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Monetary-Fiscal Interactions and Redistribution in Small Open Economies

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Abstract

Ballooning public debts in the wake of the covid-19 pandemic can present monetary-fiscal policies with a dilemma if and when *neutral* real interest rates rise, which might arrive sooner in emerging markets: policymakers can stabilize debts either by relying on fiscal adjustments (AM-PF) or by tolerating higher inflation (PM-AF). The choice between these policy mixes affects the efficacy of the fiscal expansion already today and can interact with the distributive properties of the stimulus across heterogeneous households. To study this, I build a two agent New Keynesian (TANK) small open economy model with monetary-fiscal interactions. Targeting fiscal transfers more towards high-MPC agents increases the output multiplier of a fiscal stimulus, while raising the degree of deficit-financing for these transfers also helps. However, precise targeting is much more important under the AM-PF regime than the question of financing, while the opposite is the case with a PM-AF policy mix: then deficit-spending is crucial for the size of the multiplier, and targeting matters less. Under the PM-AF regime fiscal stimulus entails a real exchange rate depreciation which might offset "import leakage" by stimulating net exports, if the share of hand-to-mouth households is low and trade is price elastic enough. Therefore, a PM-AF policy mix might break the Mundell-Fleming prediction that open economies have smaller fiscal multipliers relative to closed economies.

keywords: monetary-fiscal interactions, small open economy, hand-to-mouth agents, redistribution, public debt, Ricardian equivalence

JEL: E52, E62, E63, F41, H63

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1 Introduction

In response to the economic fallout from the covid-19 pandemic governments around the world are implementing recently unprecedented fiscal stimulus packages, insuring firms and households against the effects of the shock by cutting taxes and handing out transfers. As the resulting budget deficits lead to balooning public debt levels, the question of "how to pay for the stimulus" is asked increasingly often.

In most of the advanced economies real interest rates are low which makes the fiscal costs of public debt manageable: Blanchard (2019) pointed out that as long as safe real interest rates are below economic growth rates ($r < g$), current budget deficits need not be covered by tax increases in the future in order to keep debt-to-GDP ratios stable. Moreover, monetary policy shouldn't worry about the inflationary consequences of low interest rates since the *natural* or *neutral* interest rate is also low ($r^* \leq r$). This might be due to persistently low aggregate demand or secular stagnation caused by long-term structural trends, but the point is that in a world where $r^* \leq r < g$ applies, monetary policy can support fiscal expansion by keeping the costs of public debt low without having to worry about runaway inflation.

However, if and when *neutral* rates do rise above growth rates ($g < r^*$), monetary-fiscal policies will be presented with a dilemma. Either the central bank raises *actual* interest rates to ward off inflationary pressures, thereby forcing the fiscal authority to adjust the primary budget balance (in order to cover higher interest expenses and to stabilize public debt) – or an unresponsive monetary policy keeps interest rates low, tolerating higher inflation and essentially letting it erode the real value of nominal debt, without the need for fiscal policy to increase taxes.

In the terminology of Leeper (1991) the former regime can be characterized as an active monetary and passive fiscal policy mix (AM-PF), while the latter is the passive monetary and active fiscal policy mix (PM-AF).[1] In this framework the expectation of whether public debt will be paid for by taxes or by being "inflated away", already has an influence on the impact of fiscal stimulus today. Jacobson, Leeper and Preston (2019) argue that the success of Roosevelt's 1933 fiscal expansion was due to budget deficits not being backed by future taxes (made possible by monetary policy abandoning the gold standard), which prompted households to spend more of the windfall. Similarly, Bianchi, Faccini and Melosi (2020) show that if monetary and fiscal policies coordinate on an "emergency budget" which relies more on inflation than on costly fiscal adjustments to stabilize the resulting debt, the efficacy of fiscal stimulus is largely enhanced.

While for the time being advanced economies seem less pressed to face the dilemma of choosing between the AM-PF or PM-AF policy regimes, for emerging markets this might not be true.

[1] I.e. in AM-PF monetary policy *actively* manages the real interest rate to stabilize inflation, while fiscal policy *passively* adjusts the budget balance in order to stabilize public debt at the given interest rate. In PM-AF, fiscal *activism* means setting the path of primary budget balances independently of the need for debt stabilization, and instead having monetary policy *passively* accommodate government budgets by keeping interest rates low, tolerating higher inflation, and thereby ensuring a stable path for public debt. See discussion in Section 3.1.

Even those able to borrow in their own currency do not have the privilige of issuing highly demanded reserve currencies, which means their rising debt ratios could lead to higher neutral interest rates due to more sensitive risk premiums. In other words, they are more likely to find themselves in a $g < r^*$ world. Of course, technically they can control interest rates in their own currencies but not following the risk premium would then result in exchange rate depreciation, passing through to higher inflation. The trade-off between higher inflation and fiscal adjustment is therefore more present in small open emerging economies, which is why the choice between AM-PF or PM-AF policy mixes seems even more relevant for them.

Apart from the question of what kind of monetary-fiscal policy mix should stabilize public debt, there is another important aspect of fiscal stimulus, in particular, its distribution across heterogeneous households. The breakdown of Ricardian equivalence in such an environment already renders fiscal decisions consequential, inducing another form of monetary-fiscal interactions even under an AM-PF regime (Kaplan, Moll and Violante, 2018). Targeting the same deficit-financed transfers towards households with a higher marginal propensity to consume (MPC) who spend most of their temporary income increases (rather than towards consumption-smoothing "Ricardian" agents) is shown to yield higher multipliers on output by Bayer et al. (2020).

In addition to targeting, financing also matters with household heterogeneity. Bilbiie, Monacelli and Perotti (2013) shows that whether the same transfer to high-MPC ("hand-to-mouth", HtM) households is financed by raising taxes on Ricardians during a balanced budget redistribution, or by selling public debt to Ricardians and running a budget deficit, influences the size of the output multiplier.[2] The reason is that while in the first scenario Ricardians are *paying* in full for the HtM transfers via a reduction in their lifetime income, in the latter they are just *lending* to HtM households via the government budget. The point is that financing decisions and public debt matters even under an AM-PF policy regime, due to the breakdown of Ricardian equivalence and household heterogeneity.

All the above arguments about fiscal redistribution are made within an AM-PF policy regime, while the discussion on potentially unbacked budget deficits (PM-AF) focuses on homogenous fiscal expansion in a representative agent setting. However, given the likely dilemma about public debt stabilization soon to be facing policymakers, it is of significant interest to explore how the redistributive features of fiscal stimulus play out under a PM-AF regime, and to see if redistribution interacts with the choice of monetary-fiscal policy mix. For this reason I build a small open economy Two Agent New Keynesian (TANK) model with monetary-fiscal interactions as in Leeper (1991). This allows me to analyse the distributional aspects of a fiscal stimulus under different policy regimes, while also accounting for open economy aspects that are relevant for emerging markets.

One of the main results concerns the relative importance across policy regimes of the targeting

[2] To the extent that future taxes backing the public debt will not all be raised on Ricardian households, and to the extent that public debt is somewhat persistent.

profile of fiscal transfers on the one hand, and whether they are balanced budget or deficit financed on the other hand. With an AM-PF policy mix, while public debt matters somewhat (to the extent that Ricardian equivalence fails), it is far more consequential how fiscal transfers are distributed across households. Targeting the same transfers more towards high-MPC agents increases the output multiplier to a much larger extent than deciding to finance a given transfer to high-MPC agents with public debt instead of taxes on Ricardians.[3] In other words, as long as hand-to-mouth households receive the same transfer, balanced budget redistributions provide almost as big stimulus as debt-financed ones, and the arguments for deficit spending are not as strong. On the other hand, it is worth putting greater effort into the precise targeting of fiscal transfers, such that it reaches high-MPC households.

This is in contrast to the PM-AF policy regime, where targeting fiscal transfers towards high-MPC households matters much less than the size of the budget deficit *per se*. The essence of the transmission mechanism under this regime is that public debt does not entail future tax obilgations and therefore becomes nominal net wealth (Jacobson, Leeper and Preston, 2019), stimulating spending by bond holding Ricardians as well. In addition, an unresponsive monetary policy combined with the need of inflation to stabilize the real value of public debt results in falling real interest rates which also supports Ricardian consumption via intertemporal substitution. For these reasons, under PM-AF it is of much bigger importance whether a given transfer entails a budget deficit or not, relative to whom the transfer is targeted at, which is the opposite of the AM-PF regime's result. Cutting taxes on Ricardian households could be more stimulative as long as it is deficit financed, than giving the same transfer to hand-to-mouth agents during a balanced budget redistribution. Arguments for deficit spending are therefore much stronger with a PM-AF policy mix, i.e. if those deficits are unbacked by future tax revenues. At the same time, bothering about precise targeting is relatively less important.

The model yields other interesting results which, to the best of my knowledge, have not yet been discussed in the literature. Bilbiie (2008) shows that with a sufficiently high share of hand-to-mouth households interest rate increases can become expansionary ("inverted aggregate demand logic" or IADL), and an *inverted Taylor principle* can ensure a unique and stable dynamic equilibrium. I show that in a richer framework for monetary-fiscal interactions the inverted Taylor principle is not a necessary condition for equilibrium determinacy under IADL, and can be substituted by an active fiscal policy. In fact, in an open economy setting with sufficiently high external debt this is the only solution, as the inverted Taylor principle breaks down completely.

Open economy AM-PF models face a puzzle in the sense that they predict real appreciation following a fiscal stimulus, while empirical studies mainly detect real depreciation (Ravn, Schmitt-Grohé and Uribe, 2012; Monacelli and Perotti, 2010). This puzzle goes away with a PM-AF policy regime, where the real exchange rate depreciates after a fiscal expansion. This also changes the sign of the *expenditure switching* channel, meaning that instead of being crowded

[3] The latter decision would be completely inconsequential if future taxes backing public debt are all levied on Ricardian households. In this case, Ricardian equivalence holds, and the timing of taxes becomes irrelevant.

out, there's a beneficial effect on net exports as a result of relatively cheaper, more competitive domestic goods. Despite this, opening up the economy still reduces fiscal multipliers as some of the extra consumption spending now "leaks out" as imports, and this *expenditure changing* channel still dominates in the response of the trade balance. However, I show that this is not necessarily true if the rise in consumption is smaller due to a low share of HtM agents and/or if the price elasticity of trade is high enough, making expenditure switching dominate expenditure changing. This means that under a PM-AF regime there can be a constellation where the Mundell-Fleming prediction does not apply, i.e. that open economies need not face less effective fiscal multipliers compared to large closed economies.

This paper is most closely related to Bilbiie, Monacelli and Perotti (2013) who examine transfer multipliers and redistribution in a TANK model, and to Bayer et al. (2020) who consider in a HANK environment how targeting government transfers at high-MPC households during the covid-19 pandemic might affect multipliers. However, the above models feature closed economies and only look at an AM-PF policy mix. Regarding monetary-fiscal interactions, Bianchi, Faccini and Melosi (2020) and Jacobson, Leeper and Preston (2019) comes closest by analysing the PM-AF regime and unbacked emergency budgets, albeit in a closed economy setting with representative agents, which does not allow for studying redistribution across heterogeneous households. Finally, Leeper, Traum and Walker (2011) develop a medium-scale DSGE model which among its many features also includes hand-to-mouth households, PM-AF policy mix and open economy dimensions, however, they focus mostly on the size of government spending multipliers and not on redistribution via transfers.

Di Giorgio and Traficante (2018) build a two-country model to compare money-financed and debt-financed fiscal shocks. While money-financing (helicopter money) in their model can be thought of as analogous to the PM-AF regime studied here (see discussion in Section 3.1), it is not entirely the same. In addition, instead of utilizing a TANK model, they break Ricardian equivalence with a perpetual youth setup which prevents them from studying redistribution across households. Nevertheless, similarly to his paper's PM-AF poli9cy regime, their model also manages to predict real exchange rate depreciation after a money-financed tax cut. This is the same in Leith and Wren-Lewis (2008) who study the effects of monetary-fiscal interactions on equilibrium determinacy in their two-country OLG economy, and show that both policy branches can be active in one country, as long as monetary policy is passive in the other.

This paper is also part of a broader literature on TANK models,[4] and on monetary-fiscal inter-

[4]Closed economy reference points include Bilbiie (2018), Bilbiie (2019), Debortoli and Galí (2018) and Broer et al. (2020), while the following also feature debt-financing for fiscal policy: Galí, López-Salido and Vallés (2007), Bilbiie and Straub (2004) and Cantore and Freund (2019), all with AM-PF policy mix. Open economy TANK is developed among others by Iyer (2017), Boerma (2014) and Cugat (2019), but with perfect international risk sharing and without a fiscal block.

actions.[5] The vast literature on fiscal multipliers is also related,[6] however, their focus is mostly on government expenditures and not transfers, nor redistribution.

The rest of the paper is organized as follows. Section 2 describes the small open economy TANK model. Section 3 discusses how Ricardian equivalence and equilibrium determinacy are affected by household heterogeneity and monetary-fiscal interactions in this model. Section 4 presents the responses of the economy following an increase in fiscal transfers, and compares them across differrent policy regimes. Section 5 concludes.

2 Model

The model belongs to the family of New Keynesian small open economy models, as described in Corsetti, Dedola and Leduc (2010). It builds on the complete market model of Galí and Monacelli (2005) by adding hand-to-mouth households (Iyer, 2017) and introducing incomplete international financial markets (De Paoli, 2009). On the demand side of the economy a New Keynesian Cross is in operation, as in the closed economy two agent New Keynesian (TANK) model of Bilbiie (2019): λ fraction of households are excluded from financial markets, have unitary MPC and consume their current income (hand-to-mouth), while the rest (Ricardians) can smooth consumption intertemporally by saving/borrowing in a single, internationally traded bond and government debt.

The domestic economy faces a debt-elastic risk premium, effectively describing the asset supply of foreigners, ensuring stationary dynamics (Schmitt-Grohé and Uribe, 2003). Households consume both domestically produced and imported goods, the relative demand of which depends on the real exchange rate (as does export demand, too), which in turn affects the evolution of the trade balance and the external position of the economy, feeding back into the risk premium. The supply side of the economy consists of monopolistically competitive firms who are subject to nominal rigidities, and produce final goods with a linear production technology.

Monetary policy either sets the short term nominal interest rate on local currency bonds, or controls the nominal exchange rate. Fiscal policy sets government expenditures and collects lump sum taxes from households, financing the potential budget deficit by issuing nominal debt. Taxes react to deviations of debt-to-GDP ratio from a target value. The distribution of taxes and transfers across households is decided by fiscal policy. Monetary-fiscal interactions

[5] The literature on the framework of active and passive policy rules is nicely summarized by Leeper and Leith (2016) and Sims (2013). Corsetti et al. (2019), Jarociński and Maćkowiak (2018) and Corsetti and Dedola (2016) point out the role of central banks to provide a monetary backstop to fiscal debt, in order to rule out self-fulfilling equilibria, especially in a liquidity trap, which is similar in nature to a PM-AF regime.

[6] Here are some of the papers which consider fiscal multipliers with unresponsive monetary policy in a liquidity trap: Woodford (2011), Eggertsson (2011) in closed economies, and Farhi and Werning (2016), Cook and Devereux (2013), Cook and Devereux (2019) in currency unions and open economies. Note, however, that importing monetary policy from abroad via an exchange rate peg should not be considered "passive" monetary policy in the sense used here, but instead it forces even harsher constraints on domestic policy.

are captured via the policy rules as in Leeper (1991).

2.1 Households

2.1.1 Hand-to-mouth households

There is a mass $0 \leq \lambda \leq 1$ of hand-to-mouth (HtM) households who are excluded from financial markets and cannot smooth consumption by saving/borrowing, but rather consume their income in every period. They solve the following static problem:

$$\max_{\check{C}_t, \check{N}_t} \quad E_t \left\{ \frac{\check{C}_t^{1-\sigma}}{1-\sigma} - \frac{\check{N}_t^{1+\varphi}}{1+\varphi} \right\}$$

$$P_t\, \check{C}_t = W_t\, \check{N}_t + \frac{\tau^D}{\lambda} P_t \Omega_t - P_t \check{T}_t \tag{2.1}$$

where P_t is the price of the consumption basket, $\check{C}_t$ is consumption by a HtM household, W_t is the nominal wage, $\check{N}_t$ is hours worked by a HtM household and $\check{T}_t$ are lump sum taxes paid by them to the government, which in turn redistributes τ^D fraction of aggregate profits Ω_t from firm owners towards HtM households. φ is the inverse Frisch elasticity of labor supply, while $1/\sigma$ is the intertemporal elasticity of substitution. The solution to this problem yields the labor supply condition of HtM households:

$$w_t \equiv \frac{W_t}{P_t} = \check{C}_t^{\sigma}\, \check{N}_t^{\varphi} \tag{2.2}$$

2.1.2 Ricardian households

A mass $1 - \lambda$ of households is Ricardian, as they are able to smooth consumption by saving and borrowing in international financial markets.

$$\max_{\widehat{C}_t, \widehat{N}_t, \widehat{B}_t, \widehat{B}_t^*} \quad E_t \sum_{t=0}^{\infty} \beta^t \left\{ \frac{\widehat{C}_t^{1-\sigma}}{1-\sigma} - \frac{\widehat{N}_t^{1+\varphi}}{1+\varphi} \right\}$$

$$P_t\, \widehat{C}_t + \frac{\widehat{B}_t}{1+i_t} + \frac{e_t\, \widehat{B}_t^*}{(1+i_t^*)\psi_t} \leq \widehat{B}_{t-1} + e_t\, \widehat{B}_{t-1}^* + W_t\, \widehat{N}_t + \frac{(1-\tau^D) P_t \Omega_t}{1-\lambda} - P_t \widehat{T}_t \tag{2.3}$$

where $\widehat{B}_t$ is a local currency (LCY) denominated *nominal* bond paying one unit of domestic currency on maturity. $\widehat{B}_t^*$ is a foreign currency (FCY) denominated bond paying one unit of foreign currency on maturity, which can be converted to domestic currency at a nominal exchange rate e_t.[7] The domestic household is subject to a risk premium ψ_t which it must pay on top of the risk-free foreign interest rate i_t^*. Ricardians own the firms in the economy and receive all profits Ω_t which are taxed at a rate τ^D, in additoin to which they also pay lump sum

[7]Expressed as the local currency value of one unit of foreign currency, implying that an increase in e_t means a depreciation of the domestic currency.

taxes $\widehat{T}_t$. The solution to the above problem yields:

$$w_t = \frac{W_t}{P_t} = \widehat{C}_t^{\sigma}\ \widehat{N}_t^{\varphi} \tag{2.4}$$

$$\frac{1}{1+i_t} = \beta\ E_t \left\{ \left[\frac{\widehat{C}_{t+1}}{\widehat{C}_t}\right]^{-\sigma} \frac{1}{\Pi_{t+1}} \right\} \tag{2.5}$$

$$\frac{1+i_t}{\mathrm{E_t}\,\Pi_{t+1}} = \frac{1+i_t^*}{\mathrm{E_t}\,\Pi_{t+1}^*}\ \psi_t\ \frac{\mathrm{E_t}\,Q_{t+1}}{Q_t} \tag{2.6}$$

where (2.4) is the Ricardian labor supply condition, (2.5) is the Euler equation pricing LCY bonds and (2.6) is the real uncovered interest rate parity (UIP) condition signalling no-arbitrage between LCY and FCY bonds, and where $\Pi_t = P_t/P_{t-1}$ is gross CPI inflation and $Q_t = \frac{e_t P_t^*}{P_t}$ is the real exchange rate.

