\{\tau_0^i\}_{i=1}^I$, and net supplies $\{B_n\}_{n=0}^N$ of the date-0 assets. A positive B_n means that the government issues asset n to the private sector; a negative value means that the consolidated government purchases that asset. The date-0 government budget constraint is

$$G_0 + \sum_{i=1}^{I} \mu^i \tau_0^i = \sum_{n=0}^{N} q_n B_n. \tag{14}$$

The date-0 assets mature at date 1. Let the continuation government's inherited one-period obligation in state s be

$$\mathcal{B}_{1s} = \sum_{n=0}^{N} y_{ns} B_n.$$

For $t \geq 1$, a continuation fiscal plan satisfies

$$G_{ts} + \sum_{i=1}^{I} \mu^i \tau_{ts}^i + \mathcal{B}_{ts} = q_{ts}\mathcal{B}_{t+1,s}, \qquad t \geq 1, \tag{15}$$

together with a no-Ponzi condition. In the finite-β economy, the entire continuation fiscal plan can affect date-0 choices through h_i. In the limiting economy below, finite changes in future fiscal instruments are absorbed into the long-run normalization and do not enter the date-0 demand functions as independent state variables. Current transfers τ_0^i and current asset supplies B_n remain relevant.

Monetary policy sets the return on the policy asset, r_0. One interpretation is that a central bank elastically adjusts the supply of money or reserves to implement the desired return on short government liabilities. We therefore treat r_0 as an exogenous policy variable, while non-policy returns $r_1, \ldots, r_N$ adjust to clear their asset markets.

2.5 The long-run limit

For $\beta < 1$, date-0 choices generally depend on the entire state-contingent continuation environment $\{\mathcal{P}_s^i\}_{s\in\mathcal{S}}$, including future transfers. We now describe a useful limit under which those future objects drop out of the short-run demand system.

The limit involves two primitives, β and δ, as well as all initial stocks, α_n^i, B_n, k_0^i. Specifically, starting from some initial equilibrium with primitives β, δ and initial stocks α_n^i, B_n, k_0^i, we construct new ones by rescaling with $\lambda > 0$,

$$\beta \mapsto \frac{\beta}{\beta + \lambda (1 - \beta)}, \qquad \delta \mapsto \delta\lambda$$

$$\alpha_n^i \mapsto \alpha_n^i / \lambda, \qquad B_n \mapsto B_n / \lambda, \qquad k_0^i \mapsto k_0^i / \lambda$$

The following proposition proves that household behavior is well-defined in the limit $\lambda \to 0$.

Proposition 1. *In the limit $\lambda \to 0$, optimal consumption, investment, and asset policies converge to well-defined functions*

$$c_0^i \left(Y_0, \{r_m\}_{m=0}^N; \tau_0^i \right), \ \iota_0^i \left(Y_0, \{r_m\}_{m=0}^N; \tau_0^i \right), \ x_n \left(Y_0, \{r_m\}_{m=0}^N; \tau_0^i \right)$$

In particular, the functions are independent of $\{\mathcal{P}_s^i\}_{s \in \mathcal{S}}$.

What is convenient about these functions is that they are no longer dependent on future prices $\{\mathcal{P}_s^i\}_{s \in \mathcal{S}}$. This is because with β approaching 1, the marginal propensity to spend out of income or wealth in the long run periods $t = 1, 2, \ldots$ is approaching zero.

2.6 Reduced-form demand functions and marginal propensities

In the limiting short-run problem, aggregate consumption, net asset demand, and physical investment are functions only of current aggregate income, current asset returns, and current transfers:

$$C_0 = \sum_{i=1}^I \mu^i c_0^i = C_0 \left(Y_0, \{r_m\}_{m=0}^N; \{\tau_0^i\}_{i=1}^I \right), \tag{16}$$

$$X_n = \sum_{i=1}^I \mu^i \left(a_n^i - \alpha_n^i \right) = X_n \left(Y_0, \{r_m\}_{m=0}^N; \{\tau_0^i\}_{i=1}^I \right), \tag{17}$$

$$I_0 = \sum_{i=1}^I \mu^i \iota_0^i = I_0 \left(Y_0, \{r_m\}_{m=0}^N; \{\tau_0^i\}_{i=1}^I \right). \tag{18}$$

Here X_n is measured in units of asset n. Linear changes in asset quantities below are always valued at date-0 prices.

Let private absorption be$D_0 \equiv C_0 + I_0$. We define marginal propensities out of current

aggregate income by

$$MPC_C \equiv \frac{\partial C_0}{\partial Y_0}, \qquad MPI \equiv \frac{\partial I_0}{\partial Y_0}, \qquad MPD \equiv MPC_C + MPI, \qquad MPS_n \equiv q_n \frac{\partial X_n}{\partial Y_0}, \qquad MPD + \sum_{n=0}^{N} MPS \tag{19}$$

Thus MPD is the marginal propensity to spend on private absorption, while MPC_C is the consumption-only MPC. In the special case without date-0 investment, $MPD = MPC_C$.

Return elasticities are defined using private absorption and value-weighted net asset demands:

$$\sigma_n \equiv -\frac{1}{Y_0} \frac{\partial D_0}{\partial \log(1+r_n)}, \qquad E_{nm} \equiv q_n \frac{1}{Y_0} \frac{\partial X_n}{\partial \log(1+r_m)}, \qquad -\sigma_m + \sum_{n=0}^{N} E_{nm} = 0. \tag{20}$$

Relative to a model without investment, σ_n is the elasticity of total private absorption $C_0 + I_0$, not only consumption. We stack non-policy-asset objects as

$$\boldsymbol{\sigma} = (\sigma_n)_{n=1}^{N}, \qquad \mathbf{E} = (E_{nm})_{n,m=1}^{N}, \qquad \mathbf{e} = -(E_{n0})_{n=1}^{N}, \qquad \mathbf{MPS} = (MPS_n)_{n=1}^{N}.$$

Throughout the local analysis we assume $\mathbf{E}$ is invertible.

2.7 Equilibrium in the limiting economy

Proposition 2. *Given current policy $(r_0, G_0, \{\tau_0^i\}_i, \{B_n\}_{n=0}^N)$ satisfying the date-0 government budget constraint, aggregate output Y_0 and non-policy returns $r_1, \ldots, r_N$ are part of a competitive equilibrium in the limiting economy if and only if the non-policy asset markets clear,*

$$X_n\left(Y_0, \{r_m\}_{m=0}^N; \{\tau_0^i\}_{i=1}^I\right) = B_n, \qquad n = 1, \ldots, N, \tag{21}$$

and the goods market clears,

$$G_0 + C_0\left(Y_0, \{r_m\}_{m=0}^N; \{\tau_0^i\}_{i=1}^I\right) + I_0\left(Y_0, \{r_m\}_{m=0}^N; \{\tau_0^i\}_{i=1}^I\right) = Y_0. \tag{22}$$

The market for the policy asset clears by Walras' law.

The proposition reduces the infinite-horizon model with physical capital to a static short-run system. Relative to the no-investment benchmark, the only change is that the private-spending block is governed by $D_0 = C_0 + I_0$ and by MPD rather than by consumption alone.

3 Demand pass-through and inelastic Keynesian cross

We solve the equilibrium conditions (21) and (22) to first order around an initial equilibrium with zero net government positions in the non-policy assets, $B_n = X_n = 0$ for $n = 1, \ldots, N$. This avoids mechanical valuation terms. Below, $dr_n \equiv d\log(1 + r_n)$, $d\mathbf{r} = (dr_n)_{n=1}^N$, and dB_n denotes the date-0 value $q_n\, dB_n^{\text{qty}}$ of the change in the supply of asset n.

Linearizing the non-policy asset markets gives, for $n = 1, \ldots, N$,

$$MPS_n\, dY_0 - Y_0 e_n\, dr_0 + \sum_{m=1}^{N} E_{nm} Y_0\, dr_m + \frac{\partial X_n^v}{\partial\{\tau_0\}} d\{\tau_0\} = dB_n. \tag{23}$$

Here $X_n^v \equiv q_n X_n$ is the value of private net demand for asset n, and

$$\frac{\partial X_n^v}{\partial\{\tau_0\}} d\{\tau_0\} \equiv q_n \sum_{i=1}^{I} \frac{\partial X_n}{\partial \tau_0^i} d\tau_0^i.$$

There are no future-transfer terms because the limiting demand functions depend only on current transfers.

Linearizing the goods market gives

$$\frac{\partial D_0}{\partial\{\tau_0\}} d\{\tau_0\} + dG_0 - \sigma_0 Y_0 dr_0 - \sum_{n=1}^{N} \sigma_n Y_0 dr_n + MPD\, dY_0 = dY_0, \tag{24}$$

where $D_0 = C_0 + I_0$.