Portfolio choice is not modelled: given no-arbitrage between their expected returns, LCY and FCY bonds are perfect substitutes for the Ricardian household which should be indifferent between holding one or the other.[8] Therefore, these bonds are pinned down by the asset supply of foreigners and the government. We take look at two extreme scenarios. In our baseline setup only LCY-denominated bonds are traded internationally and FCY bonds are not (i.e. there is no *original sin*, and the domestic economy's holdings of FCY bonds B_t^* are restricted to be zero).[9] On the other hand, we can also consider the *currency mismatch* case where domestic households can borrow internationally only in FCY (original sin), and LCY bonds are restricted for domestic financial transactions with the government (see Section 2.5.4).

2.1.3 International risk-sharing

The rest of the world is modelled as a large economy which is populated by Ricardian households, solving a symmetric problem to the one above. The only difference is the absence of the risk premium ψ_t, so the foreign household faces the risk-free gross return $(1+i_t)/\psi_t$ on LCY-bonds, and $(1+i_t^*)$ on FCY bonds. Combining the resulting Euler equations with those of the domestic Ricardian household's (for the same assets) we arrive to the international risk-sharing condition:

$$\left[\frac{\mathrm{E_t}\,\widehat{C}_{t+1}}{\widehat{C}_t}\right]^{\sigma} = \left[\frac{\mathrm{E_t}\,C_{t+1}^*}{C_t^*}\right]^{\sigma}\ \psi_t\ \frac{\mathrm{E_t}\,Q_{t+1}}{Q_t} \tag{2.7}$$

(2.7) shows that due to incomplete markets there is only imperfect risk sharing, creating a less tight link between consumption and the real exchange rate than the Backus-Smith perfect risk

[8] Taking into account different uncertainty around the ex post returns of LCY and FCY bonds would make the household prefer one or the other, but up to first order this makes no difference.

[9] In this case, the UIP no-arbitrage condition still applies, and follows from the foreign household's problem who has access to both assets and earns $(1+i_t)/\psi_t$ on the LCY bond, reflecting that it is relatively less risky than the domestic household.

sharing condition $\widehat{C}_t = \vartheta\ C_t^* Q_t^{\frac{1}{\sigma}}$ (which would keep the demand imbalance ϑ constant). There is still a link between foreign and domestic consumption growth, but only in expectation which does not hold *ex post*, and the real exchange rate will not fully absorb shocks to insure the domestic household against them (i.e. the demand imbalance ϑ_t will have inefficient deviations from its steady state level *ex post*).

The risk-premium ψ_t drives a further wedge between the countries. However, were it not for this *debt-elastic* risk-premium ψ_t, the demand imbalance ϑ_t between the two countries would follow a random walk, making the model dynamics non-stationary. This is a well-known problem in incomplete market open economy models, and introducing ψ_t also serves the purpose of getting around it by providing a feedback into the consumption-saving decision, and making assets an important state variable (Schmitt-Grohé and Uribe, 2003).

$$\mathrm{E_t}\left\{\frac{\widehat{C}_{t+1}}{C_{t+1}^*}\frac{1}{Q_{t+1}^{\frac{1}{\sigma}}}\right\} = \underbrace{\frac{\widehat{C}_t}{C_t^*}\frac{1}{Q_t^{\frac{1}{\sigma}}}}_{\vartheta_t} \neq \ldots \neq \underbrace{\frac{\widehat{C}}{C^*}\frac{1}{Q_*^{\frac{1}{\sigma}}}}_{\vartheta}$$

On the aggregate economy level, market incompleteness is aggrevated by the fact that only $1-\lambda$ fraction of households can share risk internationally in any way: hand-to-mouth households are excluded from financial markets. I.e. even under complete markets, with Ricardian households having access to a full set of state-contingent securities, aggregate consumption would not be fully insured since $\widehat{C}_t \neq C_t$ (Iyer, 2017).

2.1.4 Consumption baskets and demand functions

Both households consume a composite of Home produced C_t^H and Foreign produced (imported) C_t^F goods, with elasticity of substitution η between them. The import intensity is captured by α, which is a measure of openness: $(1-\alpha)$ represents home bias in consumption. $\alpha \to 0$ is the closed economy limit.

$$\check{C}_t = \left[(1-\alpha)^{\frac{1}{\eta}}(\check{C}_t^H)^{\frac{\eta-1}{\eta}} + \alpha^{\frac{1}{\eta}}(\check{C}_t^F)^{\frac{\eta-1}{\eta}}\right]^{\frac{\eta}{\eta-1}} \tag{2.8}$$

$$\widehat{C}_t = \left[(1-\alpha)^{\frac{1}{\eta}}(\widehat{C}_t^H)^{\frac{\eta-1}{\eta}} + \alpha^{\frac{1}{\eta}}(\widehat{C}_t^F)^{\frac{\eta-1}{\eta}}\right]^{\frac{\eta}{\eta-1}} \tag{2.9}$$

Solving the corresponding expenditure minimization problem gives us the folowing demand functions:

$$\check{C}_t^H = (1-\alpha)\left[\frac{P_t^H}{P_t}\right]^{-\eta}\check{C}_t \tag{2.10}$$

$$\widehat{C}_t^H = (1-\alpha)\left[\frac{P_t^H}{P_t}\right]^{-\eta}\widehat{C}_t \tag{2.11}$$

$$\check{C}_t^F = \alpha\left[\frac{P_t^F}{P_t}\right]^{-\eta}\check{C}_t \tag{2.12}$$

$$\widehat{C}_t^F = \alpha\left[\frac{P_t^F}{P_t}\right]^{-\eta}\widehat{C}_t \tag{2.13}$$

with the consumer price index (CPI) being a weighted average of the domestic producer price index (PPI) P_t^H and the import price index P_t^F:

$$P_t = \left[(1-\alpha)(P_t^H)^{1-\eta} + \alpha(P_t^F)^{1-\eta}\right]^{\frac{1}{1-\eta}} \tag{2.14}$$

In turn, the imported good basket C_t^F is a composite of imports from particular countries C_t^j, $j \in [0,1]$, with elasticity of substitution γ between them: $\check{C}_t^F = \left[\int_0^1 (\check{C}_t^j)^{\frac{\gamma-1}{\gamma}}\,\mathrm{d}j\right]^{\frac{\gamma}{\gamma-1}}$. Solving the relevant expenditure minimization problem gives us the demand function $\check{C}_t^j = \left[\frac{P_{t,j}}{P_t^F}\right]^{-\gamma}\check{C}_t^F$, with the import price index $P_t^F = \left[\int_0^1 P_{t,j}^{1-\gamma}\,\mathrm{d}j\right]^{\frac{1}{1-\gamma}}$. A similar demand function applies to the Ricardian household.

Finally, each consumption basket is composed of differentiated goods $i \in [0,1]$ with elasticity of substitution ε between them: $\check{C}_t^j = \left[\int_0^1 \check{C}_t^j(i)^{\frac{\varepsilon-1}{\varepsilon}}\,\mathrm{d}i\right]^{\frac{\varepsilon}{\varepsilon-1}}$. Solving the relevant expenditure minimization problem gives us the demand demand function $\check{C}_t^j(i) = \left[\frac{P_{t,j}(i)}{P_{t,j}}\right]^{-\varepsilon}\check{C}_t^j$, with the price level of country j, expressed in LCY, being $e_{t,j}P_t^j = P_{t,j} = \left[\int_0^1 P_{t,j}(i)^{1-\varepsilon}\,\mathrm{d}i\right]^{\frac{1}{1-\varepsilon}}$. For $j = H$ we get demand for a Home produced good of variety i: $\check{C}_t^H(i) = \left[\frac{P_t^H(i)}{P_t^H}\right]^{-\varepsilon}\check{C}_t^H$, where the producer price index (PPI) is $P_t^H = \left[\int_0^1 P_t^H(i)^{1-\varepsilon}\,\mathrm{d}i\right]^{\frac{1}{1-\varepsilon}}$. Similarly for the Ricardian household.

For the foreign households in country j we can derive similar demand functions for the products of the Home country H:

$$C_{t,j}^F = \alpha\left[\frac{P_t^{F,j}}{P_t^j}\right]^{-\eta}C_{t,j} \tag{2.15}$$

$$C_{t,j}^H = \left[\frac{P_t^H}{e_{t,j}P_t^{F,j}}\right]^{-\gamma}C_{t,j}^F \tag{2.16}$$

$$C_{t,j}^H(i) = \left[\frac{P_t^H(i)}{P_t^H}\right]^{-\varepsilon}C_{t,j}^H \tag{2.17}$$

where $e_{t,j}$ is the bilateral exchange rate, $C_{t,j}$ indicate consumption of the foreign household in country j.

2.2 Exchange rates

The *effective* nominal exchange rate is defined as $e_t = \left[\int_0^1 e_{t,j}^{1-\gamma}\, \mathrm{d}j\right]^{\frac{1}{1-\gamma}}$. The *bilateral* real exchange rate is $Q_{t,j} = \frac{e_{t,j}P_t^j}{P_t}$, while the *effective* real exchange rate is defined as $Q_t = \left[\int_0^1 Q_{t,j}^{1-\gamma}\mathrm{d}j\right]^{\frac{1}{1-\gamma}}$, resulting in $Q_t = P_t^F/P_t$, using the definition for the import price index.

The Law of One Price holds for imports (but due to home bias, $\alpha \neq 1$, Purchasing Power Parity in terms of the CPI P_t does not apply):

$$P_t^F = e_t P_t^* \tag{2.18}$$

where P_t^* is the world price index in FCY. This also leads to the real effective exchange rate (REER) being:

$$Q_t = \frac{e_t P_t^*}{P_t} \tag{2.19}$$

Due to openness ($\alpha \neq 0$) there will be a wedge between the CPI and the PPI, which can be expressed in terms of the REER, by combining the CPI definition (2.14) with the REER definition (2.19) and the law of one price condition (2.18):

$$\frac{P_t}{P_t^H} = \left[\frac{1-\alpha}{1-\alpha\, Q_t^{1-\eta}}\right]^{\frac{1}{1-\eta}} \equiv h(Q_t) \tag{2.20}$$

2.3 Firms

2.3.1 Final good producers (retail firms)

Final good producer firms are perfectly competitive and they bundle together differentiated intermediate goods $Y_t(i)$, subject to the aggregation technology (2.21), taking as given aggregate demand Y_t, the PPI P_t^H, and individual prices $P_t^H(i)$:

$$\max_{Y_t(i)} \Big\{ P_t^H Y_t - \int_0^1 P_t^H(i) Y_t(i)\, \mathrm{d}i \Big\}$$

$$Y_t = \Big[Y_t(i)^{\frac{\varepsilon-1}{\varepsilon}} \mathrm{d}i \Big]^{\frac{\varepsilon}{\varepsilon-1}} \tag{2.21}$$

This yields the familiar demand function for an individual intermediate good $Y_t(i)$ which will be a constraint for the intermediate firm's problem.[10]

$$Y_t(i) = \left[\frac{P_t^H(i)}{P_t^H}\right]^{-\varepsilon} Y_t \tag{2.22}$$

2.3.2 Intermediate good firms

There is a continuum $i \in [0, 1]$ of monopolistically competitive firms producing differentiated intermediate goods $Y_t(i)$. They face a downward sloping demand curve from retailers (2.22)

[10] This is similar to the consumer's demand of domestically produced differentiated goods $C_t^H(i)$, but $Y_t(i)$ also contains exports

which depends on the elasticity of substitution ε between goods varieties. Intermediate goods firms are also subject to Calvo type nominal rigidities, whereby each period only a fraction $(1-\theta)$ can reset their prices. They work with a linear production technology $Y_t(i) = A_t N_t(i)$, using only labor as an input. The firm receives a wage subsidy τ^w from the government which is financed by a lump sum tax T_t^s paid by the firm.

The problem of the firm is:

$$\max_{P_t^H(i)} \quad \sum_{k=0}^{\infty} \theta^k \underbrace{\frac{1}{\prod_{s=1}^{k}(1+i_{t+s})}}_{\equiv \Psi_{t,t+k}} \left[P_t^H(i)\, Y_{t+k}(i) - (1-\tau^w) TC_{t+k}(i) - P_{t+k} T_{t+k}^s \right]$$

$$Y_{t+k}(i) = \left[\frac{P_t^H(i)}{P_{t+k}^H} \right]^{-\varepsilon} Y_{t+k}$$

where $TC_t(i) = W_t N_t(i)$. This leads to the following optimal price decision which, due to symmetry, is the same for all firms who are able to reset their prices in a given period:

$$P_t^H(*) = \underbrace{\frac{\varepsilon(1-\tau^w)}{\varepsilon - 1}}_{\mathcal{M}} \ \mathrm{E_t} \ \frac{\sum_{k=0}^{\infty} \theta^k \Psi_{t,t+k} \ Y_{t+k}(i) \ MC_{t+k}(i)}{\sum_{k=0}^{\infty} \theta^k \Psi_{t,t+k} \ Y_{t+k}(i)} \tag{2.23}$$

where $MC_t = W_t/A_t$ is the nominal marginal cost and $\Psi_{t,t+k} = \beta^k \left(\frac{\widehat{C}_{t+k}}{\widehat{C}_t} \right)^{-\sigma} \frac{1}{\Pi_{t,t+k}}$ is the stochastic discount factor of the Ricardian households, who own the firm. This shows that, when resetting their price $P_t^H(*)$ (potentially lasting for many periods), firms would like to achieve *on average* a desired markup $\mathcal{M}$ over marginal costs (which they could always achieve under flexible prices, but now price stickiness prevents them from doing so, resulting in a time-varying markup).

By the Calvo pricing scheme we have that aggregate PPI inflation and the optimal price decision are connected as:

$$\frac{P_t^H(*)}{P_t^H} = \left[\frac{1-\theta(\Pi_t^H)^{\varepsilon-1}}{1-\theta} \right]^{\frac{1}{1-\varepsilon}} \tag{2.24}$$

Real marginal costs are the inverse of the *time-varying* markup

$$\begin{aligned} rMC_t = \frac{MC_t}{P_t^H} &= \\ = \frac{W_t}{A_t P_t^H} &= \frac{w_t}{A_t} h(Q_t) \end{aligned} \tag{2.25}$$

2.3.3 Aggregate production, profits and price dispersion

Aggregate labor is $N_t = \int_0^1 N_t(i)\ \mathrm{d}i$, which together with the retailer demand function (2.22) and the firm-level production technology gives us the aggregate production function:

$$Y_t \ \Xi_t = A_t \ N_t \tag{2.26}$$

where the price dispersion $\Xi_t = \int_0^1 \left[\frac{P_t^H(i)}{P_t^H}\right]^{-\varepsilon} \mathrm{d}i$ can be expressed recursively (using (2.24)) as:

$$\Xi_t = \left(\Pi_t^H\right)^{\varepsilon} \theta\, \Xi_{t-1} + (1-\theta)\left[\frac{1-\theta\left(\Pi_t^H\right)^{\varepsilon-1}}{1-\theta}\right]^{\frac{\varepsilon}{\varepsilon-1}} \tag{2.27}$$

The (CPI-deflated) profits of the firm, using $\tau^w w_t N_t = T_t^s$, are:

$$\begin{aligned}\Omega_t &= \frac{P_t^H}{P_t} Y_t - (1-\tau^w) w_t N_t - T_t^s = \\ &= \frac{Y_t}{h(Q_t)} - w_t N_t = \frac{Y_t}{h(Q_t)}\Big[1 - \ rMC_t\, \Xi_t\Big] \end{aligned}\tag{2.28}$$

Setting the wage subsidy at $\tau^w = 1/\varepsilon$ makes the steady state markup $\mathcal{M} = 1$, getting rid of the static distortion coming from monopolistic competition. With the wage subsidy being financed by a tax levied on the firm (as in Bilbiie (2018)), this also results in zero steady state profits.[11]

2.4 Government policies

2.4.1 Monetary policy

Monetary follows a Taylor-type *instrument* rule:

$$\frac{1+i_t}{1+i} = \left(\frac{\Pi_t^H}{\Pi^H}\right)^{\phi^\pi} \left(\frac{Y_t}{\overline{Y}_t}\right)^{\phi^y} \left(\frac{e_t}{e_{t-1}}\right)^{\phi^e} v_t \tag{2.29}$$

$$\ln v_t = \rho_R \ln v_{t-1} + \epsilon_t^R \tag{2.30}$$

where $\overline{Y}_t$ is flexible price output when $\theta = 0$. This rule can be replaced by more extreme *targeting* policies:

- strict domestic inflation (or PPI) targeting: $\Pi_t^H = 1$
- exchange rate peg: $e_t/e_{t-1} = 1$
- strict inflation (CPI) targeting: $\Pi_t = 1$

2.4.2 Fiscal policy

The government spends only on domestically produced goods (perfect home bias). The public consumption good G_t is assembled from differentiated products i with the same retail technology as private consumption $G_t = \left[\int_0^1 G_t(i)^{\frac{\varepsilon-1}{\varepsilon}} \mathrm{d}i\right]^{\frac{\varepsilon}{\varepsilon-1}}$ which, after cost minimization, leads to a similar demand function as for the households (the relevant price index now being the domestic producer price index P_t^H due to perfect home bias):

$$G_t(i) = \left[\frac{P_t^H(i)}{P_t^H}\right]^{-\varepsilon} G_t \tag{2.31}$$

[11]This leads to a symmetric steady state between HtM and Ricardian households (provided that steady state bond holdings $\widehat{B}$ are also zero), independently of profit redistribution τ^D.