3.1 Demand pass-through

Consider a pure asset-market experiment. Demand for non-policy asset n increases by one dollar of date-0 goods, while demand for the policy asset falls by one dollar. Holding output and the policy rate fixed, market clearing requires

$$Y_0 \sum_{m=1}^{N} E_{nm} dr_m + \partial A_n = 0, \qquad Y_0 \sum_{m=1}^{N} E_{n'm} dr_m = 0 \quad \text{for } n' \neq n.$$

Thus

$$d\mathbf{r} = -\left(\mathbf{E}^{-1}\right)_{:,n} \frac{\partial A_n}{Y_0}.$$

The induced change in private absorption is

$$-Y_0\boldsymbol{\sigma}'d\mathbf{r} = \boldsymbol{\sigma}'\left(\mathbf{E}^{-1}\right)_{:,n}\partial A_n = z_n\partial A_n.$$

Definition 1. The demand pass-through of asset n is z_n, where

$$\mathbf{z} = (z_n)_{n=1}^{N} \equiv \mathbf{E}'^{-1}\boldsymbol{\sigma}. \tag{25}$$

Demand pass-through measures the amount of aggregate private demand generated when one dollar is moved from the policy asset into asset n. In a perfectly elastic asset market, the extra demand for asset n is absorbed without moving any return relative to the policy rate, so $\mathbf{z} = 0$. With inelastic asset markets, the same saving flow lowers the return on asset n and on related assets; those lower returns stimulate private absorption. Because $\boldsymbol{\sigma}$ is defined using $C_0 + I_0$, this pass-through includes both consumption and investment responses.

Proposition 3. *Suppose private absorption and assets are gross substitutes in aggregate: $\sigma_n > 0$ for all non-policy assets and $E_{mn} < 0$ for $m \neq n$. If $\mathbf{E}$ is invertible, then $z_n \in (0,1)$ for all $n = 1,\ldots,N$.*

The result follows from the adding-up restriction in (20). Under the gross-substitutes assumption, the substitution matrix is an M-matrix after the standard sign change, so the relevant inverse is positive. Adding-up then implies that each non-policy asset's pass-through lies strictly between zero and one.

3.2 Inelastic Keynesian cross with investment

Define the exogenous asset-market shifter ∂A_n by rewriting (23) as

$$\sum_{m=1}^{N} E_{nm}Y_0 dr_m + MPS_n\, dY_0 + \underbrace{-Y_0 e_n\, dr_0 + \frac{\partial X_n^v}{\partial\{\tau_0\}}d\{\tau_0\} - dB_n}_{\equiv\partial A_n} = 0. \tag{26}$$

Stacking across assets gives

$$-Y_0\boldsymbol{\sigma}'d\mathbf{r} = \mathbf{z}'\mathbf{MPS}\, dY_0 + \mathbf{z}'\partial\mathbf{A}.$$

Similarly, define the direct goods-demand shifter

$$\partial D \equiv \frac{\partial D_0}{\partial\{\tau_0\}} d\{\tau_0\} + dG_0 - \sigma_0 Y_0 dr_0.$$

Substituting the return effect from asset-market clearing into (24) gives

$$\partial D + \mathbf{z}'\partial\mathbf{A} + \left(MPD + \mathbf{z}'\mathbf{MPS}\right) dY_0 = dY_0. \tag{27}$$

If investment is absent, $D_0 = C_0$, $MPD = MPC_C$, and this expression reduces to the no-investment version.

Proposition 4. *The linearized output response to a general fiscal or monetary policy shock solves*

$$dY_0 = \partial D + \underbrace{\mathbf{z}'\partial\mathbf{A}}_{\text{asset-market direct effect}} + \underbrace{\left(MPD + \mathbf{z}'\mathbf{MPS}\right)}_{\text{asset-market adjusted spending propensity}} dY_0. \tag{28}$$

Equivalently,

$$dY_0 = \frac{\partial D + \mathbf{z}'\partial\mathbf{A}}{1 - MPD - \mathbf{z}'\mathbf{MPS}}. \tag{29}$$

Equation (28) is the inelastic Keynesian cross with physical investment. Shocks to asset-market clearing matter directly through $\mathbf{z}'\partial\mathbf{A}$, and the multiplier is governed by the asset-market adjusted spending propensity $MPD + \mathbf{z}'\mathbf{MPS}$. The first term captures the direct response of private absorption to income; the second captures the fact that saving out of extra income can itself stimulate demand by pushing down non-policy returns.

4 Applications

Building on proposition 4, we now consider five applications. In each case, the exercise is to identify the direct private-absorption shifter ∂D and the asset-market shifter $\partial\mathbf{A}$. It is useful to write

$$\mathcal{K} \equiv \frac{1}{1 - MPD - \mathbf{z}'\mathbf{MPS}}$$

for the inelastic Keynesian-cross multiplier. At the household level, MPD^i and $\mathbf{MPS}^i$ denote marginal propensities of private absorption and value-weighted non-policy asset demand out of one dollar of current income.

4.1 Quantitative easing

Quantitative easing (QE) is an asset-supply experiment. Suppose the consolidated government buys dx dollars of non-policy asset m from the private sector and issues the policy asset in exchange. The supply of asset m available to private portfolios falls, so $dB_m = -dx$ and therefore $\partial A_m = dx$. There is no direct goods-demand shifter, $\partial D = 0$. Hence

$$dY_0 = \mathcal{K} z_m dx.$$

QE expands output whenever the purchased asset has positive demand pass-through. The larger is z_m, the larger is the effect of a given purchase; the induced demand impulse is then amplified by $\mathcal{K}$.

4.2 Paradox of thrift

Consider a spending retrenchment by a group of households. They reduce private absorption by dc and save the proceeds in non-policy assets according to the value-weighted portfolio vector $\mathbf{s}^i$. Then

$$\partial D = -dc, \qquad \partial \mathbf{A} = \mathbf{s}^i dc,$$

and the output response is

$$dY_0 = -\mathcal{K}\left(1 - \mathbf{z}'\mathbf{s}^i\right) dc.$$

A thrift shock is less contractionary when the additional saving is directed toward high-z assets, because the induced asset-price movement stimulates private absorption. If the extra saving is directed entirely to the policy asset, then $\mathbf{z}'\mathbf{s}^i = 0$ and the usual demand loss is not offset by asset-market pass-through.

4.3 Redistribution

Next consider a transfer dx from a rich household type r to a poor household type p. The direct private-absorption shifter is

$$\partial D = \left(MPD^p - MPD^r\right) dx,$$

while the asset-market shifter is

$$\partial \mathbf{A} = \left(\mathbf{MPS}^p - \mathbf{MPS}^r\right) dx.$$

Therefore

$$dY_0 = \mathcal{K}\left[MPD^p + \mathbf{z}'\mathbf{MPS}^p - MPD^r - \mathbf{z}'\mathbf{MPS}^r\right] dx.$$

Redistribution is governed by differences in asset-market adjusted spending propensities, $MPD^i + \mathbf{z}'\mathbf{MPS}^i$, not by consumption MPCs alone. A recipient with a modest consumption response can still generate a large aggregate effect if its marginal saving flows to high-pass-through assets.

4.4 Fiscal stimulus

The limiting formulation gives a particularly clean fiscal policy result because future taxes no longer enter the date-0 demand functions. Consider a date-0 government-purchase shock dG_0 financed by issuing assets in value proportions $\mathbf{b} = (b_n)_{n=0}^N$, where $b_n \geq 0$ and $\sum_{n=0}^N b_n = 1$. In this subsection we extend the pass-through vector by setting $z_0 = 0$ for the policy asset; inner products with $\mathbf{z}$ therefore include asset 0 without changing the previous non-policy formulas. The shock is

$$\partial D = dG_0, \qquad \partial \mathbf{A} = -\mathbf{b}\, dG_0.$$

The minus sign appears because additional government supply must be absorbed by private portfolios.

Define the marginal propensity to rebalance across all assets by

$$\mathbf{MPR} \equiv \frac{\mathbf{MPS}}{1 - MPD}, \tag{30}$$

where $\mathbf{MPS} = (MPS_0, \ldots, MPS_N)$ in this subsection and the division is by the scalar $1 - MPD = \sum_{n=0}^N MPS_n$.