G_t follows an AR1 exogenous process $\ln G_t = (1-\rho_g)\ln(\Gamma Y) + \rho_g \ln G_{t-1} + \epsilon_t^g$, where $\Gamma = G/Y$ is the steady state GDP share of government spending.

The government levies a lump sum tax T_t^s on firms (as opposed to Ricardian households) which is used to finance a wage subsidy τ^w. This "sub-budget" is balanced every period: $T_t^s = \tau^w w_t N_t$. Setting $\tau^w = \frac{1}{\varepsilon}$ ensures efficient net markups in steady state $\mathcal{M} = \frac{\varepsilon(1-\tau^w)}{\varepsilon-1} = 1$, and per (2.28) also entails zero firm profits in steady state.

To finance public spending G_t the fiscal authority collects lump sum taxes T_t from households and issues nominal LCY government debt B_t^g at a discount of $(1+i_t)^{-1}$. The nominal government budget constraint is then:

$$P_t T_t + \frac{B_t^g}{1+i_t} = P_t^H G_t + B_{t-1}^g$$

$$T_t + \frac{b_t^g}{1+i_t} = [h(Q_t)]^{-1} G_t + \frac{b_{t-1}^g}{\Pi_t} \tag{2.32}$$

where we used (2.20) and defined $b_t^g \equiv B_t^g / P_t$ as the CPI-deflated real value of public debt. This equation demonstrates how surprise inflation Π_t can reduce the burden of already existing public debt stock b_{t-1}^g.[12]

A fiscal rule governs the endogenous reaction of taxes to outstanding public debt, while taxes can also be subject to exogenous (household specific) shocks. The parameter ϕ_B in the fiscal rule determines how much taxes adjust to stabilize the path of real government debt as a fraction of steady state GDP around a target level $\bar{b}^g$.

$$\frac{T_t - T}{Y} = \phi_B \left(\frac{b_{t-1}^g}{Y} - \bar{b}^g \right) - \left[\lambda \check{\varepsilon}_t^T + (1-\lambda) \hat{\varepsilon}_t^T \right] \tag{2.33}$$

The distribution of the aggregate tax burden across households is pinned down by individual tax rules as follows:

$$\frac{\check{T}_t - \frac{\phi}{\lambda} T}{Y} = \frac{\phi}{\lambda} \phi_B \left(\frac{b_{t-1}^g}{Y} - \bar{b}^g \right) - \check{\varepsilon}_t^T \tag{2.34}$$

$$\frac{\widehat{T}_t - \frac{1-\phi}{1-\lambda} T}{Y} = \frac{1-\phi}{1-\lambda} \phi_B \left(\frac{b_{t-1}^g}{Y} - \bar{b}^g \right) - \hat{\varepsilon}_t^T \tag{2.35}$$

[12] In other words, the *ex post* real interest rate $(1+r_{t-1}) = \frac{1+i_{t-1}}{\Pi_t}$, which determines the real burden of public debt, can be reduced by surprise inflation. Put differently, surprise inflation can have revaluation effects on existing public debt. Expressing the change in the real *market value* of public debt:

$$\begin{aligned}
\frac{b_t^g}{1+i_t} &= \frac{G_t}{h(Q_t)} - T_t + \frac{b_{t-1}^g}{\Pi_t} = \\
&= \left[\frac{G_t}{h(Q_t)} - T_t \right] + (1+r_{t-1}) \frac{b_{t-1}^g}{1+i_{t-1}} \\
\frac{b_t^g}{1+i_t} - \frac{b_{t-1}^g}{1+i_{t-1}} &= \underbrace{\left[\frac{G_t}{h(Q_t)} - T_t \right]}_{\text{primary deficit}} + \underbrace{i_{t-1} \frac{b_{t-1}^g}{1+i_{t-1}}}_{\text{interest payment}} - \underbrace{\frac{\Pi_t - 1}{\Pi_t} b_{t-1}^g}_{\text{revaluation}}
\end{aligned}$$

where ϕ governs the degree of exogenous redistribution, showing what fraction of *expected* aggregate tax burden is levied on HtM households. $\phi = \lambda$ corresponds to the uniform taxation case. Taxes of each household can be subject to individual shocks as well, similarly to Bilbiie, Monacelli and Perotti (2013). These equations together characterize *exogenous* redistribution via the tax system. Combined with (2.33) they also imply the relationship: $T_t = \lambda \check{T}_t + (1-\lambda)\widehat{T}_t$.

The government also taxes the dividends of Ricardian households at a rate τ^D and redistributes the proceeds to HtM households as transfers (*endogenous* redistribution).

2.5 Market clearing

2.5.1 Consumption aggregates

Aggregate consumption indices are the weighted sums of Ricardian and HtM household consumption:

$$C_t = \lambda \check{C}_t + (1-\lambda)\widehat{C}_t \tag{2.36}$$

$$C_t^H = \lambda \check{C}_t^H + (1-\lambda)\widehat{C}_t^H \tag{2.37}$$

$$C_t^F = \lambda \check{C}_t^F + (1-\lambda)\widehat{C}_t^F \tag{2.38}$$

From the above we can also create aggregated demand functions. Applying (2.37) for individual goods i, and using the individual demand functions of HtM and Ricardian agents from before we get domestic demand for a Home produced good i:

$$C_t^H(i) = \left[\frac{P_t^H(i)}{P_t^H}\right]^{-\varepsilon} \underbrace{\left[\lambda \check{C}_t^H + (1-\lambda)\widehat{C}_t^H\right]}_{C_t^H} \tag{2.39}$$

Then combining (2.37) + (2.10) + (2.11) + (2.36) we get domestic demand for Home produced goods:

$$C_t^H = (1-\alpha)\left[\frac{P_t^H}{P_t}\right]^{-\eta} \underbrace{\left[\lambda \check{C}_t + (1-\lambda)\widehat{C}_t\right]}_{C_t} \tag{2.40}$$

Combining (2.38) + (2.12) + (2.13) + (2.36) gives us the import demand of the domestic economy:

$$C_t^F = \alpha \left[\frac{P_t^F}{P_t}\right]^{-\eta} \underbrace{\left[\lambda \check{C}_t + (1-\lambda)\widehat{C}_t\right]}_{C_t} \tag{2.41}$$

Total external demand from all foreign countries faced by domestic exporters is derived by combining (2.15) + (2.16):

$$C_{t,*}^H \equiv \int_0^1 C_{t,j}^H \, \mathrm{d}j =$$

$$= \alpha \int_0^1 \left[\frac{P_t^H}{e_{t,j} P_t^{F,j}}\right]^{-\gamma} \left[\frac{P_t^{F,j}}{P_t^j}\right]^{-\eta} C_{t,j} \, \mathrm{d}j \tag{2.42}$$

2.5.2 Goods market

Output of a domestic firm i is either consumed domesticly (privately or publicly) or exported abroad to countries $j \in [0,1]$. Using demand functions (2.39), (2.31) and (2.17)

$$
\begin{aligned}
Y_t(i) &= C_t^H(i) + G_t(i) + \int_0^1 C_{t,j}^H(i)\mathrm{d}j = \\
&= \underbrace{\left[\frac{P_t^H(i)}{P_t^H}\right]^{-\varepsilon} C_t^H}_{(2.39):\ C_t^H(i)} + \underbrace{\left[\frac{P_t^H(i)}{P_t^H}\right]^{-\varepsilon} G_t}_{(2.31):\ G_t(i)} + \int_0^1 \underbrace{\left[\frac{P_t^H(i)}{P_t^H}\right]^{-\varepsilon} C_{t,j}^H \,\mathrm{d}j}_{(2.17):\ C_{t,j}^H(i)} = \\
&= \left[\frac{P_t^H(i)}{P_t^H}\right]^{-\varepsilon} \underbrace{\left[C_t^H + G_t + \underbrace{\int_0^1 C_{t,j}^H \,\mathrm{d}j}_{(2.42):\ C_{t,*}^H}\right]}_{\text{based on (2.22): } Y_t}
\end{aligned} \tag{2.43}
$$

Applying (2.22), we see that aggregate Home output Y_t is either consumed domestically or exported. Plugging in domestic and external demand functions (2.40) and (2.42), goods market clearing will entail:

$$
\begin{aligned}
Y_t &= C_t^H + G_t + C_{t,*}^H = \\
&= \underbrace{(1-\alpha)\left[\frac{P_t^H}{P_t}\right]^{-\eta} C_t}_{C_t^H} + G_t + \underbrace{\alpha \int_0^1 \left[\frac{P_t^H}{e_{t,j}P_t^{F,j}}\right]^{-\gamma} \left[\frac{P_t^{F,j}}{P_t^j}\right]^{-\eta} C_{t,j}\,\mathrm{d}j}_{C_{t,*}^H} = \\
&= \left[\frac{P_t^H}{P_t}\right]^{-\eta} \left[(1-\alpha)\, C_t \;+\; \alpha \left(\frac{P_t^H}{P_t}\right)^{\eta} \int_0^1 \left(\frac{P_t^H}{e_{t,j}P_t^{F,j}}\right)^{-\gamma} \left(\frac{P_t^{F,j}}{P_t^j}\right)^{-\eta} C_{t,j}\,\mathrm{d}j\right] + G_t = \\
&= \underbrace{\left[\frac{P_t^H}{P_t}\right]^{-\eta}}_{\left[h(Q_t)\right]^{\eta}} \left[(1-\alpha)\, C_t \;+\; \alpha \int_0^1 \left(\frac{e_{t,j}P_t^{F,j}}{P_t^H}\right)^{\gamma-\eta} \Bigg(\underbrace{\frac{e_{t,j}P_t^j}{P_t}}_{Q_{t,j}}\Bigg)^{\eta} C_{t,j}\,\mathrm{d}j\right] + G_t = \\
&= \left[h(Q_t)\right]^{\eta} \left[(1-\alpha)\, C_t \;+\; \alpha \int_0^1 \Bigg(\underbrace{\frac{P_t^{F,j}}{P_t^j}}_{X_t^j}\ \underbrace{\frac{P_t^j e_{t,j}}{P_t^H}}_{X_{t,j}}\Bigg)^{\gamma-\eta} Q_{t,j}^{\eta}\, C_{t,j}\,\mathrm{d}j\right] + G_t
\end{aligned} \tag{2.44}
$$

Assuming symmetric foreign countries we substitute j notation with $*$, and use $P_t^{F,*} = P_t^*$. Furthermore, we impose foreign goods market clearing, treating the rest of the world as a closed economy $C_{t,*} = Y_t^*$. Then:

$$
\begin{aligned}
Y_t &= \left[h(Q_t)\right]^{\eta} \Big[(1-\alpha)\, C_t \;+\; \alpha \left[h(Q_t)Q_t\right]^{\gamma-\eta} Q_t^{\eta}\, Y_t^*\Big] + G_t = \\
&= \left[h(Q_t)\right]^{\eta} \Big[(1-\alpha)\, C_t \;+\; \alpha \left[h(Q_t)\right]^{\gamma-\eta} Q_t^{\gamma}\, Y_t^*\Big] + G_t
\end{aligned} \tag{2.45}
$$

In an open economy with $\alpha \neq 0$ (2.45) is one of most important relationships governing aggregate demand. It shows how output is affected by domestic and external demand through C_t and Y_t^*, respectively (*expenditure changing* channel), and how the latter also depend on the real exchange rate Q_t through *expenditure switching* effects. Just like producers selling domestically, exporters face a downward sloping demand curve: a real depreciation makes exports more competitive boosting external demand, while it also makes imports more expensive causing substitution towards domestically produced goods. The real exchange rate Q_t is the most important international relative price and the sensitivity of aggregate demand to it is governed by elasticities η and γ.

2.5.3 Labor market

$$N_t = \lambda \check{N}_t + (1-\lambda)\widehat{N}_t \tag{2.46}$$

2.5.4 Asset market

Both LCY and FCY bonds are in zero net supply *globally*.

$$0 = \tilde{B}_t + \underbrace{(1-\lambda)\widehat{B}_t - B_t^g}_{\equiv B_t} \tag{2.47}$$

$$0 = \tilde{B}_t^* + \underbrace{(1-\lambda)\widehat{B}_t^*}_{\equiv B_t^*} \tag{2.48}$$

where $\tilde{B}_t, \tilde{B}_t^*$ denote foreigners' bond holdings, i.e. the opposite side of any domestic bond position must necessarily be taken by the foreign economy. Foreign asset demand is basically the mirror image of foreign asset supply $(-\tilde{B}_t, -\tilde{B}_t^*)$, and as discussed in Section 2.1.2, in the absence of modelling the portfolio choice problem (which would yield domestic asset demand functions for LCY and FCY), the currency composition of the net domestic bond position (B_t and B_t^*) will be determined by foreign asset supplies.

We consider two extreme scenarios for asset supply. In our baseline setup only LCY-denominated bonds are traded internationally and FCY bonds are not (i.e. there is no *original sin*, and the domestic economy's holdings of FCY bonds B_t^* are restricted to be zero).

$$-\tilde{B}_t^* = \qquad B_t^* = 0 \tag{2.49}$$

On the other hand, we can also consider the *currency mismatch* case where domestic households can borrow internationally only in FCY (original sin), and LCY bonds are restricted for domestic financial transactions between Ricardian households and the government.

$$-\tilde{B}_t = \qquad B_t = 0 \tag{2.50}$$

Under both scenarios, international asset supply in the unrestricted currency is implicitly determined by the debt-elastic risk premium function (2.55) defined below.

2.6 External balance

2.6.1 Trade balance

The *CPI-deflated* real trade balance is defined as:

$$NX_t = \frac{P_t^H}{P_t} C_{t,*}^H - \frac{P_t^F}{P_t} C_t^F$$
$$= \frac{P_t^H}{P_t} (Y_t - G_t) - C_t = \frac{Y_t - G_t}{h(Q_t)} - C_t \tag{2.51}$$

which is the difference between CPI-deflated exports and imports.[13] Substituting into to the trade balance (2.51) the aggregate demand equation (2.45), aggregate consumption (2.36) and international risk sharing (2.7) for Ricardian consumption, we see that it is affected by the real exchange rate (e.g. a depreciation) through several channels:

- through the *expenditure switching* channel both domestic and foreign consumers substitute towards relatively cheaper Home goods, pushing NX_t upwards, governed by trade elasticities η and γ
- through the *terms-of-trade revaluation* channel, due to the CPI/PPI wedge $h(Q_t)$ which is increasing in Q_t through (2.20), *even if actual quantities do not change*, the CPI-deflated NX_t will drop as the same nominal export revenue from domestic goods is now worth less in terms of the consumption basket (which includes imported goods).
- through the *risk sharing* channel: even under incomplete markets the real exchange rate acts as a shock absorber partially insuring the ratio of cross-country consumption values between Ricardians and foreigners. This means that if the relative price of foreign consumption (Q_t) goes up, then Home Ricardians get to consume more. I.e. for given foreign output, weaker exchange rate allows higher aggregate Ricardian consumption in Home, some of which goes towards higher imports, pushing NX_t downwards, governed by the intertemporal elasticity of substitution $1/\sigma$.
- through the *hand-to-mouth* channel (New Keynesian Cross): a higher share λ of HtM means that the average MPC is higher in the economy, leading to potentially higher "New Keynesian" multipliers for any demand shifter shock. Since a real depreciation boosts aggregate demand through (2.45), a larger λ can amplify this increase in output Y_t (to the extent that it doesn't limit the initial real depreciation too much, so the condition set out in Bilbiie (2019) that HtM income *overreacts* aggregate income must hold). Despite the

[13] This can be verified by starting from the nominal trade balance and applying previous definitions:

$$\mathcal{NX}_t = P_t^H (Y_t - G_t) - P_t C_t =$$
$$= P_t^H \underbrace{(C_t^H + C_{t,*}^H)}_{(2.44):\ Y_t - G_t} - \underbrace{(P_t^H C_t^H + P_t^F C_t^F)}_{P_t C_t} =$$
$$= P_t^H C_{t,*}^H - P_t^F C_t^F$$

higher output multplier however, consumption would increase even more as part of it goes towards imports, which is why this would mitigate the rise in the trade balance. Through a lower share of Ricardians, a higher λ would also weaken the risk-sharing channel.

In the special case of Galí and Monacelli (2005) with $\lambda = 0$ and $\sigma = \eta = \gamma = 1$ with a symmetric steady state of zero NFA, and complete international financial markets, all of these channels exactly offset each other, and the trade balance does not depend on the real exchange rate but stays zero at all times. Any deviation from this benchmark will make the trade balance react to the real exchange rate.[14]

2.6.2 Balance-of-payments

The Net Foreign Asset (NFA) position of the economy becomes an important state variable under incomplete markets, as it provides crucial feedback into the consumption-saving decision via the debt-elastic risk premium (in other words, foreign asset supply is a function of the domestic NFA position). The law of motion for the NFA position is governed by the Balance-of-Payments (BoP) equation which is derived by combining the budget constraints of domestic households (2.1) and (2.3) with the firm's profit equation (2.28) and the government budget constraint (2.32):

$$\left[\frac{b_t}{1+i_t} - \frac{b_{t-1}}{\Pi_t}\right] + \left[\frac{b_t^*}{(1+i_t^*)\psi_t} - \frac{b_{t-1}^*}{\Pi_t^*}\frac{Q_t}{Q_{t-1}}\right] = NX_t \tag{2.52}$$

where $b_t + b_t^* \equiv \frac{B_t}{P_t} + \frac{e_t B_t^*}{P_t}$ is the *face value* of the Net Foreign Asset (NFA) position of the economy (expressed in LCY and in CPI-deflated real terms). The Balance-of-Payments states that the change in NFA (the "Financial Account balance") must be equal to the net savings of the domestic economy (the "Current Account balance" which in turn is the sum of the trade balance and net interest income). A country that is producing more than it is consuming (i.e. saves) will lend the resulting savings to foreigners and accumulate claims on them.