Proposition 5. *For the government-purchase shock financed by the asset-issuance vector* $\mathbf{b}$*, the output multiplier is*

$$\frac{dY_0}{dG_0} = \frac{1 - \mathbf{z}'\mathbf{b}}{1 - MPD - (1 - MPD)\mathbf{z}'\mathbf{MPR}} = \left(1 + \frac{\mathbf{z}'(\mathbf{MPR} - \mathbf{b})}{1 - \mathbf{z}'\mathbf{MPR}}\right) \frac{1}{1 - MPD}. \tag{31}$$

If $\mathbf{b} = \mathbf{MPR}$*, then* $dY_0/dG_0 = 1/(1 - MPD)$ *and the multiplier is independent of the degree of asset-market inelasticity.*

The algebra is transparent from the inelastic Keynesian cross:

$$dY_0 = dG_0 - \mathbf{z}'\mathbf{b}\, dG_0 + MPD\, dY_0 + (1 - MPD)\mathbf{z}'\mathbf{MPR}\, dY_0.$$

Borrowing tilted toward high-pass-through assets, meaning a large $\mathbf{z}'\mathbf{b}$ relative to $\mathbf{z}'\mathbf{MPR}$, lowers the multiplier. Borrowing tilted toward low-pass-through assets raises it. In the no-investment special case, $MPD = MPC_C$ and this expression becomes the familiar consumption-only formula.

The same logic applies to any partial-equilibrium goods-demand shock. Let ∂D be an increase in private or public demand for goods, and suppose it is financed by asset issuance in proportions $\mathbf{a}$, so that $\partial \mathbf{A} = -\mathbf{a}\,\partial D$. Then

$$dY_0 = \left(1 + \frac{\mathbf{z}'(\mathbf{MPR} - \mathbf{a})}{1 - \mathbf{z}'\mathbf{MPR}}\right) \frac{\partial D}{1 - MPD}. \tag{32}$$

Thus the aggregate effect of a spending shock depends not only on the size of the direct demand impulse, but also on which assets are supplied or retired to finance it. For example, a corporate investment boom financed by issuing claims with high demand pass-through can have a smaller multiplier than the same boom financed by issuing claims with low pass-through or by reducing payouts on low-pass-through assets.

4.5 Monetary policy

A monetary policy shock is a change in the policy return $dr_0 = d\log(1 + r_0)$. Holding current fiscal instruments fixed, equations (26) and (27) imply

$$\partial \mathbf{A} = -Y_0 \mathbf{e}\, dr_0, \qquad \partial D = -\sigma_0 Y_0 dr_0.$$

Hence the general output response is

$$d\log Y_0 = -\frac{\sigma_0 + \mathbf{z}'\mathbf{e}}{1 - MPD - \mathbf{z}'\mathbf{MPS}}\, dr_0. \tag{33}$$

In elastic asset markets, all returns move one-for-one with the policy rate and the comparable response is

$$d\log Y_0 = -\frac{\sum_{n=0}^{N} \sigma_n}{1 - MPD}\, dr_0. \tag{34}$$

Inelastic markets dampen the direct movement in non-policy returns, but they also raise the spending multiplier through $\mathbf{z}'\mathbf{MPS}$. The net effect depends on both forces.

Proposition 6. *Consider the no-local-investment benchmark $MPI = 0$, so that $MPD = MPC_C$. If there are no date-0 transfers, all households have log date-0 utility, and date-0 income scales*

proportionally with aggregate output for every household, then a monetary policy shock satisfies

$$d \log Y_0 = -dr_0. \tag{35}$$

The output effect is independent of the elasticity of asset markets, and all non-policy returns move one-for-one with the policy return.

The neutrality benchmark is useful because it isolates two offsetting forces. Inelastic markets weaken the direct pass-through from the policy return to other returns. At the same time, any income response induces extra saving, and saving in high-z assets creates additional demand. Under the assumptions of the proposition, these two forces exactly offset.

Proposition 7. *In the same no-local-investment benchmark, allow household i's date-0 income to have elasticity χ^i with respect to aggregate output. Define household marginal portfolio shares by*

$$\mathbf{MPR}^i \equiv \frac{\mathbf{MPS}^i}{1 - MPC_C^i}.$$

Then the output response to a monetary policy shock can be written as

$$d \log Y_0 = -\frac{1}{1 - \frac{\mathrm{Cov}_i\left[MPC_C^i, \chi^i\right]}{1 - MPC_C}} \left(1 + \frac{\mathrm{Cov}_{1-MPC_C}\left[\mathbf{z}'\mathbf{MPR}^i, \chi^i\right]}{1 - \frac{\mathrm{Cov}_i\left[MPC_C^i, \chi^i\right]}{1 - MPC_C} - \mathbb{E}_{1-MPC_C}\left[\mathbf{z}'\mathbf{MPR}^i \chi^i\right]} \right) dr_0. \tag{36}$$

Here Cov_{1-MPC_C} and $\mathbb{E}_{1-MPC_C}$ use weights proportional to $\mu^i(1 - MPC_C^i)$. If all households have identical marginal portfolio shares, the inelastic-market term collapses and the response coincides with the elastic-market benchmark.

5 Quantitative model

5.1 Setup

Assets. There are three assets in this economy, a short-term (ST) bond, a long-term (LT) bond with a payment stream $1, \delta, \delta^2, \ldots$, and an equity that pays dividend d_t in each period t. Their prices are $q_{ST,t}, q_{LT,t}, p_t$, and the returns from period t to $t+1$ satisfy $1 + r_{ST,t+1} = \frac{1}{q_{ST,t}}, 1 + r_{LT,t+1} = \frac{1+\delta q_{LT,t+1}}{q_{LT,t}}, r_{e,t+1} = \frac{p_{t+1}+d_{t+1}}{p_t}$. The ST and LT bonds are issued by both the government and the firm, whereas the equity is in unit supply and is

a claim on the firm's dividends. At the steady state, the asset prices are q_{ST}, q_{LT}, p and returns are r_{ST}, r_{LT}, r_e.

Financial intermediary. There is a financial intermediary that invests in the three assets in the economy. In allocating investment, its manager maximizes a nested CES objective period by period, with $\eta_e^I + \eta_b^I = \eta_{LT}^I + \eta_{ST}^I = 1$,

$$\begin{aligned}\max_{\{w_{e,t}^I, w_{LT,t}^I, w_{ST,t}^I\}} & \left(\eta_e^I\right)^{\frac{1}{\sigma_e}} \left[\left(\frac{1+\mathrm{E}_t\, r_{e,t+1}}{1+r_e}\right) w_{e,t}^I\right]^{\frac{\sigma_e-1}{\sigma_e}} \\ & + (\eta_b)^{\frac{1}{\sigma_e}} \left\{\sum_{n\in\{LT,ST\}} \left(\eta_n^I\right)^{\frac{1}{\sigma_b}} \left[\left(\frac{1+\mathrm{E}_t\, r_{n,t+1}}{1+r_n}\right) w_{n,t}^I\right]^{\frac{\sigma_b-1}{\sigma_b}}\right\}^{\frac{\sigma_b}{\sigma_b-1}\frac{\sigma_e-1}{\sigma_e}}\end{aligned} \tag{37}$$

subject to

$$\sum_{n\in\{e,LT,ST\}} w_{n,t}^I \leq w_t^I \tag{38}$$

At the steady state, when returns follow $\mathrm{E}_t\, r_{n,t+1} = r_n, \forall n \in \{e, LT, ST\}$, the optimal portfolio share in equity, LT bond and ST bond is $\eta_e^I, \eta_b^I\eta_{LT}^I, \eta_b^I\eta_{ST}^I$ respectively. Away from the steady state, the portfolio choice is governed by constant elasticities σ_e, σ_b and gives rise to an intermediary portfolio return $r_{I,t+1}$.

Households. There are six permanent-income groups. Each group g has a μ_g mass (normalized so that $\sum_g \mu_g = 1$ across groups) of infinitely-lived households indexed by i, who face idiosyncratic income processes. Each agent i has an idiosyncratic ability state e_{it} that follows a Markov process with fixed transition matrix Π. The mass of agents in state e is always equal to π_e, the probability of e in the stationary distribution of Π. We normalize idiosyncratic productivity levels e to have mean one, so $\sum_e \pi_e e = 1$. Each agent i's post-tax labor income is given by $x_{it} = \frac{e_{it}^{1-\theta}}{\int e_{it}^{1-\theta}} X_t^g$ in which X_t^g is the total labor income earned by the permanent-income group g. We denote X_t as the aggregate labor income and assume that $X_t^g = \bar{e}_g X_t$ with $\bar{e}_g \mu_g^{-1}$ capturing permanent difference in productivity across groups.

Each agent i saves in an illiquid account a and a liquid account b. The liquid account consists entirely of ST bond. The illiquid account of each agent in group i invests a fixed (dollar) share in the intermediary, equity, LT bond, and ST bond with share $\left(\eta_I^i, \eta_e^i, \eta_{LT}^i, \eta_{ST}^i\right)$ that add up to one. We model the illiquidy account a la Calvo after Bayer, Born and Luetticke (2020).