In the baseline scenario there is no original sin, and international trade is financed by LCY

---

[14] Under complete markets where (2.7) is replaced by $\widehat{C}_t = Q_t^{\frac{1}{\sigma}} Y_t^*$, doing the above substitutions leads to the following representation of the trade balance:

$$NX_t = \left[h(Q_t)\right]^{\eta-1}\left\{(1-\alpha)\left[\lambda\check{C}_t + (1-\lambda)Q_t^{\frac{1}{\sigma}}Y_t^*\right] + \alpha\left[h(Q_t)\right]^{\gamma-\eta} Q_t^{\gamma}\, Y_t^*\right\} - \left[\lambda\check{C}_t + (1-\lambda)Q_t^{\frac{1}{\sigma}}Y_t^*\right] =$$

$$= \underbrace{\left\{\underbrace{(1-\alpha)\left[h(Q_t)\right]^{\eta}\left[h(Q_t)\right]^{-1}\left[\lambda\check{C}_t + (1-\lambda)Q_t^{\frac{1}{\sigma}}Y_t^*\right]}_{\left[h(Q_t)\right]^{-1}C_t^H} + \underbrace{\alpha\left[h(Q_t)Q_t\right]^{\gamma}\left[h(Q_t)\right]^{-1}Y_t^*}_{\left[h(Q_t)\right]^{-1}C_{t,*}^H}\right\}}_{\left[h(Q_t)\right]^{-1}(Y_t-G_t)} - \underbrace{\left[\lambda\check{C}_t + (1-\lambda)Q_t^{\frac{1}{\sigma}}Y_t^*\right]}_{C_t} =$$

$$= \underbrace{\alpha\left[h(Q_t)Q_t\right]^{\gamma}\left[h(Q_t)\right]^{-1}Y_t^*}_{\text{real exports}} - \underbrace{\alpha\, Q_t^{-\eta}\, Q\left[\lambda\check{C}_t + (1-\lambda)Q_t^{\frac{1}{\sigma}}Y_t^*\right]}_{\text{real imports}}$$

With incomplete markets there is no such clean representation, but it also depends on the full future expected paths of foreign output $\{Y_t^*\}$ and the real exchange rate $\{Q_t\}$.

bonds only. Applying (2.49) to the BoP equation (2.52) we get

$$\frac{b_t}{1+i_t} - \frac{b_{t-1}}{\Pi_t} = NX_t \tag{2.53}$$

This demonstrates how the ability to issue LCY debt (or save in LCY bonds) can allow surprise domestic inflation Π_t to reduce the real burden of already existing external debt stock $(-b_{t-1})$, as determinded by the *ex post* real interest rate $(1 + r_{t-1}) = \frac{1+i_{t-1}}{\Pi_t}$, similarly to how it can ease the burden of public debt on the government.[15] Put differently, surprise inflation can have revaluation effects on the existing external debt stock.[16]

Notice how this makes monetary policy non-neutral even under flexible prices, as suprise inflation can affect the real trade balance and next period's real borrowing/saving needs b_t which in turn feeds back into the effective real interest rate through the risk premium $\psi_t(b_t)$. This introduces another important channel through which monetary policy affects the economy.[17]

This is not the case in the alternative scenario with original sin, when the small open economy can only borrow (or save) in FCY. Then, after inserting (2.49) into (2.52), the balance-of-payments will be:

$$\frac{b_t^*}{(1+i_t^*)\psi_t} - \frac{b_{t-1}^*}{\Pi_t^*}\frac{Q_t}{Q_{t-1}} = NX_t \tag{2.54}$$

In the case of FCY bonds the above described valuation effects can only happen via changes in the real exchange rate (or foreign inflation, which we treat here as fixed), which monetary policy cannot affect under flexible prices. In other words, FCY debt inherited from last period B_{t-1}^* cannot be inflated away by surprise domestic inflation, since it needs to be paid back in FCY, and under flexible prices higher inflation would just lead to an offsetting nominal depreciation (such that the real exchange rate does not change $\bar{Q} = \frac{\uparrow e_t P_t^*}{P_t \uparrow}$), and more LCY would be needed to pay back the same FCY amount. On the other hand, surprise real exchange rate fluctuations

[15]Manipulating (2.53) leads to:

$$\underbrace{\frac{b_t}{1+i_t}}_{NFA_t} = NX_t + \underbrace{\frac{1+i_{t-1}}{\Pi_t}}_{1+r_{t-1}} \underbrace{\frac{b_{t-1}}{1+i_{t-1}}}_{NFA_{t-1}}$$

$$\underbrace{\frac{b_t}{1+i_t} - \frac{b_{t-1}}{1+i_{t-1}}}_{FA_t} = \underbrace{NX_t + \overbrace{i_{t-1}\frac{b_{t-1}}{1+i_{t-1}}}^{\text{interest payment}} + \overbrace{\left[\frac{1}{\Pi_t} - 1\right] b_{t-1}}^{\text{revaluation}}}_{CA_t}$$

[16]Note that here NFA is defined as the real *market value* $\frac{b_t}{1+i_t}$ (as opposed to *face value* b_t) of the net bond position, and the Financial Account the change of this NFA position $FA_t = NFA_t - NFA_{t-1}$.

[17]Note the parallel with government debt. With passive monetary policy (in the Leeper (1991) sense) inflation would play a large role in real public debt stabilization which seems to carry over to the open economy setting when it is the external debt of the whole economy instead of the government's which needs stabilizing. But even with active monetary policy it matters whether it fixes the nominal exchange rate, CPI inflation or just follows a flexible Taylor rule, since these imply different paths for inflation Π_t – just like in the absence of Ricardian equivalence when monetary policy matters also via its fiscal consequences.

can cause valuation effects in the NFA position, potentially affecting the current account. Under sticky prices unexpected nominal exchange rate movements also suffice to achieve this, since they translate into real exchange movements.[18]

The difference between the LCY or FCY regimes, in terms of the dynamics of the real *market value* of NFA position, can be precisely captured by surprise nominal depreciation.[19] Since the nominal uncovered interest rate parity does not necessarily hold ex post, generally we have an expectation error $\nu_t \equiv \frac{e_t}{\mathrm{E}_{t-1} e_t} \neq 1$ such that $(1 + i_{t-1})\nu_t = (1 + i^*_{t-1})\,\psi_{t-1}\,\frac{e_t}{e_{t-1}}$. Applying this to the balance-of-payments equations (2.53) and (2.54), after some manipulations (see in the footnotes), we get:

$$NFA_t = NX_t + (1 + r_{t-1})\,NFA_{t-1}$$

$$NFA^*_t = NX_t + (1 + r_{t-1})\,\nu_t\,NFA^*_{t-1}$$

In other words, the effective *ex post* real interest rate will be different in the two currencies due to this exchange rate expectation error ν_t.

[18] Manipulating (2.54), and applying the nominal UIP condition, we get:

$$\underbrace{\frac{b^*_t}{(1+i^*_t)\psi_t}}_{NFA^*_t} = NX_t + \frac{e_t/e_{t-1}}{\Pi_t}\,b^*_{t-1} =$$

$$= NX_t + \underbrace{\frac{(1+i^*_{t-1})\,\psi_{t-1}\,e_t/e_{t-1}}{\Pi_t}}_{\frac{(1+i_{t-1})\,\nu_t}{\Pi_t} = (1+r_{t-1})\,\nu_t}\;\underbrace{\frac{b^*_{t-1}}{(1+i^*_{t-1})\,\psi_{t-1}}}_{NFA^*_{t-1}}$$

$$\underbrace{\frac{b^*_t}{(1+i^*_t)\psi_t} - \frac{b^*_{t-1}}{(1+i^*_{t-1})\psi_{t-1}}}_{FA_t} = \underbrace{NX_t + \overbrace{\left[(1+i^*_{t-1})\psi_{t-1} - 1\right]\frac{b^*_{t-1}}{(1+i^*_{t-1})\,\psi_{t-1}}}^{\text{interest payment}} + \overbrace{\left[\frac{e_t/e_{t-1}}{\Pi_t} - 1\right] b^*_{t-1}}^{\text{revaluation}}}_{CA_t}$$

[19] Note that in the symmetric equilibrium with zero steady state NFA, the first-order valuation effects coming from either higher inflation or real depreciation are zero, thereby making the FCY and LCY regimes identical.

2.6.3 Premium function

A debt-elastic premium function ψ_t represents the asset supply of foreigners which is a negative function of the economy's NFA position. The intuitive way to think about it is that if the domestic economy were to go deeper in debt (lower and negative b_t) than some exogenous tolerated ζ_t value, then foreigners would lend only at a higher interest rate.

The premium function depends on the *face value* of the NFA position $b_t + b_t^*$ (relative to GDP) which is determined by the consumption-saving decisions of the domestic economy as captured by the BoP equation (2.52):

$$\psi_t = e^{-\delta\left(\frac{B_t + e_t B_t^*}{P_t^H Y_t} - \zeta_t\right)} = $$

$$= e^{-\delta\left((b_t + b_t^*)\frac{h(Q_t)}{Y_t} - \zeta_t\right)} \tag{2.55}$$

$$\zeta_t = (1-\rho_\zeta)\zeta + \rho_\zeta \zeta_{t-1} + \epsilon_t^\zeta \tag{2.56}$$

where shocks to ζ_t are used to model "sudden stops", i.e. a sudden worsening of international lending conditions leading to a reversal of capital inflows and forcing the domestic economy to rapid external adjustment.

Apart from being used to capture sudden stops, the presence of ψ_t also serves the purpose of making the dynamics of our incomplete market economy stationary, and to pin down a unique steady state, as shown by Schmitt-Grohé and Uribe (2003). In the absence of idiosyncratic risk, assets would not feature in the consumption/saving decision of households (as governed by the Euler equation or international risk sharing condition) without the presence of ψ_t, and therefore nothing would anchor the NFA position of the economy (which is a result of past consumption/saving choices as pinned down by the balance-of-payments). This would not only make the effect of unexpected shocks permanent (making the demand imbalance across countries a random walk, as shown above), but would also prevent pinning down a unique steady state NFA position. The presence of ψ_t allows the asset position of the economy to feed back into consumption-saving decisions via risk-adjusted interest rates, and thereby rendering it stationary.

If foreign households also have a personal discount factor of β, then based on (2.6) the steady state risk premium consistent with a stationary equilibrium (i.e. one without real depreciation/appreciation) is $\psi = 1$, which means that the steady state NFA position is pinned down as $b\frac{h(Q)}{Y} = \zeta$.[20]

2.7 Dynamic equilibrium

Equilibrium is depicted in the above model by equations as listed in Appendix A.

[20] Notice that this does not really get around the problem of *endogenously* pinning down the steady state asset distribution. Conditional on the parameter ζ, the steady state NFA is determined, but ζ is still chosen arbitrarily. Without idiosyncratic risk and a borrowing constraint, however, there's no precautionary saving motive (at least up to second order) which would pin it down, so this choice is necessarily arbitrary.

3 Monetary-fiscal interactions, heterogeneity and openness

3.1 Active and passive monetary and fiscal policies

Monetary-fiscal interactions are modelled in the framework of Leeper (1991), via the monetary and fiscal policy rules (2.29) and (2.33). Depending on the policy reaction parameters ϕ^{π} and ϕ_B we can talk about "active" or "passive" policies. In a coordinated setting only one of the policy branches can be active, meaning that it can freely *lead* in pursuing a given objective while the other policy branch must passively *follow*, in a sense "subordinating" itself to the objective of the former.[21]

In a regime with active monetary and passive fiscal policy mix (AM-PM), the central bank actively manages the real interest rate to stabilize inflation (through affecting aggregate demand), while fiscal policy must passively adjust the primary budget balance to offset the monetary-induced changes in interest rates such that it ensures a stable path for public debt. In terms of the policy parameters (and assuming raising real interest rates is contractionary for aggregate demand) this policy regime is characterized by $\phi^{\pi} > 1$ and $\phi_B > 1 - \beta$, since these ensure a strong enough reaction of nominal interest rates to inflation (such that real rates move in the same direction), together with a strong enough reaction of fiscal surpluses to public debt[22] (upper right quadrant of Table 1 amd Figure 1).

	$\phi^{\pi} < 1$	$1 < \phi^{\pi}$
$\phi_B > 1 - \beta$	PM-PF	AM-PF
$\phi_B < 1 - \beta$	PM-AF	AM-AF

Table 1: Policy regimes in the "Keynesian" (non-IADL) region of the paramter space.

In contrast, under a regime with passive monetary and active fiscal policy mix (PM-AF), instead of being constrained by the need for debt stabilization, fiscal policy is free to actively set the path of primary budget surpluses, while monetary policy must passively accommodate fiscal shocks by tolerating deviations from price stability and letting inflation adjust to revalue nominal public debt. Thereby, instead of the primary budget balance, inflation becomes the primary tool for public debt stabilization to which monetary policy is forced to subordinate its price stability objective. In terms of policy parameters this translates to $\phi^{\pi} < 1$ and $\phi_B < 1 - \beta$, since these

[21] With both policies being passive (PM-PF) the price level is not pinned down uniquely, giving rise to multiple sunspot equilibria, while both policies being active (AM-AF) leads to conflict between them resulting in explosive dynamics (see Figure 1).

[22] By looking at the log-linearized government budget constraint (ignoring G_t for simplicity, and tilde denoting linear deviations from steady state) and substituting in policy rules, real public debt becomes a mean reverting stationary process (which can be solved backward) precisely iff $\phi_B < 1 - \beta$:

$$\tilde{b}_t^g = \beta^{-1}\tilde{b}_{t-1}^g + \bar{b}^g\left[i_t - \beta^{-1}\pi_t\right] - \beta^{-1}\tilde{T}_t$$
$$\tilde{b}_t^g = \beta^{-1}\left(1 - \phi_b\right)\tilde{b}_{t-1}^g + \bar{b}^g\left[\phi_{\pi} - \beta^{-1}\right]\pi_t + \varepsilon_t^T$$

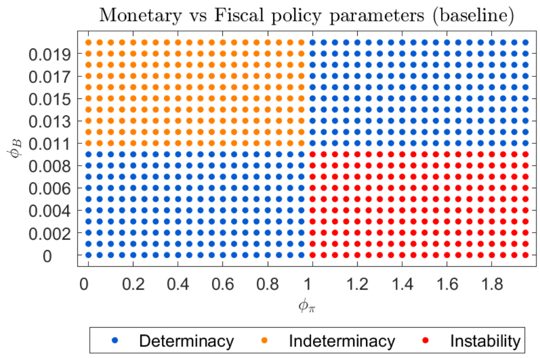

Figure 1: Model determinacy properties in the (ϕ^π, ϕ_B) plain, given other parameters at baseline values $(\lambda = 0.3, \alpha = 0.5, \varphi = 2$, i.e. non-IADL, Keynesian region).

reflect relatively unresponsive interest rates to inflation, which help stabilize debt dynamics, enabling fiscal surpluses to react less to public debt.

In other words, in the PM-AF regime monetary policy essentially helps keep the real burden of public debt manageable, creating fiscal space for the government to run larger primary deficits. In this sense the PM-AF regime in this model can be thought of as the analogue of "helicopter money" or money-financed fiscal stimulus. In both cases an unresponsive monetary policy accommodates the fiscal expansion by keeping interest rates low and "inflating away" or "monetizing" some of the nominal debt. The only difference is that in the latter case the monetary policy rule is defined not in terms of interest rate policy, but by a money supply rule. Instead of directly influencing interest rates to keep them low, the central bank prints money, which *in turn* will lead to lower interest rates (via the interaction of money demand and the increased money supply). As argued by Bianchi, Faccini and Melosi (2020), money is just a tool to deliver a given interest rate, and modelling it explicitly or just assuming the central bank is able to set the nominal interest rate makes no big difference to equilibrium dynamics.[23] What matters instead is whether monetary policy is conducted with price stability as the primary objective,

[23] There is a slight difference though, to the extent that money is non-interest bearing liability of the consolidated government – as opposed to bonds. Therefore, the decision whether to finance the budget deficit by issuing bonds or money (or whether to have the central bank buy up some of the bonds with newly printed money) does matter somewhat as far as the difference between interest rates on bonds and money is positive. In such a case monetary financing can generate some *seigniorage* revenue for the government. However, in most modern economies the monetary liabilities of the government (central bank reserves) do pay an interest rate similar to those of government bonds, which limits the scope for obtaining seizable seigniorage revenue. In any case, the significance of seigniorage pales in comparison to the distinction between AM-PF and PM-AF regimes which relates to the *objectives* of monetary policy (instead of the debt management policy of the consolidated government, trying to optimize the *composition* of its liabilities). Even though in the PM-AF regime of the above model the deficit is fully debt-financed, this debt can be thought of as the joint (money and bond) liabilities of the consolidated state, and the interest rate being the average interest on central bank reserves and government bonds.

or is subordinated to the needs of fiscal debt stabilization.

Rewriting the government budget constraint (2.32) in terms of the CPI-delfated real *market value* of public debt, we can see how debt dynamics depend on the primary budget balance, nominal interest rates and inflation.

$$\frac{b_t^g}{1+i_t} - \frac{b_{t-1}^g}{1+i_{t-1}} = \left[\frac{G_t}{h(Q_t)} - T_t\right] + r_{t-1}\,\frac{b_{t-1}^g}{1+i_{t-1}}$$
$$= \underbrace{\left[\frac{G_t}{h(Q_t)} - T_t\right]}_{\text{primary deficit}} + \underbrace{i_{t-1}\frac{b_{t-1}^g}{1+i_{t-1}}}_{\text{interest payment}} - \underbrace{\frac{\Pi_t - 1}{\Pi_t} b_{t-1}^g}_{\text{revaluation}}$$

where $r_{t-1} = \frac{1+i_{t-1}}{\Pi_t}$ is the *ex post* real interest rate. The distinction between AM-PF and PM-AF can be captured by the relative roles of the above components. In an AM-PF regime debt stabilization mainly depends on the primary balance, while relatively stable inflation keeps debt revaluation in check, and actively managed interest rates could even force the hand of the fiscal authority to adjust the budget. In contrast, in a PM-AF regime the primary balance can be set completely exogenously, so stationarity of debt dynamics must be ensured by relatively unresponsive interest costs, and inflation providing more cushion for fiscal policy through revaluation. The latter channel is present because the government issues *nominal* bonds, whose real value can be eroded by *surprise* inflation. The joint effects of nominal interest rates and inflation are nicely summarized by the *ex post* real interest rate, reflecting the real burden of debt: from this perspective a PM-AF policy regime stabilizes public debt less via adjusting the primary government budget, and more via letting inflation move the *ex post* real interest rate.