Each agent i maximizes her life-time utility by choosing consumption and savings

$$\max \mathrm{E}_0 \left[\sum_{t=0}^{\infty} \beta_i^t \frac{(\tilde{c}_{it})^{1-\theta}}{1-\theta} \right] \tag{39}$$

subject to

$$\begin{aligned} \tilde{c}_{it} + b_{it} &= x_{it} + (1 + r_{ST,t} - \zeta)\, b_{i,t-1} - nt_{it} \cdot 1_{\{adj_{it}=1\}} && (40) \\ a_{it} &= \left(1 + r_{a,t}^{g}\right) a_{i,t-1} + nt_{it} \cdot 1_{\{adj_{it}=1\}} && (41) \\ a_{it}, b_{it} &\geq 0 && (42) \end{aligned}$$

where nt_{it} represents net transfer from the illiquid account to the liquid account. Within the illiquid account, the portfolio is rebalanced in each period. But the treansfer between the illiquid account and the liquid one happens ($adj_{it} = 1$) with i.i.d. probability ν^g. Saving in the liquid account b incurs a flow cost of $\zeta b_{i,t-1}$ paid in period t. Thus consumption inclusive of the liquidity services is

$$c_{it} \equiv \tilde{c}_{it} + \zeta b_{i,t-1} \tag{43}$$

The aggregate consumption is thus $C_t = \int c_{it} di$.

We denote the wealth invested in equity, LT and ST bonds by individual i at time t, either directly or through the intermediary, as $w_{e,it}, w_{LT,it}, w_{ST,it}$. We denote the aggregate savings accordingly as $W_{n,t} = \int w_{n,it} di$ for $n \in \{e, LT, ST\}$.

Firms. There is a unit measure of firms. Each chooses its dividend d_t, quantities of LT and ST debt $b_{LT,t}^f$, $b_{ST,t}^f$ (with steady-state value $\bar{b}_{LT}^f$, $\bar{b}_{ST}^f$), investment i_t, capital k_t and labor input n_t, to maximize the sum of dividends discounted by the equity investor's return

$$\max_{\left\{d_t, b_{LT,t}^f, b_{ST,t}^f, i_t, k_t, n_t\right\}} \sum_{t=0}^{\infty} \mathrm{E}_0 \left[\left(\prod_{s=1}^{t} \frac{1}{1 + r_{e,s}} \right) d_t \right] \tag{44}$$

subject to

$$\tilde{i}_t + \Phi\left(\frac{\tilde{i}_t}{\tilde{i}_{t-1}}\right) \tilde{i}_t + d_t + (1 + \delta q_{LT,t})\, b_{LT,t-1}^f + b_{ST,t-1}^f + \Psi_t + w_t n_t = q_{LT,t} b_{LT,t}^f + q_{ST,t} b_{ST,t}^f + F(k_t, n_t) \tag{45}$$

$$k_{t+1} = (1 - \delta_K)\, k_t + \tilde{i}_t \tag{46}$$

in which $\Phi\left(\frac{\tilde{i}_t}{\tilde{i}_{t-1}}\right)\tilde{i}_t = \frac{\phi}{2}\left(\frac{\tilde{i}_t}{\tilde{i}_{t-1}}-1\right)^2\tilde{i}_t$ and Ψ_t represent investment adjustment cost and financing cost that enter aggregate demand together with investment $\tilde{i}_t$. We denote $i_t = \tilde{i}_t + \Phi\left(\frac{\tilde{i}_t}{\tilde{i}_{t-1}}\right)\tilde{i}_t + \Psi_t$ for an individual firm and $I_t = i_t$ as aggregate investment (including adjustment cost). The production function is Cobb-Douglas

$$F\left(k_t, n_t\right) = k_t^{\alpha} n_t^{1-\alpha} \tag{47}$$

with capital share α. At the equilibrium, the firm's income $X_{f,t} = \alpha Y_t$. The financing cost Ψ_t is linear-quadratic

$$\Psi\left(d_t, \bar{q}_{ST} b^f_{ST,t}, \bar{q} b^f_{LT,t}, k_t\right) = \frac{\varphi}{2} x^2_{div,t} + \frac{\nu_{sum}}{2} x^2_{sum,t} + \frac{\nu_{diff}}{2} x^2_{diff,t} + \nu_{ST} x_{ST,t} + \nu_{LT} x_{LT,t} \tag{48}$$

with linear terms under coefficients $\nu_{ST} = \frac{r_e - r_{ST}}{1+r_e}, \nu_{LT} = \frac{r_e - r_{LT}}{1+r_e}$

$$\begin{aligned} x_{ST,t} &= q_{ST}\left(b^f_{ST,t} - b^f_{ST}\right) \\ x_{LT,t} &= q_{LT}\left(b^f_{LT,t} - b^f_{LT}\right) \end{aligned}$$

and quadratic terms

$$\begin{aligned} x_{div,t} &= d_t - \frac{d}{k} k_t \\ x_{sum,t} &= q_{ST} b^f_{ST,t} + q_{LT} b^f_{LT,t} - \frac{q_{ST} b^f_{ST} + q_{LT} b^f_{LT}}{k} k_t \\ x_{diff,x} &= q_{ST} b^f_{ST,t} - \frac{q_{ST} b^f_{ST}}{b_{LT}} b^f_{LT,t} \end{aligned}$$

The linear terms ensure that firms finance their expenditure with finite amounts of LT and ST bonds even if their interest rates are lower than r_e. Various papers in the literature have used linear-quadratic cost in quantitative macro models to capture firms' financing frictions (Jermann and Quadrini, 2012, Jungherr and Schott, 2021, 2022, Deng and Fang, 2022, Poeschl, 2023), which is without loss of generality as local approximation. Two quadratic costs $\frac{\varphi}{2} x^2_{div,t}$ and $\frac{\nu_{sum}}{2} x^2_{sum,t}$ parametrize the cost of deviation from pre-shock leverage ratio, and the quadratic cost $\frac{\nu_{diff}}{2} x^2_{diff,t}$ regulates the cost of deviation from pre-shock debt maturity. We use book value of debt in these linear-quadratic terms, but our analysis is not sensitive to this choice.

Monetary policy. The monetary authority sets a real interest rate $r_{ST,t+1}$ in each period, which could be achieved via a Taylor rule with a unit coefficient on expected inflation.

In terms of quantitative easing, the monetary authority maintains a non-zero balance sheet that invests in LT bond (or equity) by the dollar amount of $\chi_{LT,t}$ (or $\chi_{e,t}$) financed by selling ST bond by the same dollar amount. Thus the quantities of LT bond, equity, and ST bond on the Fed's balance sheet are

$$b_{LT,t}^{Fed} = \frac{\chi_{LT,t}}{q_{LT,t}},\ e_t^{Fed} = \frac{\chi_{e,t}}{p_t},\ b_{ST,t}^{Fed} = -\frac{\chi_{LT,t} + \chi_{e,t}}{q_{ST,t}}$$

The capital gain or loss from time $t-1$ to t accrues to the fiscal authority discussed next.

Fiscal policy. The government finances its spending by labor income tax T and LT and ST bond of fixed quantities b_{LT}^g, b_{ST}^g. The government budget satisfies

$$\begin{aligned} &T_t + q_{ST,t}\left(b_{ST}^g - b_{ST,t}^{Fed}\right) + q_{LT,t}\left(b_{LT}^g - b_{LT,t}^{Fed}\right) + (d_t + p_t)\, e_{t-1}^{Fed} \\ &= G_t + \left(b_{ST}^g - b_{ST,t-1}^{Fed}\right) + (1 + \delta q_{LT,t})\left(b_{LT}^g - b_{LT,t-1}^{Fed}\right) \end{aligned} \tag{49}$$

Elastic benchmark economy. We compare our economy against an economy with perfectly elastic asset markets. There, we assume that the financial intermediary treats all assets as perfectly substitutable and ensures that all returns move in perfect tandem

$$\frac{1 + \mathrm{E}_t\, r_{e,t+1}}{1 + r_e} = \frac{1 + \mathrm{E}_t\, r_{LT,t+1}}{1 + r_{LT}} = \frac{1 + \mathrm{E}_t\, r_{ST,t+1}}{1 + r_{ST}} \tag{50}$$

The intermediary's portfolio is indeterminate and features portfolio shares $s_{e,t}, s_{LT,t}, s_{ST,t}$ at equilibrium with $s_{e,t} + s_{LT,t} + s_{ST,t} = 1$. At steady state, they equal $\eta_e^I, \eta_b^I \eta_{LT}^I, \eta_b^I \eta_{ST}^I$.

Definition of equilibrium. The equilibrium definition is standard. Households and firms optimize, taking returns as given, and markets clear. The goods market clearing condition is

$$Y_t = C_t + I_t$$

The asset market clearing conditions are

$$\begin{aligned} p_t &= W_{e,t} + p_t e_t^{Fed} \\ q_{LT,t}\left(b_{LT}^g + b_{LT,t}^f\right) &= W_{LT,t} + q_{LT,t} b_{LT,t}^{Fed} \\ q_{ST,t}\left(b_{ST}^g + b_{ST,t}^f\right) &= W_{ST,t} + q_{ST,t} b_{ST,t}^{Fed} \end{aligned}$$

where the last terms with superscript *Fed* indicate QE. Due to the Walras' law, any one of the market clearing conditions is implied by the rest.

5.2 Calibration

Parameters governing steady state. For households, we match moments from 2016 Survey of Consumer Finances. We calculate asset holdings of households between age 25 and 70 as follows: equity holdings are the sum of businesses, directly held stocks, stock mutual funds, other mutual funds and half of combination mutual funds; LT bond holdings are the sum of certificates of deposit, savings bonds, directly held bonds, bond mutual funds, and half of combination mutual funds; ST bond holdings are the sum of all types of transaction accounts including money market accounts and bank accounts; holdings of the financial intermediary are quasi-liquid retirement accounts. We assume six permanent-income groups, based on cuts of asset values of all items above except bank accounts plus primary residence, to capture the uneven distribution of illiquid asset holdings. For each group, we calculate their holdings of all assets as discussed above. We assume that all households invest in the same financial intermediary whose portfolio shares in equity and LT and ST bonds are calculated by pooling quasi-liquid retirement accounts across them.

All households have log utility (with EIS of one), but differ across permanent-income groups in their time-discount factor β^g, Calvo probability ν^g of rebalancing between illiquid and liquid accounts, and their illiquid-account portfolio shares $\eta^{g,a}$ in intermediary, equity, LT and ST bonds at steady state. We assume that the illiquid account consists of financial intermediary, equity, LT and ST bonds, while the liquid account is entirely invested in ST bond. For each group, we set $\eta_I^{g,a}, \eta_e^{g,a}, \eta_{LT}^{g,a}$ in the same proportion as their holdings which leaves us with one degree of freedom $\eta_{ST}^{g,a}$. We choose $\beta^g, \nu^g, \eta_{ST}^{g,a}$ to match three targets: the total holdings (direct and through intermediary) of equity and ST bond, and a target quarterly income-weighted MPC. Due to our choices of $\eta_I^{g,a}, \eta_e^{g,a}, \eta_{LT}^{g,a}$, matching total equity holdings implies matching total LT bond holdings too. As for one-quarter MPC, we target 0.4 for the lowest income group and 0.25 for the rest.

Table 1: Calibrated parameters across permanent-income groups

Household group	1	2	3	4	5	6
Population share	Bottom 50%	Next 20%	Next 10%	Next 10%	Next 5%	Top 5%
Target 1-quarter MPC	0.4	0.25	0.25	0.25	0.25	0.25
Labor income share	22.2%	15.9%	10.6%	14.0%	11.6%	25.6%
Equity wealth share	1.0%	1.9%	2.4%	6.4%	8.8%	79.5%
LT bond wealth share	2.5%	4.9%	6.0%	14.2%	15.7%	56.7%
ST bond wealth share	4.5%	6.7%	6.4%	15.0%	14.6%	52.8%
Quarterly β^g	0.968	0.976	0.982	0.985	0.986	0.984
ν^g	0.683	0.64	0.159	0.058	0.051	0.055
$\eta_{ST}^{g,a}$	19.3%	11.8%	-3.0%	-9.0%	-10.8%	-12.1%

In terms of aggregates, we mostly target the average US numbers since the middle of last century. We set the annual returns of equity, LT and ST bonds as $r_e = 6\%, r_{LT} = 3\%, r_{ST} = 1\%$, and the flow cost of saving in liquid account $\zeta = 5\%$ so that the spread between illiquid and liquid accounts is about 8% across household groups. We set $\delta = 0.95$ at quarterly frequency to target a LT bond duration of about four years, which is the average duration of Treasuries held by investors. The implied LT bond price is thus $q_{LT} = 17.4$. We set quarterly GDP to be one. For the firm, we set the total value of equity (in unit supply) to be 140% of annual GDP, and the total value of LT and ST bonds issued by firms to be 40% and 20% of annual GDP respectively, to be consistent with an equity:bonds:loans ratio of 7:2:1 for US nonfinancial corporate capital structure from Flow of Funds. We set an annual capital depreciation rate $\delta_K = 5.3\%$. We set the total value of LT and ST bonds supplied by the government to be 40% and 20% of annual GDP. These numbers imply a capital share of $\alpha = 18.5\%$, income tax of 28.4% and post-tax labor income of 53.1% of GDP.

Table 2: Calibration

Parameter	Description	Value	Parameter	Description	Value
r_e	Equity returns (p.a.)	0.06	Y	Quarterly GDP	1
r_{LT}	LT bond return (p.a.)	0.03	p	Equity price	5.6
r_{ST}	LT bond return (p.a.)	0.01	d	Dividend	0.084
ζ	Liquid account spread (p.a.)	0.05	q_{LT}	LT bond price	17.39
δ	Decaying rate of LT bond coupon	0.95	$q_{LT}b_{LT}^f$	Value of LT corporate bond	1.6
θ^{-1}	EIS	1	$q_{ST}b_{ST}^f$	Value of ST corporate bond	0.8
ρ_e	Autocorrelation of earnings	0.966	$q_{LT}b_{LT}^g$	Value of LT Treasury	1.6
Σ_e	Cross-sectional std of earnings	0.7	$q_{ST}b_{ST}^g$	Value of ST Treasury	0.8
η_e^I	Equity share of intermediary demand	26.2%	δ_K	Capital depreciation rate (p.a.)	0.053
$\eta_b^I\eta_{LT}^I$	LT share of intermediary demand	54.8%	α	Capital share	0.185
$\eta_b^I\eta_{ST}^I$	ST share of intermediary demand	18.9%	T	Income tax	0.214
σ_e	EoS of intermediary demand	1.5	ϕ	Investment adjustment cost	0.187
σ_b	EoS of intermediary demand	1000.0	φ	Cost of dividend change	14.5
			ν_{sum}	Cost of leverage change	0.002
			ν_{diff}	Cost of debt maturity change	0.06

Parameters governing impulse responses. There are two groups of parameters that matter for impulse responses, the cost parameters of firm $(\phi, \varphi, \nu_{sum}, \nu_{diff})$ and the elas-

ticities of intermediary demand (σ_e, σ_b).

For the firm, we exactly match four moments from the literature: the sensitivity of investment to Tobin's Q from Philippon (2009, Table III), the sensitivity of net equity repurchases to equity price change and the sensitivity of bond issuance to term premium from Ma (2019, Tables III and VII), and the sensitivity of LT share in bond issuance to term premium from Baker, Greenwood and Wurgler (2003, Tables 3 and 7).

For the intermediary, we target two demand elasticities estimated in the literature: the sensitivity of stock price to demand shock and the semi-elasticity of LT bond return to demand shock. Gabaix and Koijen (2023) estimate the former to be around 5 and review other estimates in the literature that has a lower bound of 1.5 from Hartzmark and Solomon (2022). Mian, Straub and Sufi (2022) summarize estimates on the latter, most of which lie in the range of -1.1% to -2.5%. We set the intermediary elasticities $(\sigma_e, \sigma_b) = (1.5, 1000)$ which imply a stock price sensitivity of 2.5 and a LT bond return semi-elasticity of -1.8%.

5.3 Intertemporal inelastic Keynesian cross

We generalize the inelastic Keynesian cross from our 2-period setting to this infinite-horizon setting. We use bold letters for vectors and matrices to denote the sequence of one variable and the sequence-space Jacobians. For example, $\mathbf{Y} \equiv (Y_t)_{t=0,\ldots,\infty}$ stands for the sequence of output, and $\mathbf{M} \equiv \left(\frac{\partial C_s}{\partial X_t}\right)_{s,t}$ represents the intertemporal marginal propensity to consume (iMPC) for households. In this infinite-horizon setting, we have a "pass through matrix" $\mathbf{Z}_n = (Z_{n,st})_{st}$ for each asset n denoting how the aggregate demand in period s responds to a unit asset-n demand shock in period t.