However, there is a more discontinuous contrast between the two policy regimes than just quantitative differences in the relative roles of budget balances and inflation in stabilizing debt dynamics. As explained in Leeper and Leith (2016), under the AM-PF regime (as long as Ricardian equivalence holds), monetary-fiscal interactions are like a one way street, going from the central bank to the government. A rise in interest rates can force the government to adjust the budget balance, but inflation is completely insulated from how fiscal policy is conducted and fiscal imbalances are not relevant for inflation determination. Bianchi and Melosi (2019) call this "*Monetary and Fiscal Dischotomy*". By contrast, under the PM-AF regime this dichotomy breaks down, and inflation becomes a joint monetary-fiscal phenomenon, determined by the very need the stabilize the real value of public debt. This rhymes with the Fiscal Theory of the Price Level.

Of course, when Ricardian equivalence fails (e.g. due to household heterogeneity and fiscal redistribution), fiscal policy does matter even under the AM-PF regime. The timing of taxes via ϕ_B affects the disposable *current* income of high MPC hand-to-mouth households which then influences aggregate demand and inflation. These kind of monetary-fiscal interactions due to the breakdown of Ricardian equivalence, however, are of a fundamentally different nature than the one arising under a PM-AF regime. In fact, with a PM-AF policy mix Ricardian equivalence breaks down even in a representative agent model without redistributive fiscal policies *because of* the kind of monetary-fiscal interactions in this regime (as explained in the next section by the nominal wealth effect).

3.2 Ricardian equivalence

Strictly speaking, Ricardian equivalence means that the *timing* of taxes does not matter, i.e. that the debt stabilization decisions of fiscal policy are irrelevant. By the same token, evironments where Ricardian equivalence breaks down and fiscal policy matters more, present an obvious candidate for richer monetary-fiscal interactions which is why it is worth exploring when this occurs.

In terms of our model Ricardian equivalence translates to ϕ_B being irrelevant for equilibrium dynamics. While household heterogeneity and the presence of high-MPC hand-to-mouth agents seems to make it straightforward that in this TANK model Ricardian equivalence fails even in the AM-PF policy regime, there are some special conditions under which it still holds. Such a condition is that no taxes are paid by hand-to-mouth agents, i.e. that $\phi = 0$. In this case, optimizing and consumption-smoothing Ricardian households completely internalize the government's budget constraint and do not care about the time path of taxes or government bonds: they are the only holders of public debt which is exactly offset by the present value of their tax obligations (in other words, government bonds constitute zero net wealth for them).[24]

Whenever $\phi > 0$, HtM households also pay some of the taxes, and since they consume their current after-tax income every period, the timing of taxes ϕ_B obvioulsy matters, and Ricardian equivalence breaks down. Ricardian households are still optimizing lifetime income consumers so the time path of *their* taxes $\widehat{T}_t$ should not directly matter (as long as their present value is the same), and it is primarily the path of HtM taxes $\check{T}_t$ what matters for aggregate dynamics. But notice that with $\phi > 0$ government bonds become net wealth for Ricardians, as they hold all the public debt but are liable for only a $(1 - \phi)$ fraction of the present value of the offsetting tax burden. This net wealth essentially represents a loan from Ricardians to HtM households

[24] Bilbiie, Monacelli and Perotti (2013) point out another important special case. Even if $\phi > 0$ (i.e. HtM households, for whom timing matters, are also taxed), with flexible prices $\theta = 0$ and with equal steady state consumption $\widehat{C} = \check{C}$ (or with fully inealstic labor supply $\varphi \to \infty$) this would still not affect the *aggregate* dynamics. Therefore the timing of taxes is also irrelevant and Ricardian equivalence still prevails in this limited sense (i.e. meaning only aggregate variables). While $\phi > 0$ means that government bonds *are* net wealth for Ricardians (as they hold all the public debt but are liable for only a $(1 - \phi)$ fraction of the present value of the offsetting tax burden), holding this net wealth crowds out precisely as much Ricardian consumption and leisure, as the increase in HtM consumption and leisure induced by their tax cut: income effects on labor supply exactly offset each other in this case. Although the timing of taxes ϕ_B certainly matters for the time path of distributional variables, it does not affect aggregate dynamics. **For Ricardian equivalence to break down also in the latter sense, (barring steady state consumption inequalities) nominal rigidities are crucial** as they introduce an additional negative income effect on Ricardians' labor supply via countercyclical profit variations. This will prompt them to work more than by which the HtM is willing to work less, supporting the aggregate expansion in output.

(who are otherwise shut out of financial markets) via the intertemporal government budget. The timing of taxes ϕ_B determines for how long Ricardians must hold this net wealth, i.e. how fast HtM will repay their share of the public debt to Ricardians. The more persistent public debt is (lower ϕ_B), the more it crowds out Ricardian consumption (which in turn hurts HtM households too, as lower demand hurts their incomes).

The breakdown of Ricardian equivalence due to the above reasons of household heterogeneity will naturally induce some monetary-fiscal interactions. On the one hand, monetary policy has fiscal consequences via interest expenses and the revaluation of nominal public debt, which now have differing impact on the real economy depending on how fiscal policy is managing public debt and how it distributes taxes across households. On the other hand, as pointed out by Kaplan, Moll and Violante (2018), the decision of the fiscal authority whether to finance current public expenditures by raising taxes or by issuing debt, or how the tax burden is shared between households would no longer be inconsequential, which in turn affects monetary policy and could force the central bank to react. In other words, inflation would no longer be completely insulated from fiscal policy and the *Monetary-Fiscal Dichotomy* would break down even in an AM-PF policy regime.

3.2.1 Nominal wealth effect under the PM-AF regime

Everything drastically changes under the PM-AF policy regime when fiscal policy gives up debt stabilization ($\phi_B \approx 0$) and runs budget deficits unbacked by the present value of future primary surpluses. As already mentioned above, in this case Ricardian equivalence fails even in a RANK model (with only optimizing Ricardian agents, $\lambda = 0$), precisely *because of* the kind of monetary-fiscal interactions under this policy mix, and not due to household heterogeneity: even a simple debt-financed tax cut for Ricardian agents can set off large dynamic effects.

Jacobson, Leeper and Preston (2019) explain that this is due to the wealth effects of unbacked nominal debt issuance on aggregate demand: deficit-financed transfers to households today do not entail tax increases in the future, which prompts consumers to spend rather than save them. Government bonds become *nominal* net wealth. However, in equilibrium there's nobody to sell their windfall nominal bonds to in exchange for consumption goods, so it leads to a collapse in the real value of bonds via higher consumer price inflation.[25] At the same time, since output is demand determined with nominal rigidities, the rise in aggregate demand due to the nominal wealth effect, results in real economic expansion.

[25] Putting it another way, government bonds are still not *real* net wealth ex post, since the real intertemporal government budget constraint (which households internalize) must hold. As Bianchi and Melosi (2019) point out, since nominal public debt is no longer backed by the present value of future tax revenues, agents realize that the government will not be able to repay it with consumption goods in the future, therefore everyone wants to sell bonds in exchange for consumption goods, the price of which must go up to clear the market. And the fiscal deficit will have been paid for by the erosion of the real value of household assets: inflation tax instead of explicit taxation.

The rise in the price level also ensures that the intertemporal *real* government budget constraint still holds: even though the present value of future primary surpluses has fallen as a result of the unbacked tax cut, the real value of outstanding debt has also been eroded by inflation. It is essentially this revaluation of already existing nominal assets via an "inflation tax" which ends up paying for the fiscal deficit in real terms – but in a way that (with rigid prices) generates a huge expansion in the meantime. For all this to work, monetary policy must passively accommodate rising inflation and let it "inflate away" or stabilize the real value of public debt in the spirit of the Fiscal Theory of the Price Level. The above discussion again underlines how an unbacked fiscal expansion can influence inflation, and how debt has monetary consequences in such an environment.

Exploring how openness ($\alpha > 0$) and the HtM amplification ($\lambda > 0$) via the New Keynesian Cross interacts with this PM-AF policy regime, as exchange rate movements influence inflation and income, including that of high-MPC HtM households, is an important objective of this paper.

3.3 Open economy New Keynesian Cross with redistribution

As in the closed economy TANK model of Bilbiie (2019), there is a New Keynesian Cross in operation. This gives the economy a more "Keynesian flavor" in the sense that the influence of monetary policy on aggregate demand operates more through *indirect* general equilibrium propagation on income, rather than mainly through *direct* intertemporal substitution in response to real interest rate changes (as in RANK models). The reason for this is that in presence of hand-to-mouth agents the average MPC of the economy rises, meaning that aggregate consumption will be more responsive to changes in current income than with only permanent income consumer Ricardian agents who smooth out temporary income changes. A higher average MPC implies a steeper planned expenditure (PE) curve, so whatever shifts aggregate demand, its effect will be multiplied through the effect on HtM consumption in a similar fashion than in the old Keynesian Cross analysis. In other words, the HtM channel can deliver amplification. The same channel manages to deliver positive fiscal multipliers on aggregate consumption.

However, as Bilbiie (2019) points out, it is not the mere addition of HtM agents (and the ensuing increase in average MPC) that delivers amplification, but an income distribution such that *their* income rises more than proportionally to aggregate income, which in turn depends on endogenous profit redistribution in their favor through τ^D, and the labor supply elasticity φ. Bilbiie (2019) refers to this as the *counter-cyclical inequality channel.* In a closed economy amplification through the HtM channel occurs if and only if the elasticity of HtM income to aggregate income is higher than unity: $\chi = 1+\varphi\left(1 - \frac{\tau^D}{\lambda}\right) > 1$. Otherwise the smaller size of the direct effect due to HtM presence (the shift of the PE curve is decreasing in λ) will dominate the larger indirect effect coming from higher average MPC (the slope of the PE curve is increasing both λ and χ). As long as $\chi > 1$ is satisfied, income inequality is countercyclical and there is AD amplification of monetary policy as well as positive fiscal multipliers which increase in the share of HtM λ. Bilbiie (2019) shows that the interest elasticity of aggregate demand (in the aggregate Euler equation) is $-\frac{1}{\sigma}\frac{1-\lambda}{1-\lambda\chi}$.[26]

As pointed out by Broer et al. (2020), countercyclical profit variations are an important part of the New Keynesian transmission mechanism through inducing income effects on the labor supply of households who receive them. To the extent that there is *endogenous profit redistribuition* towards HtM households ($\tau^D > 0$), it is important also because its part of their current disposable income which they consume every period. Bilbiie (2019) shows that, since profits are countercyclical, τ^D can dampen the degree to which the income of HtM households *overreacts* aggregate income, potentially making it *underreact* (if $\tau^D > \lambda$).[27] This effect on the cyclicality of HtM income reduces the amplification through the New Keynesian Cross, originally coming from higher average MPC.

Bilbiie (2019) also considers *exogenous redistribution* by varying the ϕ share of aggregate taxes which fall on HtM households ($\phi = \lambda$ being the uniform taxation case): a higher ϕ mitigates the fiscal multiplier. However, he looks at *balanced budget* multipliers where taxes rise immediately to cover higher government expenditures. In contrast, the government budget inthis model can be in deficit which is financed fully by issuing debt – taxes adjust only later to service public debt, and in this setup ϕ will have a different effect, mainly via effecting Ricardian lifetime income, which can get multiplied via the New Keynesian Cross, also affecting HtM households (see Figure 12 in the Appendix).

In our open economy setup these multipliers are mitigated as α increases, since some of the increase in consumption will be directed towards import goods. Boerma (2014) and Iyer (2017) shows that in a complete market small open economy with $\tau^D = 0$ we get $\chi = 1 + \varphi(1-\alpha)$. With incomplete markets, however, the conditions are likely to be different.Due to imperfect international risk sharing, the real exchange rate is decoupled from Ricardian consumption (in addition to also affecting HtM income), so it enters differently in the aggregate IS curve.

3.4 Equilibrium determinacy

3.4.1 Inverted Aggregate Demand Logic

Bilbiie (2008) shows that with a sufficiently high share of Hand-to-Mouth agents $\lambda^* < \lambda$, the interest elasticity of aggregate demand can change sign, i.e. decreasing real interest rates have contractionary effects. In a closed economy without endogenous profit redistribution ($\tau^D = 0$) he shows this threshold to be a decreasing function of the inverse Frisch elasticity of labor supply φ. Boerma (2014) generalizes this condition in a complete market open economy setting

[26] With $\chi = 1$ (e.g. with uniform profit distribution such that $\tau^D = \lambda$, or with $\varphi = 0$ infinitely elastic labor supply) the total effect in RANK and TANK models are identical, and it is only their decomposition into direct and indirect effect which changes, as also shown by Kaplan, Moll and Violante (2018). In other words, under acyclical income inequality the HtM-TANK channel cannot amplify the total effect.

[27] At the same time, more profit redistribution away from Ricardians reduces the income effect on their labor supply.

to get $\lambda^* = \frac{1}{1+\varphi(1-\alpha)}$, which shows that openness shrinks the "non-Keynesian" region where this *inverted aggregate demand logic* (IADL) applies.

The intutition is that falling real interest rates affect aggregate demand via three channels: i) intertemporal substitution induces Ricardian households to bring consumption forward, ii) a depreciating real exchange rate stimulates external demand for domestic goods, and iii) higher real wages erode firm profits, causing a negative income effect and thereby *hurting* the consumption for firm-owning Ricardian households (while also prompting them to work more). Real interest rate reductions become contractionary when the third channel dominates the previous two. This can happen with more inelastic labor supply (high φ) when real wages need to rise more to satisfy higher labor demand, thereby causing a shaper fall in firm profits; and/or when a given fall in profits is concentrated on a smaller fractions of firm-owning households (high λ). As Boerma (2014) explains, in a more open economy (higher α) this negative income effect now has to additionally offset expanding external demand (channel ii)) as well in order to reach the IADL region.

Figure 22 in the Appendix shows the combinations of of λ, φ and α which constitute the IADL region of the paramter space in the model of this paper, corresponding to the points where Figure 22 indicates model indeterminacy.[28] This is similar to the analogous figure in Boerma (2014).[29]

3.4.2 Policy regimes, IADL and openness

The existence of a unique and stable dynamic equilibrium depends crucially on the specification of monetary and fiscal policies to rule out self-fulfilling expectations and to pin down the price level. Determinacy requires that only one of the policy branches be "active", while the other must remain "passive" (AM-PF or PM-AF). With both policies being passive (PM-PF) the equilibrium is not pinned down uniquely, while both policies being active (AM-AF) leads to conflict between them resulting in explosive dynamics. When monetary policy actively manages the real interest rate to keep inflation around its target (through affecting aggregate demand), then fiscal policy cannot rely on inflation to make public debt stationary, but instead must passively adjust the primary budget balance ($\phi_B > 1 - \beta$) otherwise debt would explode. In contrast, when fiscal policy actively ignores debt stabilization ($\phi_B < 1 - \beta$), then monetary policy must passively accommodate fiscal shocks by letting inflation adjust to revalue nominal public debt.

Consider first a debt stabilizing passive fiscal policy featuring $\phi_B > 1 - \beta$. In the "Keynesian" (non-IADL) region of the model, with $\phi^y = \phi^e = 0$ in the monetary rule, a unique equilibrium

[28] In the IADL region the model will have multiple stable solutions (indeterminacy) under a monetary policy rule satisfying the Taylor-principle $\phi^\pi > 1$ (and fiscal rule with $\phi_B < 1 - \beta$). See explanation later.

[29] Although does not match it exactly probably due to different parametrization and imperfect international risk sharing in the current model. For example, trade elasticities η, γ can also infuence the IADL region as they determine the strength of real exchange rate effects on external demand, for given openness α.

requires the central bank to satisfy the Taylor-principle: $\phi^{\pi} > 1$ ensures that the effect of inflationary news about the future entails a rise in the real interest rate, dampening the effect of such news by constraining aggregate demand. The baseline scenario satisfies this AM-PF policy mix.

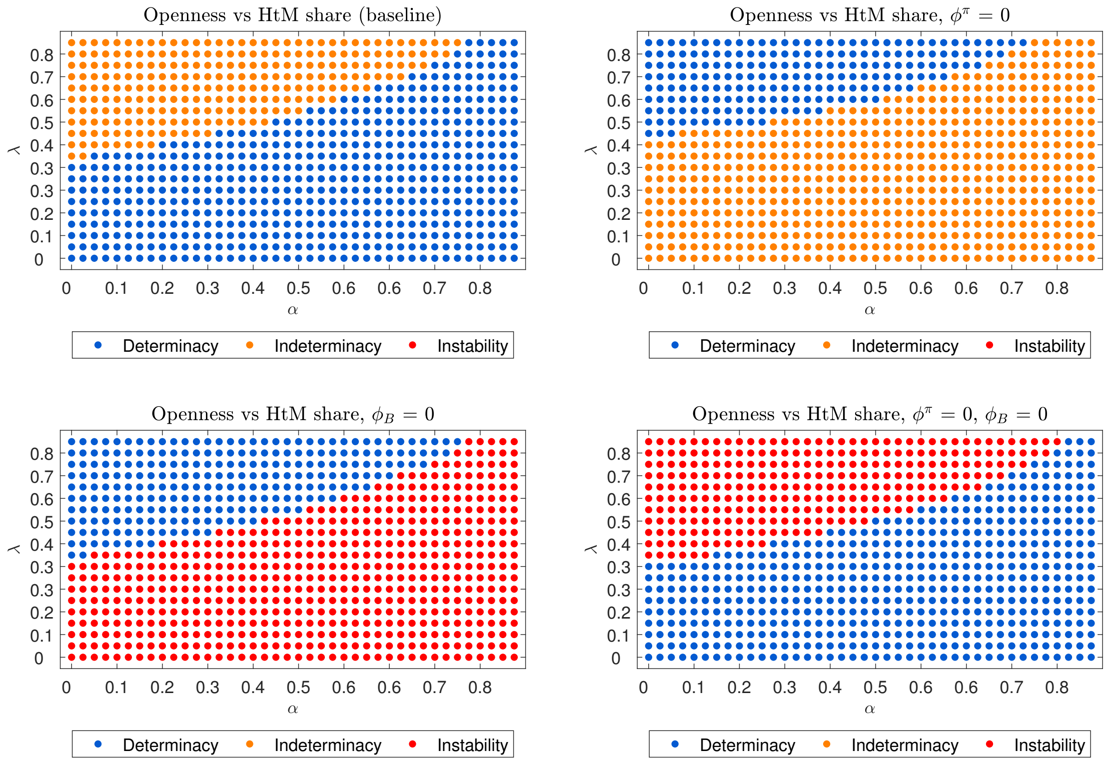

Figure 2: Model determinacy properties in the (α, λ) plain, for different policy regimes. Unless otherwise indicated, baseline parameters are $\phi^{\pi} = 1.5$ and $\phi_B = 0.2 > 1 - \beta$.

However, as we have seen above, in the IADL region of the parameter space a rise in the real interest rate is *expansionary*. Therefore, satisfying the Taylor principle would mean that that in response to inflationary (potentially unfounded) news the central bank would raise the real interest rate, which in the IADL region *stimulates* aggregate demand, further amplifying the initial inflationary shock (or validating the unfounded beliefs, enabling self-fulfilling sunspot equilibria), resulting in indeterminacy and multiple stable equilibria.

This is what can be seen in the top left panel of Figure 2: while the baseline policy specification satisfying the Taylor principle yields a unique equilibrium in the Keynesian region, in the northwest corner of high λ and low α combinations constituting the IADL region (for given φ), it yields indeterminacy. The solution to this, as proposed by Bilbiie (2008) and generalized by Boerma (2014), is the *inverted Taylor principle*. For instance, by making monetary policy completely unresponsive to inflation and setting $\phi^{\pi} = 0$, as in the top right panel of Figure 2, determinacy is ensured in the IADL region.

So far we looked at cases where fiscal policy is passive. However, **by allowing for a richer framework of monetary-fiscal interactions, I show that the inverted Taylor principle**

is not necessary to restore equilibrium determinacy in the IADL region. The lower panels of Figure 2 represent an *active* fiscal policy which completely ignores debt stabilization ($\phi_B = 0$). In this case, keeping the baseline monetary policy rule, which satisfies the traditional Taylor principle $\phi^\pi > 1$, does in fact deliver a uniqe stable equilibrium in the IADL region (bottom left panel). In other words, **active fiscal policy can substitute the inverted Taylor principle under IADL.** Moreover, applying the inverted Taylor principle prescription of $\phi^\pi = 0$ when fiscal policy is active, is not only unnecessary but, instead of ensuring determinacy, would just lead to instability and explosive solutions in the IADL region (bottom right panel).

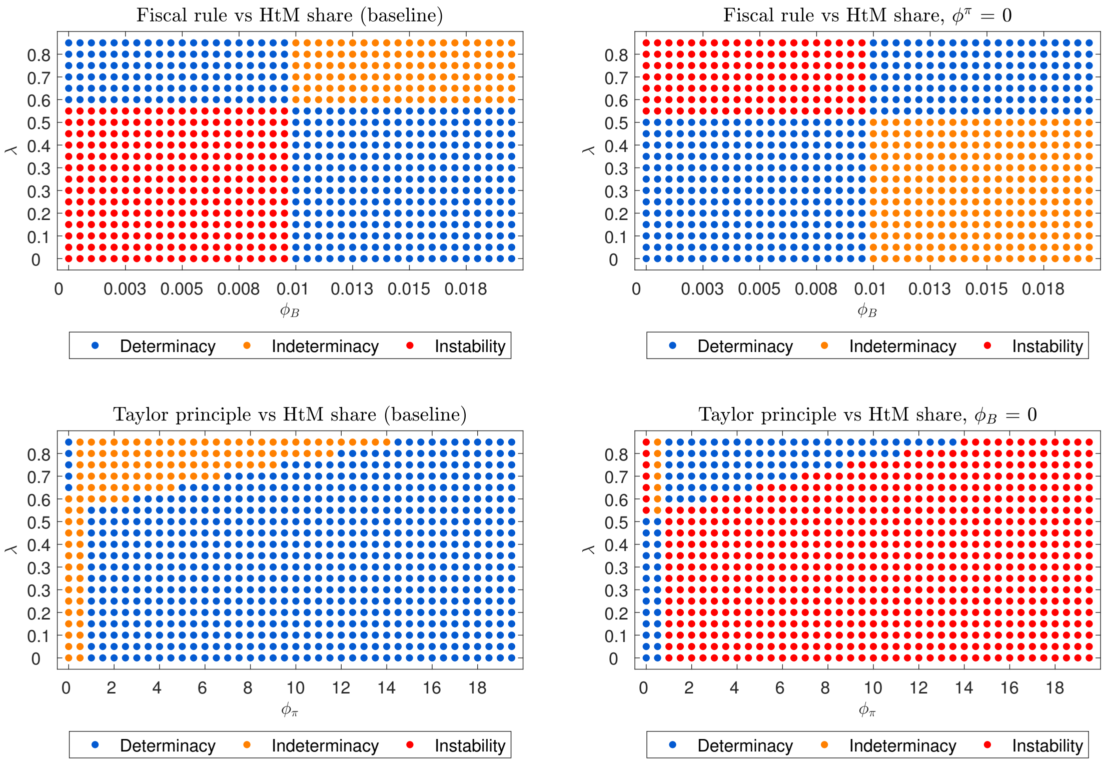

Figure 3: Model determinacy properties in the (ϕ_B, λ) and the (ϕ^π, λ) plains. Unless otherwise indicated, baseline parameters are $\phi^\pi = 1.5$ and $\phi_B = 0.2 > 1 - \beta$, with openness set at $\alpha = 0.5$.

The reason for this can be found in the discussion on active and passive monetary and fiscal policies. A unique and stable equilibrium requires that we are in either the AM-PF regime or the PM-AF regime, while PM-PF yields indeterminacy, and AM-AF leads to instability. But notice that **what constitutes "active" monetary policy, changes in the IADL region** of high λ and/or low α. Since it is now real interest rate *decreases* that are contractionary, actively countering an inflationary shock requires the central bank to let the real interest rate fall – as opposed to raising it via the Taylor-principle. Therefore, $\phi^\pi = 0$ becomes the active monetary policy under IADL. This gives determinacy in combination with passive fiscal policy according to the inverted Taylor principle (top right panel), but leads to instability with active fiscal policy (bottom right panel). On the other hand, $\phi^\pi > 1$ will mean passive monetary policy in the IADL region, which results in indeterminacy together with passive fiscal policy (top left panel), but can still deliver a unique equilibrium with fiscal activism (bottom left panel).

This is why the left column of Figure 2 is basically the flipside of the right column, precisely along the border of the IADL region. Depending on which side of that border we are, it differs whether $\phi^\pi > 1$ or $\phi^\pi = 0$ constitutes active monetary policy.

Figure 3 tells the same story from another perspective, exploring a continuum of values for ϕ^π or ϕ_B instead of just two discrete points. The upper panels show how the threshold for active fiscal policy lies at $\phi_B = 1 - \beta$ without being affected by the share of hand-to-mouth households λ.[30] The bottom panels show that with a Taylor rule that reacts to *current* inflation (as opposed to expected inflation) such as (2.29), monetary activism in the IADL region of high λ can not only be achieved by reducing ϕ^π to close to zero, but also by *raising* ϕ^π above a sufficiently high threshold $\hat{\phi}^\pi$ which is increasing in HtM share λ. The threshold $\hat{\phi}^\pi$ is decreasing in openness, so making monetary policy active in this way requires harder efforts in closed economies.

Figure 4: Model determinacy properties in the (ϕ_B, ϕ^π) plain for different values of λ and α.

Another paramter which interacts with the threshold $\hat{\phi}^\pi$ is the passivity of fiscal policy ϕ_B. As Figure 4 shows, $\hat{\phi}^\pi$ is increasing in ϕ_B when λ is high enough. In other words, **when IADL**

[30]This is in contrast to Leith and Wren-Lewis (2008) who show in a perpetual youth model that having more non-Ricardian consumers raises the required degree of fiscal feedback ϕ_B which would make fiscal policy passive. According to their argument, in this case a more agressive fiscal response is necessary to avoid a debt interest spiral, since with non-Ricardian households higher debt can stimulate demand and inflation more (due to larger multipliers), which is offset by higher real interest rates from the part of an active monetary policy, which then raises interest expenditures on public debt. Instead of having hand-to-mouth agents, they introduce non-Ricardian households by making them finitely lived with a positive probability of death. Apparently this difference is crucial for their result, since the same amplification via the New Keynesian Cross should also exist in this model with HtM households, and yet the threshold for ϕ_B remains independent of λ.

applies, a more passive fiscal policy requires a more aggressive inflation reaction ϕ^{π} from the central bank to make monetary policy active.[31] This interaction between the degree of monetary activism and fiscal passivism applies only in the IADL region (i.e. λ must be high enough, unlike in the baseline scenario in the top left panel). The trade-off is also much more relevant in open economies: as the bottom right panel shows, in a closed economy ($\alpha = 0$) the threshold $\hat{\phi}^{\pi}$ is already higher than realistic values, even for very low levels of ϕ_B.

Throughout the above anaylsis we looked at the case of a symmetric external steady state, with zero NFA position ($\zeta = 0$). However, another interesting result, applying solely in the open economy context, is that **with a sufficiently negative NFA position, the inverted Taylor principle under IADL fails.** Figure 23 in the Appendix illustrates that with $\zeta << 0$ applying $\phi^{\pi} = 0$ cannot restore determinacy under IADL (top right panel), so the only remaining option is to keep $\phi^{\pi} > 1$ and switch to active fiscal policy instead (bottom left panel). It seems like in an IADL environment sufficiently high external debt can prevent $\phi^{\pi} = 0$ from making monetary policy active.[32] Running sensitivity analyses it can be confirmed that more fiscal passivity (higher ϕ_B) can help in pushing down the threshold for ζ where this phenomenon occurs, as if more aggressive debt stabilization by the government can address issues stemming from higher external indebtedness of the economy. Reducing openness has the same effect, as external debt becomes less relevant for the whole economy.

A very similar issue exists with regards to steady state public debt. Under $\phi^{\pi} = 0$ a larger $\bar{b}^{g}$ makes indeterminacy more likely, i.e. applying even at IADL values of λ where $\phi^{\pi} > 1$ also yields indeterminacy. This rhymes with the findings of Leith and von Thadden (2008) who pointed out the role of the fiscal steady state in the determinacy conditions of a model without Ricardian equivalence. They show that without referring to steady state public debt it is not possible to determine the degree of monetary and fiscal activism necessary for ensuring unique and stable equilibrium dynamics.

4 Responses to transfer shocks

4.1 Calibration

We are going to consider several fiscal transfer shocks to compare the dynamic responses in our model economy across different policy regimes. For the purposes of this exercise the parameters of the model are set such that we are in the non-IADL, Keynesian region where interest rate increases are contractionary. In particular, the share of HtM households λ is not too high given the labor supply elasticity φ and openness α, but still significant such that the New Keynesian

[31] Of course, the inverted Taylor principle of applying $\phi^{\pi} \approx 0$ keeps working as well, and it is not affected by the degree of fiscal passivism ϕ_B. In addition, the above result only concerns Taylor rules which react to current, and not to expected inflation.

[32] Not only that, but as the bottom right panel indicates, it also seems to make fiscal policy passive even with $\phi_B = 0$, since indeterminacy implies we must be in a PM-PF policy regime.

Cross is visibly in operation.

As for the distributive characteristics of the tax system, in the baseline parametrization all households pay their fair share of *expected* aggregate taxes (uniform taxation), meaning that $\phi = \lambda$ must hold.[33] There is no profit redistribution ($\tau^D = 0$) so countercyclical profit variations will not mitigate multipliers. The wage subsidy is calibrated to offset static distortions due to monopolistic competition $\tau^w = \frac{1}{\varepsilon}$ which (together with the lump sum taxes T^s levied on firms) results in zero steady state firm profits.

Parameters					
discount factor	β	0.99	openness	α	0.5
(inverse) Frisch-elasticity	φ	2	share of HtM households	λ	0.3
risk aversion	σ	1	risk-premium sensitivity	δ	0.1
elasticity of subs. bw H and F	η	1.5	steady state NFA-to-GDP	ζ	-0.25
elasticity of subs. bw countries	γ	1.5	share of government spending	Γ	0.2
elasticity of subs. bw varieties	ε	6	Calvo price rigidities	θ	0.75
Fiscal policy parameters			**Monetary policy parameters**		
debt stabilization (AM-PF; PM-AF)	ϕ_B	0.2; 0	Taylor inflation coeff (AM-PF; PM-AF)	ϕ^π	1.5; 0.2
public debt-to-GDP target	$\bar{b}^g$	0.6	PPI inflation target	$\bar{\Pi}^H$	1
tax distribution	ϕ	λ	Taylor output gap coeff.	ϕ^y	0
profit redistribution	τ^D	0	Taylor NEER coeff.	ϕ^e	0
wage subsidy	τ^w	$1/\varepsilon$			
Steady states					
Consumption, HtM	$\check{C}$	0.8577	Consumption, Ricardian	$\widehat{C}$	0.8610

Table 2: Parameters and selected steady state values.

In order to allow for a rather general setup, we look at the non-symmetric steady state with external indebtedness, i.e. the steady state NFA position ζ is negative. However, it is smaller in absolute value than public debt $\bar{b}^g$ which means that Ricardian households have positive net worth in steady state, subjecting them to surprise revaluation effects (via inflation and in case of FX-debt, also via the exchange rate). The interest income earned on this asset position results in some steady state consumption inequality, despite uniform taxation and zero profits. Trade is set to be slightly more price elastic than the Obstfeld-Cole case of $\sigma = \eta = \gamma = 1$ such that the expenditure switching channel is not completely offset, giving rise to variations in the trade balance.

The AM-PF and PM-AF policy mixes feature ad-hoc parameters ϕ_B and ϕ^π which capture the nature of the given policy regime. As monetary policy is not completely unresponsive under PM-AF, it lends the inflation process some persistency. Other parameters are set to standard values and are reported in Table 2.

[33]Note that this does not mean that *unexpected* shocks to taxes are also uniform. In fact, their heterogeneity will be important in some of the scenarios.

4.2 AM-PF policy mix – the role of redistribution

In order to assess how fiscal transfers with different redistributive properties affect the economy in the presenece of household heterogeneity and public debt, we look at several different shock scenarios. We consider a persistent debt-financed tax cut amounting to one percentage point of steady state output, targeted either solely to HtM households, or spread out uniformly across all consumers, or focused solely on Ricardian agents. In addition, we also look at a (persistent) balanced budget within period redistribution from Ricardian households to Hand-to-Mouth agents. These exercises are summarized in Table 3. The "debt-financed uniform tax" cut and the "balanced budget redistribution" scenarios are analogous to those analysed by Bilbiie, Monacelli and Perotti (2013) in the context of their closed economy TANK model, in an AM-PF policy regime.

	HtM tax cut	uniform tax cut	Ricardian tax cut	BB redistribution
HtM shock: $\check{\varepsilon}_t^T$	ϵ/λ	ϵ	0	ϵ
Ricardian shock: $\hat{\varepsilon}_t^T$	0	ϵ	$\frac{1}{1-\lambda}\,\epsilon$	$\frac{-\lambda}{1-\lambda}\,\epsilon$
total: $(1-\lambda)\hat{\varepsilon}_t^T + \lambda\,\check{\varepsilon}_t$	ϵ	ϵ	ϵ	0

Table 3: Description of tax cut shocks for different scenarios (with total tax cut ε_t^T kept the same, except for the balanced budget redistribution). ϵ denotes a shock size which is one percentage point of steady state output on impact, and declines with persistence $\rho_T = 0.3$.

Consider first the case of an AM-PF policy mix, where monetary policy is actively responding to deviations of inflation from target and fiscal policy is committed to raise future primary budget surpluses for debt stabilization purposes. As the results in Figure 5 indicate,[34] **in the presence of household heterogeneity transfer multipliers of a debt-financed tax cut depend very much on whom they target. Tax cuts are much more effective if they are targeted at high MPC Hand-to-Mouth agents,** who consume all their current disposable income, relative to the case where every household gets the same transfer, and even more so relative to cutting the taxes only of consumption-smoothing Ricardians. This is in line with the findings of Bayer et al. (2020) in the context of their closed HANK model. In the present open economy setting ($\alpha > 0$), however, these impact multipliers are mitigated relative to a closed economy (see Figure 16 in Appendix), as net exports are crowded out by public debt: i.e. some of the fiscal stimulus "leaks" out as import spending (*expenditure changing*), further encouraged by the appreciating real exchange rate (*expenditure switching*).

The New Keynesian Cross is in operation, providing amplification of transfer multipliers. Given that fiscal stimulus is expansionary, incomes rise which prompts HtM households to consume more, pushing income further upwards. However, as discussed earlier (see Section 3.3), it is not the mere presence of a $\lambda > 0$ share of HtM agents that manages to raise the average MPC in

[34]For all variables percentage (log) deviations from their steady state are shown, except for the trade balance NX_t, public debt b_t^g and taxes T_t, for which level (linear) deviations are plotted expressed as a percentage of steady state output.