The intertemporal inelastic Keynesian cross follows

$$\begin{aligned} d\mathbf{Y} =& \partial\mathbf{C} + \sum_{n \neq ST} \mathbf{Z}_n \partial\mathbf{A}_n \\ &+ \underbrace{\left[(1-\alpha)\,\mathbf{M} + \alpha\mathbf{M}^d + \alpha\mathbf{M}^I + \sum_{n \neq ST} \mathbf{Z}_n \left((1-\alpha)\,\mathbf{MPS}_n + \alpha\mathbf{MPS}_n^d - \alpha\mathbf{MPB}_n \right) \right]}_{\equiv \mathcal{M}} d\mathbf{Y} \end{aligned} \tag{51}$$

where $\mathbf{M} \equiv \frac{\partial \mathbf{C}}{\partial \mathbf{X}}$ is the intertemporal marginal propensity to consume (iMPC) matrix, $\mathbf{M}^I \equiv \frac{\partial \mathbf{I}}{\partial \mathbf{X}^f}$ is the intertemporal marginal propensity to invest by firms (including various adjustment costs that enter aggregate demand), and $\mathbf{M}^d \equiv \frac{\partial \mathbf{C}}{\partial \mathbf{d}} \frac{\partial \mathbf{d}}{\partial \mathbf{Z}^f}$ is the household spending out of dividend changes induced by changes in firm income. Note that $\mathbf{M}$ and $\mathbf{M}^d, \mathbf{M}^I$ are defined for each dollar to households and to the representative firm respec-

tively. Averaging across them, if the capital share is α, the aggregate demand response to aggregate output Y is $\alpha \mathbf{M}^d + \alpha \mathbf{M}^I + (1-\alpha)\,\mathbf{M}$. $\partial \mathbf{C}$ is a (partial equilibrium) shock to aggregate demand and $\partial \mathbf{A}_n$ is a (partial equilibrium) shock to asset demand for asset n. $\mathbf{MPS}_n \equiv \frac{\partial \mathbf{W}_n}{\partial \mathbf{X}}$ is intertemporal marginal propensity to save matrix, mapping income change at date s into demand for asset n change at date t. $\mathbf{MPB}_n$ is firm's propensity to borrow in different securities with $\mathbf{MPB}_n \equiv \frac{\partial \mathbf{W}_n^f}{\partial \mathbf{X}^f}$ for $n \in \{LT, ST\}$ and $\mathbf{MPB}_e \equiv \frac{\partial \mathbf{P}}{\partial \mathbf{d}} \frac{\partial \mathbf{d}}{\partial \mathbf{X}^f}$. $\mathbf{MPS}_n^d \equiv \frac{\partial \mathbf{W}_n}{\partial \mathbf{d}} \frac{\partial \mathbf{d}}{\partial \mathbf{X}^f}$ is the household saving out of dividend changes induced by changes in firm income.

Proposition 8. *The intertemporal version of the inelastic Keynesian cross is then*

$$d\mathbf{Y} = (I - \mathcal{M})^{-1} \left(\partial \mathbf{C} + \sum_{n \neq ST} \mathbf{Z}_n \partial \mathbf{A}_n \right) \tag{52}$$

where $\mathcal{M} \equiv (1-\alpha)\,\mathbf{M} + \alpha \mathbf{M}^d + \alpha \mathbf{M}^I + \sum_{n \neq ST} \mathbf{Z}_n \left((1-\alpha)\,\mathbf{MPS}_n + \alpha \mathbf{MPS}_n^d - \alpha \mathbf{MPB}_n \right)$ *is the asset market adjusted MPC.*

Elastic benchmark. If markets are elastic, we have $\mathbf{Z}_n = 0$ and the Keynesian cross simplifies to

$$d\mathbf{Y} = \partial \mathbf{Y} + \left[(1-\alpha)\,\mathbf{M} + \alpha \mathbf{M}^d + \alpha \mathbf{M}^I \right] d\mathbf{Y} \tag{53}$$

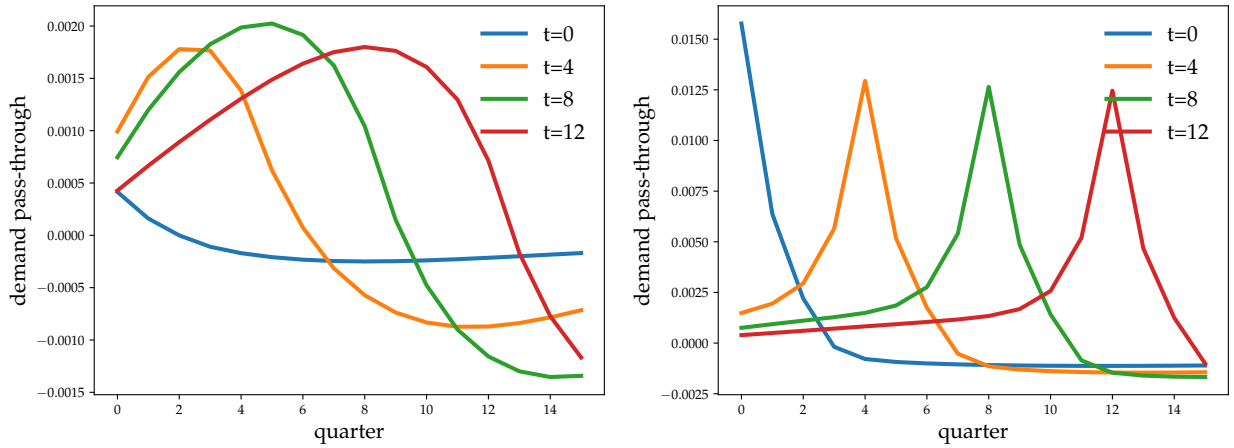
This further reduces to Auclert, Rognlie and Straub (2024) by setting $\mathbf{M}^d = 0$ or $\alpha = 0$.

5.4 Demand pass-through matrices and asset market adjusted MPCs

We illustrate the demand pass-through matrices via LT bond and equity $\mathbf{Z}_{LT}, \mathbf{Z}_e$ in Figures 2 and 3. Figure 2 plots the columns of $\mathbf{Z}_{LT}, \mathbf{Z}_e$, showing the change in aggregate demand in all periods in response to a unit asset demand shock in period t. The pass-through via LT bond is hump-shaped and spreads out, due to firms' investment responses. The pass-through via equity is sharp-pointed, thanks to the households' consumption response.

Figure 2: Columns of demand pass-through matrices $\mathbf{Z}_{LT}, \mathbf{Z}_e$

(a) LT bond $\mathbf{Z}_{LT}$ (b) Equity $\mathbf{Z}_e$



The magnitude of Z depends on the length of each period we set. To better understand its magnitude, Figure 3 shows the cumulative change as follows. We consider a unit demand shock in asset market n that persists from period 0 to period T, which induces a time-s change in aggregate demand of $\partial Y_{s|T} = \sum_{t=0}^{T} Z_{LT,st}$. We plot the cumulative impact up to period t, defined as $\partial Y_{t|T}^{cum} = \sum_{s=0}^{t} \frac{1}{(1+r_{ST})^s} \partial Y_{s|T}$, in Figure 3. We plot the cumulative pass-throughs via LT bond and equity on the same scale side by side, and note that the peak response of the latter is about three to four times larger.

Figure 3: Cumulative demand pass-through from persistent demand

(a) LT bond (b) Equity

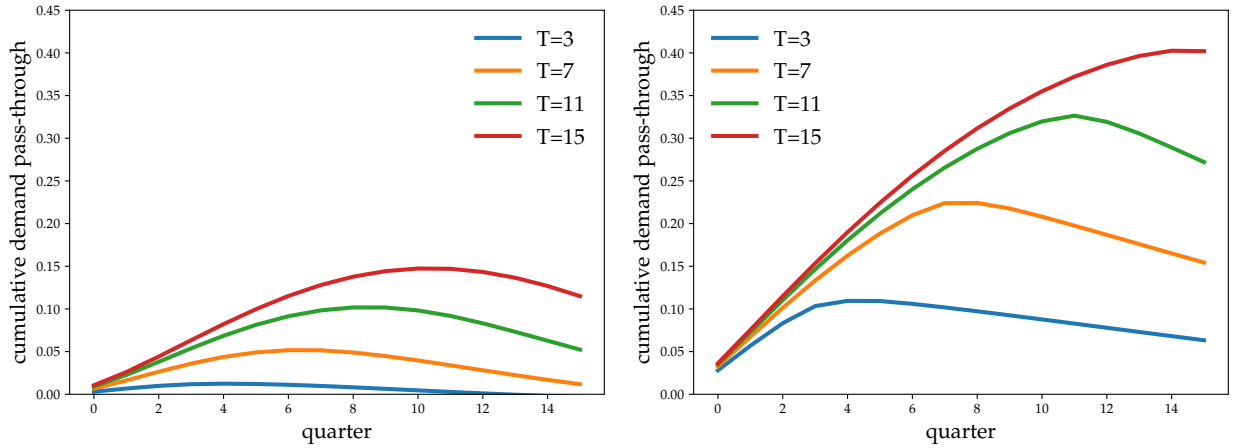


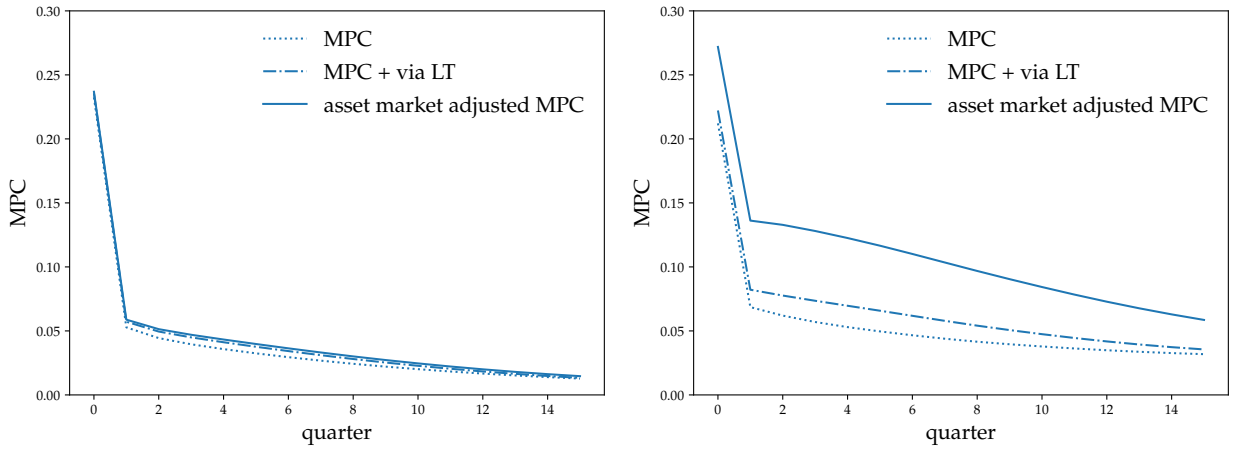
Figure 4(a) shows the first column of the iMPC $\mathcal{M} \equiv (1-\alpha)\,\mathbf{M} + \alpha\mathbf{M}^d + \alpha\mathbf{M}^I + \sum_{n \neq ST} \mathbf{Z}_n \left((1-\alpha)\,\mathbf{MPS}_n + \alpha\mathbf{MPS}_n^d - \alpha\mathbf{MPB}_n \right)$, i.e., the change in aggregate demand in

response to a time-0 unit shock to aggregate output. In the dotted line, we plot $(1-\alpha)\,\mathbf{M} + \alpha\mathbf{M}^d + \alpha\mathbf{M}^I$ which is the MPC. To arrive at the dashed line, we add the adjustment via the LT bond market, $\mathbf{Z}_{LT}\left((1-\alpha)\,\mathbf{MPS}_{LT} + \alpha\mathbf{MPS}^d_{LT} - \alpha\mathbf{MPB}_{LT}\right)$. Last, to show the full asset market adjusted MPC, we add $\mathbf{Z}_e\left((1-\alpha)\,\mathbf{MPS}_e + \alpha\mathbf{MPS}^d_e - \alpha\mathbf{MPB}_e\right)$, which is the adjustment via the equity market.

Figure 4: MPC and asset market adjusted MPC out of time-0 income

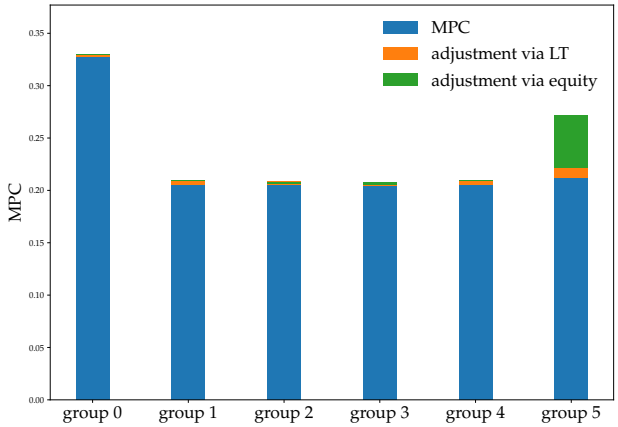
(a) Economy-wide

(b) Using $\mathbf{M}, \mathbf{M}^d, \mathbf{MPS}_n, \mathbf{MPS}^d_n$ of highest-income group



In Figure 4(b), we replace $\mathbf{M}, \mathbf{M}^d, \mathbf{MPS}_n, \mathbf{MPS}^d_n$ by those of the highest-income group instead of population averages, while holding fixed $\mathbf{Z}_n$ which is jointly determined by all household groups' behavior. We notice that the adjustment via asset markets, especially the equity market, matters hugely for this highest-income group. We repeat the same exercise by using the $\mathbf{M}, \mathbf{M}^d, \mathbf{MPS}_n, \mathbf{MPS}^d_n$ of each income group, and plot in Figure 5 by group the $(0,0)$ element of $\mathcal{M}$, i.e., the contemporaneous response of aggregate demand to a time-0 aggregate output change. We notice that the asset market adjustments are significant for only the highest income group.

Figure 5: MPC adjustment by income group



6 Quantitative applications

We illustrate the transmission of monetary and fiscal policy in the quantitative model.

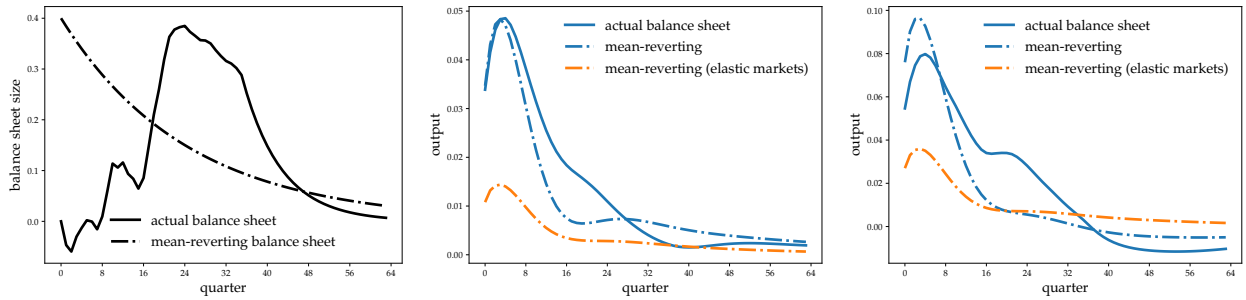
6.1 Quantitative easing

We study the effects on output of quantitative easing (QE) that purchases LT bond or equity. We consider two shock sequences of purchase, one capturing the actual evolution of balance sheet during the financial crisis,[3] and one mean-reverting shock that has a half-life of 4 years. For the mean-reverting shock, we set an initial size of 10% of annual GDP, to match the peak size of the actual balance sheet.

In Figure 6, panel (a) plots these two shock sequences, and panel (b) and (c) shows the output responses if the purchase is in LT bond and equity respectively. The output response to equity QE is about twice as large as that of LT bond QE.

[3]QE1 was announced in May 2009, which we take as time 0 in generating this shock. Taper tantrum was in 2013, after three rounds of QE. The Fed purchase did not end until October 2014. To form this shock, we concatenate the Fed's balance sheet between 2009Q2 and 2017Q3 with an exponetially decaying sequence afterwards, with the decay rate fitted to the unwinding of balance sheet from 2017Q3 to 2019Q1.