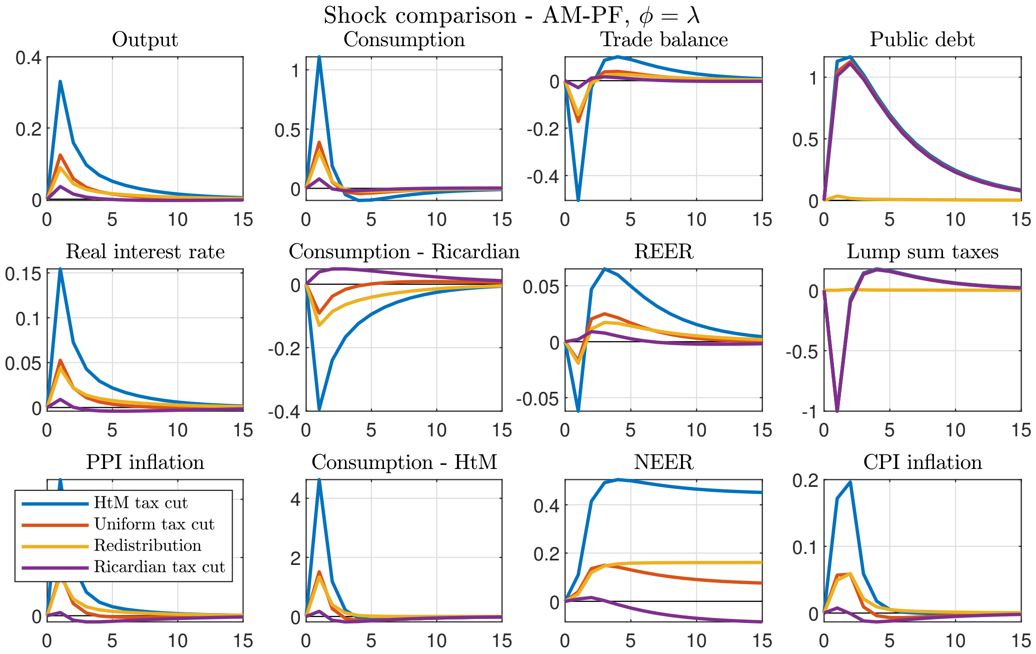

Figure 5: Shock comparison under AM-PF policy regime, with uniform tax distribution $\phi = \lambda$

the economy, but also countercyclical income inequality meaning that HtM income overreacts aggregate income. This condition is satisfied in the baseline parametrization for *pre-tax* income ($\chi > 1$). With heterogeneous tax cuts, in terms of the *after-tax* income this is further amplified when the tax cut is focused on HtM, and is mitigated when it falls only on Ricardians. But even in the latter case, income inequality remains countercyclical and therefore amplification is present, the more so, the higher the λ share of HtM agents are (see Figure 14 in Appendix).

Instead of comparing different scenarios about how the *same* budget deficit is distributed across households (as above, and by Bayer et al. (2020)), Bilbiie, Monacelli and Perotti (2013) compare the "debt-financed uniform tax cut" and the within period "balanced budget redistribution" scenarios. In this case HtM agents get the same tax cut in both scenarios, but while in the former it is financed by selling government bonds to Ricardians (to be paid off by future taxes), in the latter it is financed by raising taxes on Ricardians today. Both necessarily crowd out Ricardian consumption (facilitated by an active monetary policy raising the real interest rate), but the former implies a fiscal deficit and rising public debt, while the latter does not.

As discussed before in Section 3.2, with $\phi = 0$ Ricardian equivalence holds, meaning that the irrelevance of the timing of taxes translates into the irrelevance of what happens with Ricardian taxes altogether (since they are the ones paying all taxes). I.e. whether the needed funds for the HtM transfer are raised by taxing Ricardians today or by selling them debt today and swapping it for taxes later, should not make any difference. The only relevant factor for model dynamics should be the size of the HtM transfer, which is the same across the two scenarios, and public debt should not matter at all.

However, with $\phi = \lambda$ this is no longer true, since in this case it is not only the timing of

Ricardians' taxes which differs between the two scenarios, but also their present value, making Ricardian lifetime income different – which is something even optimizing consumption-smoothers react to.[35] The debt-financed tax cut scenario does not involve any lifetime income redistribution (everybody is liable for a fair share of public debt), while the balanced budget redistribution by construction does, from Ricardians to HtM (equivalently to the $\phi = 0$ debt-financed tax cut, when Ricardians are liable even for the part of debt which finances the HtM transfer).[36] In response to this more adverse lifetime income profile, Ricardians cut their consumption back more, which explains the differences on impact *despite* the HtM transfer being the same.

To put it another way, when $\phi = 0$ (Ricardian equivalence), government debt is not net wealth, so its size does not matter: debt-financed tax cut and balanced budget redistribution yield the same dynamics (see top left panel of Figure 7). But **when $\phi \neq 0$ (Ricardian equivalence fails), government debt *is* net wealth, and its size *does* matter,**[37] making the two scenarios different (top right panel of Figure 7). Ricardians who hold this net wealth will have a better lifetime income position, so their consumption will be higher than without public debt (conditional on the same HtM transfer). This captures a kind of "redistribution via public debt" as explained by Bilbiie, Monacelli and Perotti (2013): Ricardians hold all the debt, but they are liable only for a $(1 - \phi)$ fraction of it.

Notice that in the balanced budget redistribution scenario, the sharper drop in Ricardian consumption, by hurting aggregate demand, also harms HtM incomes and consumption: more redistribution towards them is actually harmful for their consumption! The same argument can be illustrated by comparing debt-financed tax cut scenarios for different values of tax distribution ϕ (see Figure 12 in the Appendix), where lower ϕ leads to a smaller rise in HtM consumption, and therefore smaller output multipliers, too.

The takeaway is that in the absence of Ricardian equivalence public debt matters, as it has redistributive consequences. However, it does not matter *much*. The differences between the debt-financed tax cut and balanced-budget redistribution scenarios are small[38] compared to differences relative to scenarios where the size of HtM transfers changes. In other words, **while**

[35]The breakdown of Ricardian equivalence is perhaps best illustrated by looking at the pure Ricardian tax cut scenario in Figure 5. Under Ricardian equivalence it should generate any dynamics as housholds just save all the tax windfall to pay debt off in the future. However, with $\phi > 0$ some of the debt financing this transfer to Ricardians will be paid by HtM agents, which is why it constitutes a lifetime income change for Ricardians, setting of a dynamics response.

[36]Notice that the balanced budget redistribution scenario can be equivalently rewritten as a debt financed uniform tax cut scenario with $\phi = 0$, since in this case Ricardian taxes do not matter. Then, the above comparison is equivalent to comapring two debt-financed tax cut scenarios with different values for ϕ. It also illustrates how ϕ captures the amount of redistribution via public debt.

[37]Ricardians must still buy all the public debt, but ϕ portion of it will not be backed by their future tax liabilities – it is like lending to HtM households via the giverment budget, and holding a real claim on them.

[38]To a lesser extent, but this still holds true for more agressive debt stabilization policy (higher ϕ_B) as illustrated in Figure 13 in the Appendix. Bilbiie, Monacelli and Perotti (2013) show that as ϕ_B tends to its passive fiscal policy lower bound of $1 - \beta$, the two scenarios essentially become equivalent.

public debt matters somewhat under an AM-PF policy mix to the extent that Ricardian equivalence fails, far more important is how fiscal transfers are distributed across households, and in particular, to what extent the same budget deficit is targeted at high-MPC agents. This result will not hold for with a PM-AF policy regime.

4.3 PM-AF policy mix – the role of public debt

Under a PM-AF policy mix, fiscal policy can run debt-financed budget deficits that are unbacked by the present value future tax revenues. The real burden of such unbacked debt is kept manageable by a passive monetary policy which keeps nominal interest rates unresponsive and tolerates deviations of inflation from target. This is similar to the unbacked fiscal deficit of Roosevelt in 1933 as described in Jacobson, Leeper and Preston (2019), or to the "emergency budget" advocated by Bianchi, Faccini and Melosi (2020). As discussed in Section 3.2.1, in such an environment Ricardian equivalence breaks down even in a RANK model due to the *nominal wealth effect*, which results in debt having important monetary consequences.

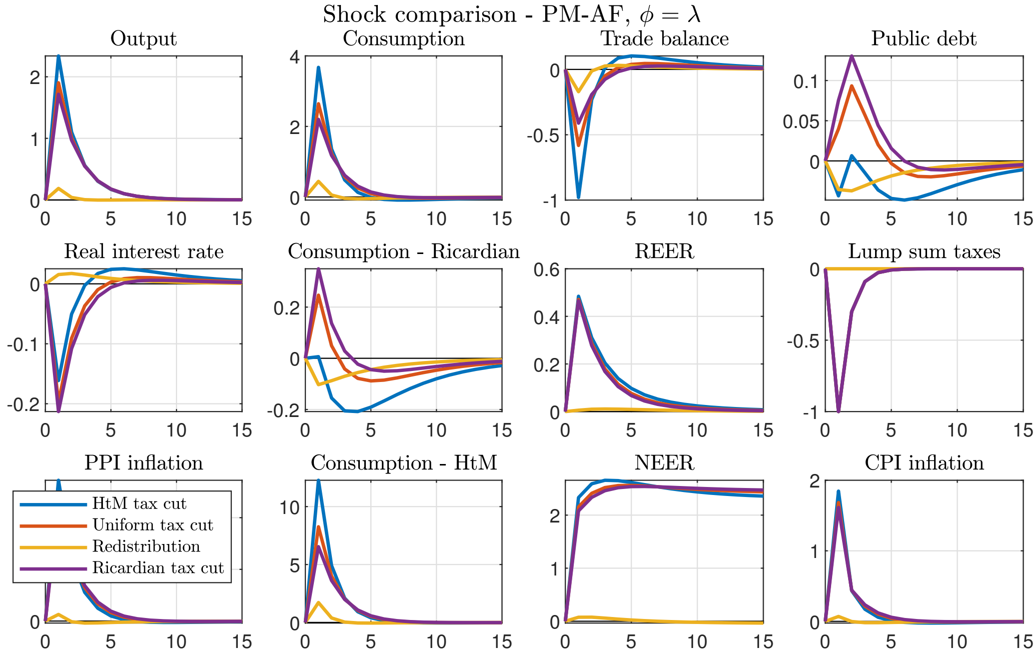

Figure 6: Shock comparison under PM-AF policy regime, with uniform tax distribution $\phi = \lambda$

For this reason, **with a PM-AF policy mix public debt *per se* will have a much more important role relative to the redistributive profile of fiscal transfers, than in the AM-PF regime.** As can be seen in Figure 6, transfer multipliers are still influenced by how much of a given aggregate tax cut is targeted at high MPC households. But while in the AM-PF regime this was the dominant factor, now its significance pales in comparison to whether there is a budget deficit or not. In particular, HtM taxes drop by the same amount in the "debt-financed uniform tax cut" scenario as in the "balanced budget redistribution" scenario. But in the former they are deficit-financed, while in the latter the government budget stays in balance,[39] and this

[39] The trajectory of "lump sum taxes" T_t is equivalent to the primary budget surplus, given government spending

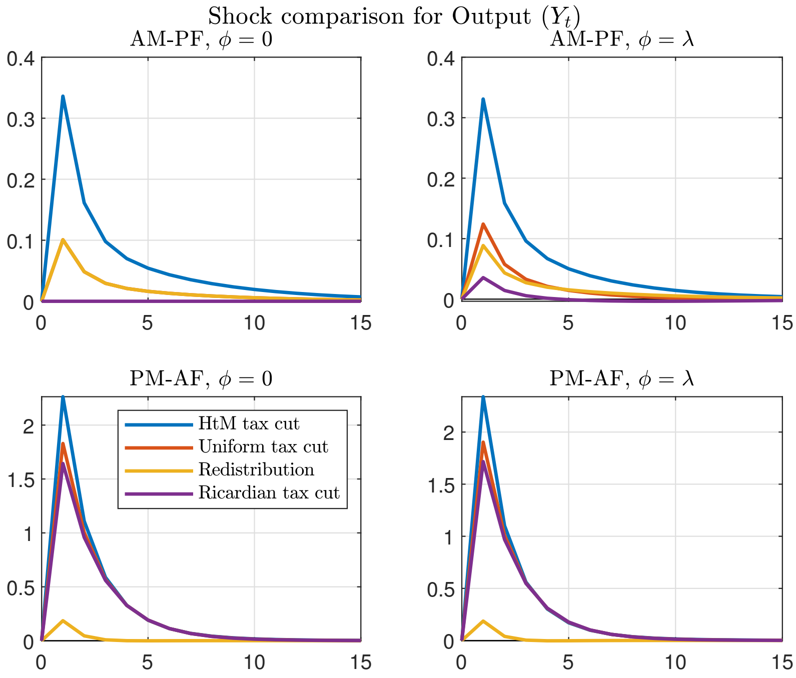

Figure 7: Shock comparison for output, across policy regimes and tax distribution ϕ (as in Table...)

difference makes a much bigger impact on the transfer multiplier than altering the size of HtM transfers. This is in contrast to the AM-PF regime where financing played secondary role only (if any, conditional on $\phi > 0$), and the responses are more similar (mainly driven by the equality of HtM transfers between these two scenarios). Figure 7 facilitates this comparison.

Evidently, debt matters a lot in the PM-AF regime. But unlike in the AM-PF regime, it is not through its redistributive properties that this influence manifests itself. In other words, it is not that the redistributive properties of public debt become much more important with active fiscal policy. After all, debt is unbacked by future taxes so it shouldn't matter who *doesn't* pay those taxes (with $\phi_B = 0$ the previously important tax distribution parameter ϕ even drops out of the model's equilibrium conditions).[40] Instead, debt matters via its monetary consequences due to the *nominal wealth effect* (see Section 3.2.1 and Jacobson, Leeper and Preston (2019)). Inflation has to rise to erode real value of unbacked nominal debt, which is why it is the the size of the budget deficit *per se* that is important.[41]

The bottom line is the following. Under the AM-PF regime it made little difference whether a transfer to HtM households was financed by raising Ricardian taxes or by issuing debt, but it is of paramount importance with a PM-AF policy mix. While previously the distribution of transfers across households was the crucial factor, it now takes a back seat relative to the question of

G_t is unchanged.

[40]In Section 3.2.1 we even discussed how unbacked nominal government bonds are not real net wealth for their holders as they understand the government will not pay them back with consumption goods.

[41]There is *some* redistribution though via the revaluation of *already existing* public debt which is all held by Ricardians. Suprise inflation will reduce the real value of their assets, imposing on them a kind of "inflation tax" which ends up paying for the budget deficit in real terms.

financing. **With passive, accommodative monetary policy a deficit-financed transfer can provide a much bigger output multiplier than a balanced budget redistribution.**

4.4 Transmission of fiscal shocks across policy regimes

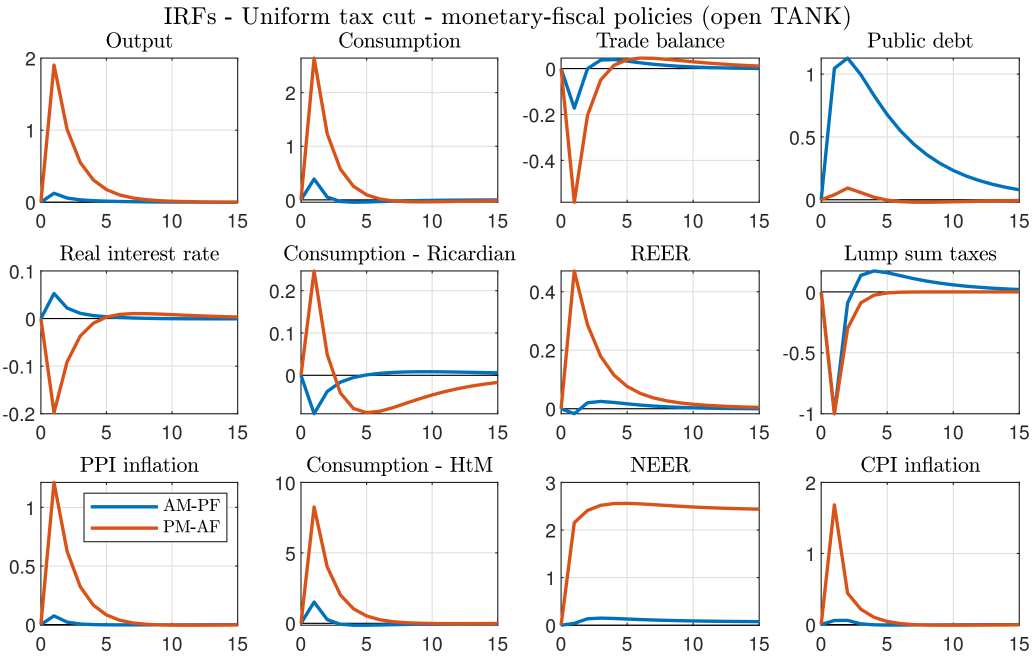

Figure 8: Impulse responses to a uniform tax cut

In other words, **it is with a PM-AF policy mix, that deficit-financing can really be potent.** Figure 8 compares the two policy regimes after a debt-financed uniform tax cut, illustrating the large difference not just in output multipliers but also in the transmission mechanism of the shock itself. With PM-AF, the need for inflation to stabilize the real value of public debt, coupled with relatively unresponsive nominal interest rates, leads to *falling* (as opposed to increasing) real interest rates. Via intertemporal substitutin channels this *crowds in* Ricardian consumption instead of the usual crowding out effect of public debt. Expanding Ricardian demand is also in line with the *nominal wealth effect* as they try to consume their new bonds which have no future tax obligation attached to them. These positive developments on aggregate demand are also beneficial for high-MPC HtM households, beyond the direct effect of their tax cut, since pre-tax incomes are further boosted by Ricardian spending. Higher HtM consumption then amplifies the expansion in output via the New Keynesian Cross. Despite taxes not rising in the future to offset the initial (persistent) budget deficits, the real value of public debt rises much less as a result of the higher price level. Inflating away public debt revalues the assets of Ricardian households, who suffer a negative wealth effect, in effect putting all the real burden of the fiscal stimulus on them in the form of on "inflation tax".

The open economy aspects of the different transmission mechanism under PM-AF are worth noting, too. The fall in the real interest rate makes the real exchange rate *depreciate* instead of the impact appreciation under AM-PF. This improved external competitiveness works towards *crowding in* net exports (*expenditure switching* effect due to trade elasticities η, γ), and thereby provides further stimulus. The trade balance, however, still moves deeper into deficit, as the import leakage out of a much higher consumption (*expenditure changing* effect, governed by openness α) dominates the weaker real exchange rate. **The weakening real exchange rate under the PM-AF policy regime following a fiscal stimulus is also more in line with empirical evidence** (see Monacelli and Perotti (2010), Ravn, Schmitt-Grohé and Uribe (2012)), which otherwise presents real appreciatrion-predicting AM-PF open economy models with a puzzle. In an open economy, subordinating monetary policy to the objectives of public debt stabilization and accommodating higher inflation also necessarily leads to a permanently weaker nominal exchange rate.