Figure 6: Quantitative Easing



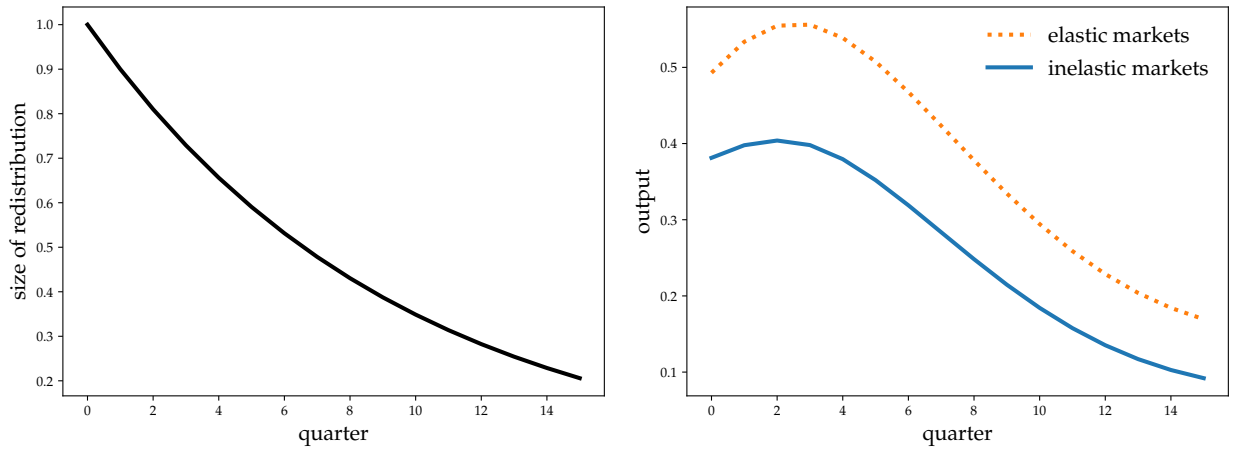
(a) Size of balance sheet (b) QE in LT bond (c) QE in equity

6.2 Redistribution

We examine the output response to a redistribution from the rich to the poor. For this experiment, we feed in a mean-reverting transfer of 1% quarterly GDP from the highest-income group to the lowest-income group (within each group, the tax/transfer is proportional to idiosyncratic earnings). Figure 7(b) suggests that such a redistribution is less expansionary under inelastic markets than under elastic markets. The mechanism is that, as the rich draws from their savings in LT bond and equity, this lowers the aggregate demand through the asset market adjustments.

Figure 7: Redistribution

(a) Size of shock (b) Output response



6.3 Fiscal stimulus

We illustrate the fiscal multiplier, considering a mean-reverting government spending shock of 1% of quarterly GDP. In Figure 8, panels (b-d) show the output response when the spending is balanced-budget, deficit-financed by ST bond and LT bond, respectively.[4] Panel (c) suggests that when the deficit is financed by ST bond, it is more stimulative under inelastic markets. That is because, the asset markets adjusted MPC is higher under inelastic markets. In contrast, panel (d) demonstrates that when the deficit is financed by LT bond, it is less stimulative under inelastic markets. That occurs because the government issuance of LT bond lowers the LT bond price and raises its yield, passing into lower aggregate demand as a supply shock to the asset market.

6.4 Monetary policy

Here, we demonstrate the transmission of monetary policy. We solve for the impulse response of output, to a mean-reverting shock in the policy rate $r_{ST,t+1}$. Figure 9(b) suggests that, the output response under inelastic and elastic markets are closely comparable. That is, our earlier neutrality result largely holds in this quantitative model.

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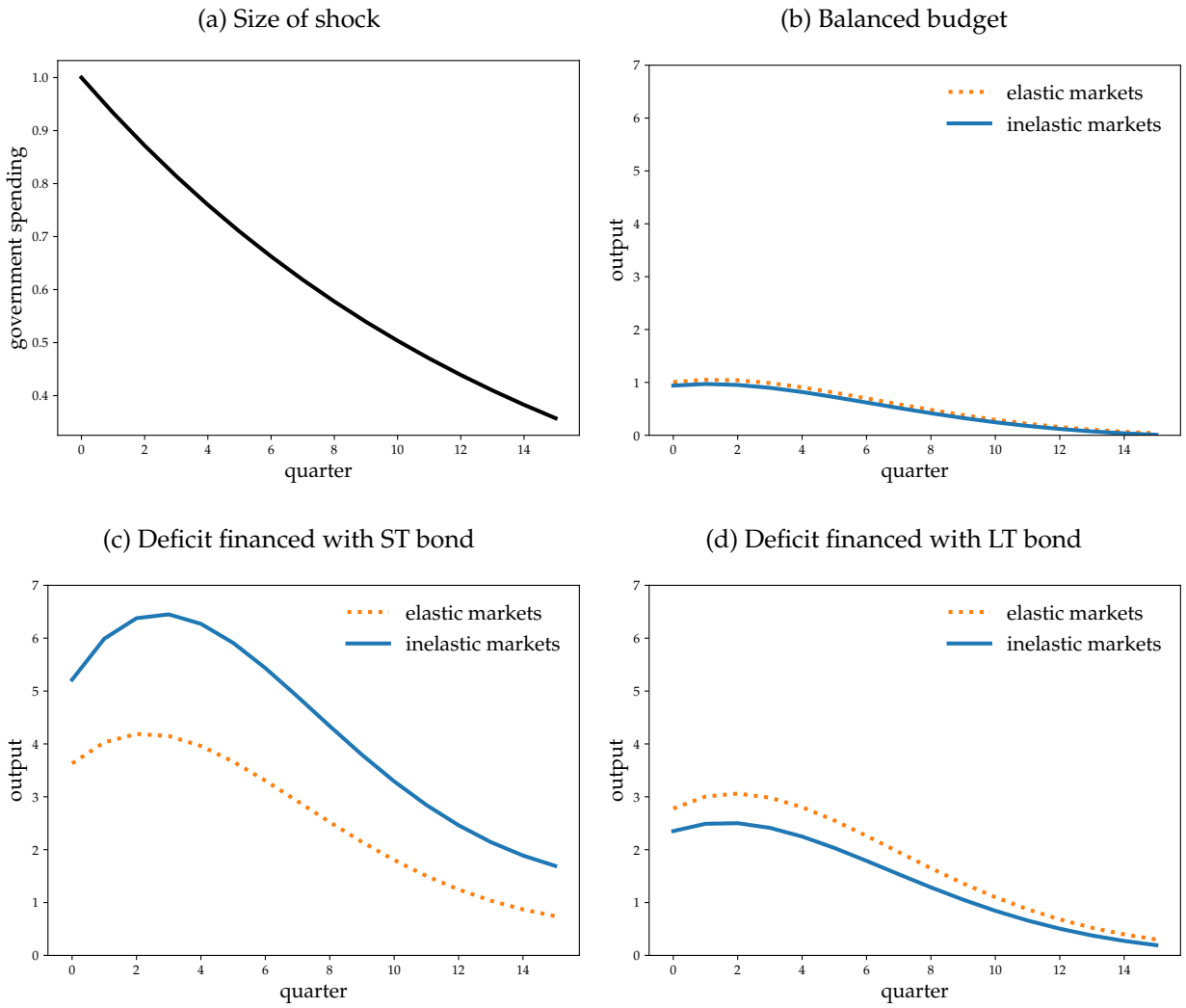
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[4] As known previously (Auclert et al., 2024; Angeletos, Lian and Wolf, 2024), the output response is larger when the the spending is deficit-financed.

Figure 8: Fiscal stimulus



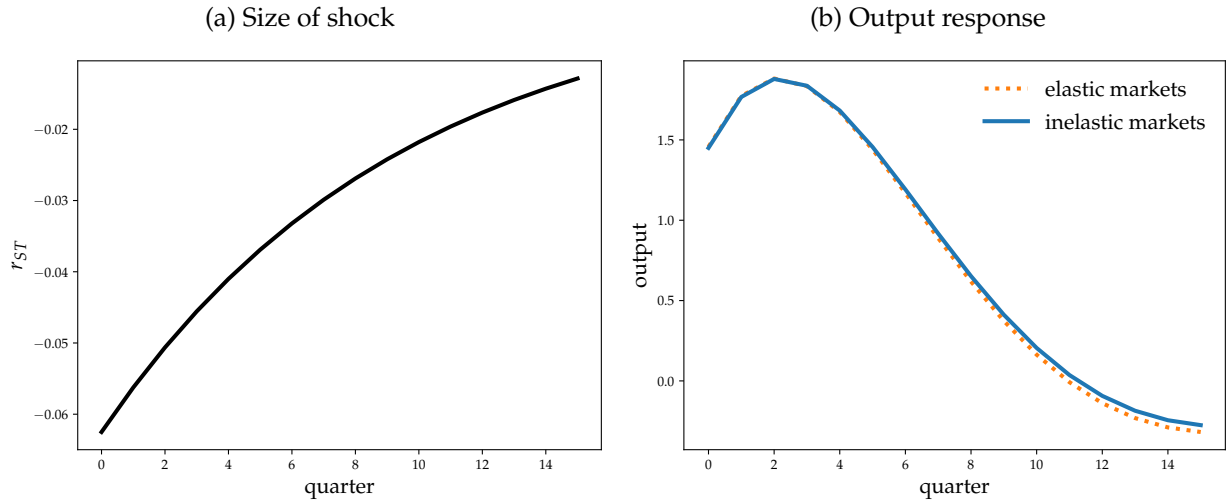
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Figure 9: Monetary policy



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