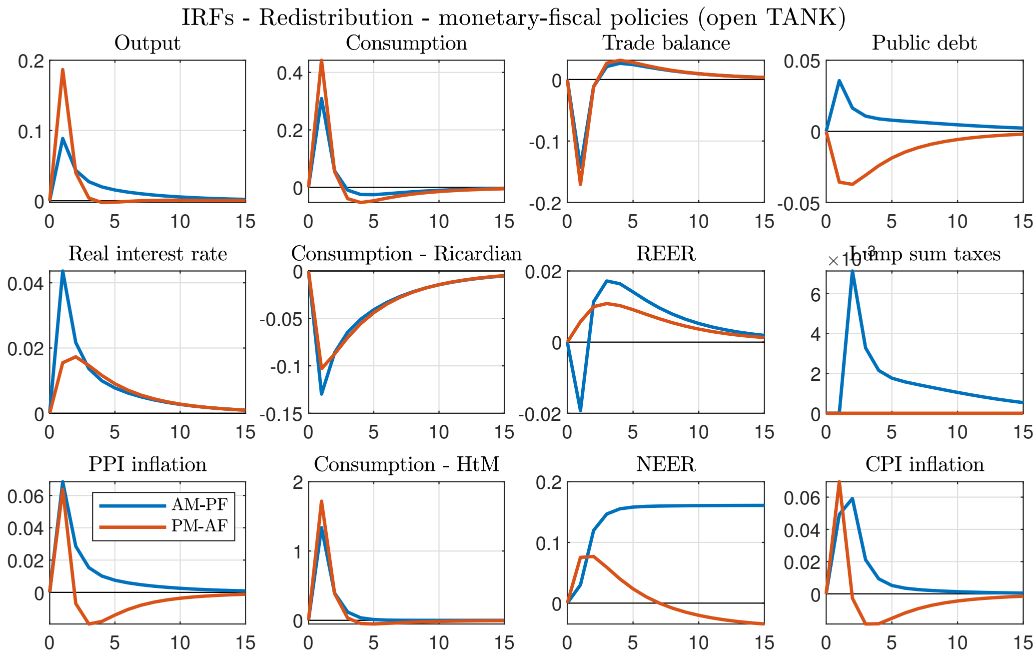

Figure 9: Impulse responses to a balance budget redistribution

The choice of policy regime makes a difference even in the case when there is no deficit. Figure 9 compares the two policy mixes in the balanced budget redistribution scenario. The differences are much smaller in this case, underlining the fact that the main distinctive feature of PM-AF is how it handles unbacked fiscal deficits (which do not arise here). However, redistributing to high-MPC households necessarily sets off some aggregate demand effects under nominal rigidities, and absent an active monetary policy to stabilize the economy, something else must take its place: this something is the need to stabilize the real value of public debt.

Although there's no primary budget deficit, public debt will rise somewhat under AM-PF due to the active response of monetary policy, which reacts to aggregate demand expansion by raising real interest rates, that in turn raise interest expenditure on existing government debt.[42] A passive fiscal policy raises some taxes to cover this. However, with PM-AF the real value of pre-existing public debt *falls* on impact due to the inflationary effect of rising demand. This means

[42] Up to first order, this effect only exists if steady state public debt is non-zero.

that debt stabilization now requires rising real interest rates to push debt back up towards its steady state target. In the absence of a responsive central bank this can only be brought about by falling prices, i.e. deflation. Therefore, **both regimes will produce rising real rates in response to the demand expansion set off by redistribution. But while in AM-PF this is engineered by monetary policy raising the nominal interest rate in response to inflation, in PM-AF it happens via the need for deflation to stabilize public debt.** In this scenario the price level (and the nominal exchange rate) rise permanently in the AM-PF regime, while it is the PM-AF policy mix which preserves the value of local currency. Note that on balance, the output multiplier is larger with PM-AF.

4.5 Effect of open economy – sensitivity analysis

As we have seen, the response of the real exchange rate differs markedly across AM-PF and PM-AF policy mixes, which is why open economy dimensions can be important when comparing these different policy regimes.

4.5.1 Openness and HtM share

The effects of any aggregate demand shock on output are normally mitigated in an open economy setting ($\alpha > 0$) since some of the increase in spending will "leak out" in the form of rising imports. This effect on the trade balance due to changes in domestic spending is called *expenditure changing*. In an AM-PF regime, to the extent that the stimulus leads to a real exchange rate appreciation, this effect is further aggrevated by a crowding ot of net exports due to a loss of external competitiveness (*expenditure switching* channel). This echoes the results of a simple Mundell-Fleming model where the effects of a fiscal expansion are completely offset by a deteriorating trade balance.

Under a PM-AF regime, however, the real exchange rate *depreciates* which changes the sign of the expenditure switching channel. Now external demand expands and domestic households direct more of their consumption increase towards home produced goods as those become more competitive. The strength of this channel depends on trade price elasticities η and γ, and in the baseline calibration it is not strong enough to completely offset the expenditure changing channel (import leakage) which is now even more significant, given the much larger increase in consumption. On balance, thererfore, **opening up the economy still hurts the output multipliers even under the PM-AF policy mix.** This is illustrated in Figure 10 by comparing the red and purple lines.

However, Figure 10 also shows that this result is almost non-existent in a RANK setting ($\lambda = 0$).[43] Without HtM households, the amplification via the New Keynesian Cross is almost completely muted, which results in a much smaller increase of consumption, thereby reducing

[43]Under the AM-PF regime a RANK model would produce no dynamics at all in response to a tax cut, since Ricardian equivalence prevails. So comparing open and closed settings would not make any sense. But with a PM-AF policy mix that is no longer true due to the nominal wealth effect.

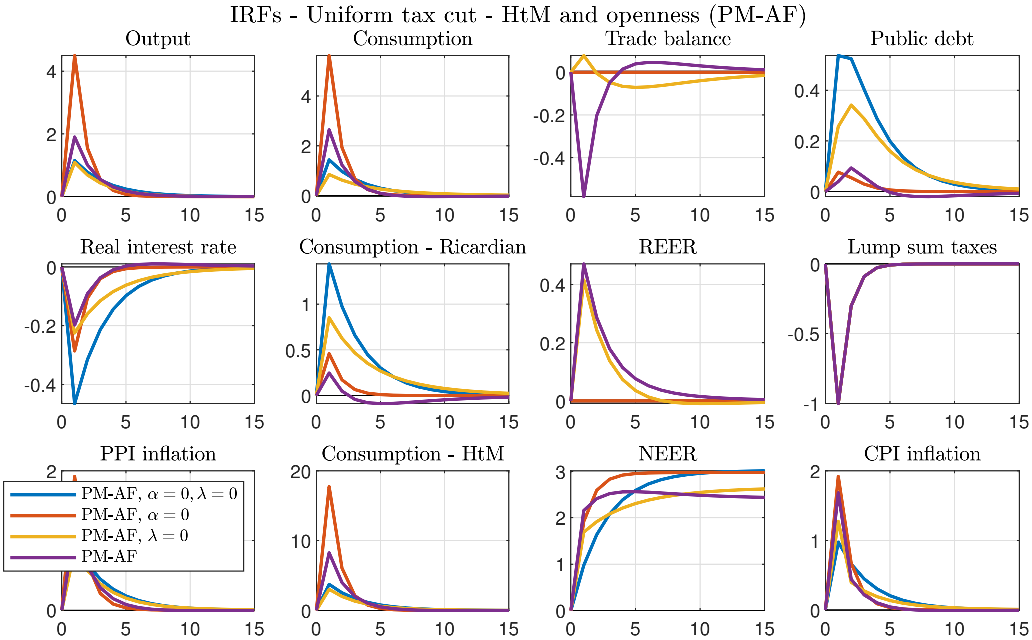

Figure 10: Impulse responses to a debt-financed uniform tax cut, in open/closed TANK/RANK models (given PM-AF policy mix). Unless otherwise indicated, baseline values $\alpha = 0.5$ and $\lambda = 0.3$ apply.

import leakage. At the same time, the extent of real depreciation is similar, so the stimulative effects of expenditure switching can manage to roughly offset the smaller import leakage via the expenditure changing channel. This is why **in a RANK economy with PM-AF policy mix, opening up is not as harmful for multipliers,** if at all,[44] which runs contrary to the standard Mundell-Fleming type results.[45]

As noted above, the importance of the expenditure switching channel depends on how price elastic import demand for foreign goods (η) and external demand for domestic goods (γ) are. These trade elasticities influence how sensitively net exports react to real exchange rate movements which, in turn, move in different directions depending on the policy regime (appreciating in AM-PF, and depreciating in PM-AF). Since they amplify an expenditure switching channel with opposite sign, **increasing trade elasticities affects the output multiplier in opposite ways across different policy mixes, *mitigating* it in AM-PF, but *amplifying* it in PM-AF** (see Figures 20 and 21 in the Appendix).[46]

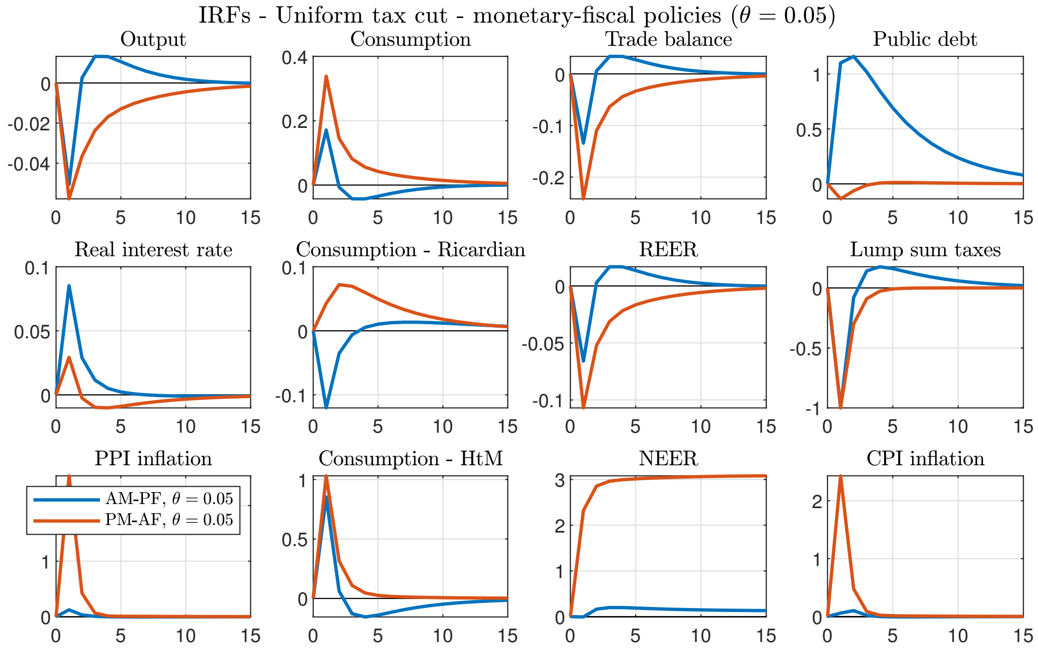

Figure 11: Impulse responses to a debt-financed uniform tax cut across policy regimes (very flexible prices $\theta = 0.05$)

4.5.2 Price rigidities

It is also in relation to the expenditure switching channel that **in an open economy a sufficient amount of nominal rigidities are crucial for the PM-AF policy mix to yield higher multipliers than AM-PF.** Figure 11 shows how very flexible prices (low θ) result in such a sharp jump in inflation under the PM-AF regime that the real exchange rate appreciates instead of depreciating. Moreover, it does so to a larger extent than with AM-PF, crowding out net exports even more forcefully and hurting output so much that it not only *decreases*, but is actually going lower than with AM-PF. This is in contrast to our baseline with stickier prices (shown in Figure 8) where the PM-AF policy mix managed to achieve larger, and not smaller, output multipliers after a debt-financed fiscal expansion.

Notice that this phenomenon only applies to open economies. While increasing price flexibility reduces the the effect of fiscal stimulus on aggregate demand in open and closed economies alike, as well as under both AM-PF and PM-AF regimes, it does not do so to the same extent. In a closed economy, absent the above described expenditure switching channel, the response of output would still remain positive even with $\theta \to 0$, and PM-AF would still yield weakly

[44] With large enough η, γ price elasticities of trade, opening up in a RANK model (PM-AF regime) might even slightly increase the output multiplier, as the expenditure switching channel comes to dominate expenditure changing.

[45] See results for more values of α in the Appendix, in Figure 17 (TANK model) and Figure 18 (RANK model).

[46] A very similar pattern is observable regarding the currency denomination of external debt. With FX-debt (i.e. negative steady state NFA position) unexpected exchange rate movements on impact revalue outstanding liabilities in a way which, via the debt-elastic risk premium, amplify the original exchange rate movement, thereby strengthening the expenditure switching channel. See Figure 19 in the Appendix.

higher multipliers than AM-PF. Therefore, open economies with more flexible prices would not necessarily see as much gain from switching to a PM-AF regime than those with higher nominal rigidities.

5 Conclusion

In this paper I have explored a dilemma regarding the choice of the monetary-fiscal policy mix in open economies with heterogeneous households. After a fiscal disturbance, the central bank can either raise real interest rates to ward off inflationary pressures, which would force costly fiscal adjustment to stabilize public debt – or an unresponsive monetary policy could keep interest rates low, tolerating higher inflation and letting it erode the real value of nominal debt without fiscal policy having to raise taxes. The choice between these policy mixes affects the efficacy of the fiscal expansion already today and can interact with the distributive properties of the stimulus. Targeting fiscal transfers more towards high-MPC agents increases the output multiplier of a fiscal stimulus, while raising the degree of deficit-financing for these transfers also helps. One of the main results of this paper is that precise targeting is much more important under the AM-PF regime than the question of financing, while the opposite is the case with a PM-AF policy mix: then deficit-spending is crucial for the size of the multiplier, and targeting matters less.

Under the PM-AF regime fiscal stimulus entails a real exchange rate depreciation which might offset "import leakage" by stimulating net exports, if the share of hand-to-mouth households is low and trade is price elastic enough. Therefore, a PM-AF policy mix might break the Mundell-Fleming prediction that open economies have smaller fiscal multipliers relative to closed economies.

I also showed that the inverted Taylor principle is not a necessary condition for equilibrium determinacy under inverted aggregate demand logic, and can be substituted by an active fiscal policy. In fact, in an open economy setting with sufficiently high external debt this is the only solution, as the inverted Taylor principle breaks down completely.

This is a highly stylized model framework which, while forcefully illustrates the role of MPC heterogeneity, has its limitations in generating a full fledged distribution with much richer wealth heterogeneity. In addition, the model also abstracts from uninsured idiosyncratic uncertainty which is why it cannot capture precautionary saving motives. It would be especially interesting to see how precautionary saving affects results under the PM-AF regime where nominal assets of households can be subject to sudden revaluations, prompting them to rebuild their portfolios, potentially affecting aggregate outcomes, too. Introducing monetary-fiscal interactions into a full-fledged heterogeneous agent incomplete market (HANK) model could provide insights into these issues, and can be a promising avenue for further research.

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A Model equations

Hand-to-Mouth households optimize

(2.2): HtM labor supply $$w_t = \check{C}_t^{\sigma}\ \check{N}_t^{\varphi} \tag{A.1}$$

(2.1): HtM budget $$\check{C}_t = w_t\ \check{N}_t + \frac{\tau^D}{\lambda}\Omega_t - \check{T}_t \tag{A.2}$$

Ricardian households optimize

(2.4): Ricardian labor supply $$w_t = \widehat{C}_t^{\sigma}\ \widehat{N}_t^{\varphi} \tag{A.3}$$

(2.5): LCY bond Euler $$\frac{1}{1+i_t} = \beta\ E_t\left\{\left[\frac{\widehat{C}_{t+1}}{\widehat{C}_t}\right]^{-\sigma}\frac{1}{\Pi_{t+1}}\right\} \tag{A.4}$$

(2.7): int'l risk sharing $$\left[\frac{\widehat{C}_{t+1}}{\widehat{C}_t}\right]^{\sigma} = \left[\frac{Y^*_{t+1}}{Y^*_t}\right]^{\sigma}\ \psi_t\ \frac{Q_{t+1}}{Q_t} \tag{A.5}$$

(2.6): real UIP $$\frac{1+i_t}{\mathrm{E}_t\,\Pi_{t+1}} = \frac{1+i^*_t}{\mathrm{E}_t\,\Pi^*_{t+1}}\ \frac{\mathrm{E}_t\,Q_{t+1}}{Q_t}\ \psi_t \tag{A.6}$$

(2.55): risk premium $$\psi_t = e^{-\delta\left(b_t\,\frac{h(Q_t)}{Y_t} - \zeta_t\right)} \tag{A.7}$$

(2.53): balance-of-payments $$\frac{b_t}{1+i_t} - \frac{b_{t-1}}{\Pi_t} = NX_t \tag{A.8}$$

Firms optimize

(??): AS-1 $$\Theta_t = \widehat{C}_t^{-\sigma}\,Y_t\,rMC_t\,\mathcal{M}\xi_t\ +\ \theta\,\beta\,\mathrm{E}_t\left\{\frac{h(Q_t)}{h(Q_{t+1})}\left(\Pi^H_{t+1}\right)^{\varepsilon}\ \Theta_{t+1}\right\} \tag{A.9}$$

(??): AS-2 $$\Delta_t = \widehat{C}_t^{-\sigma}\,Y_t\ +\ \theta\,\beta\,\mathrm{E}_t\left\{\frac{h(Q_t)}{h(Q_{t+1})}\left(\Pi^H_{t+1}\right)^{\varepsilon-1}\ \Delta_{t+1}\right\} \tag{A.10}$$

(2.24): AS-3 (NKPC) $$\frac{\Theta_t}{\Delta_t} = \left[\frac{1-\theta\left(\Pi^H_t\right)^{\varepsilon-1}}{1-\theta}\right]^{\frac{1}{1-\varepsilon}} \tag{A.11}$$

(2.25): real marginal costs $$rMC_t = \frac{w_t}{A_t}\ h(Q_t) \tag{A.12}$$

(2.26): production function $$Y_t\ \Xi_t = A_t\ N_t \tag{A.13}$$

(2.27): price dispersion $$\Xi_t = \left(\Pi^H_t\right)^{\varepsilon}\ \theta\ \Xi_{t-1} + (1-\theta)\left[\frac{1-\theta\left(\Pi^H_t\right)^{\varepsilon-1}}{1-\theta}\right]^{\frac{\varepsilon}{\varepsilon-1}} \tag{A.14}$$

(2.28): profits $$\Omega_t = \frac{Y_t}{h(Q_t)}\left[1 -\ rMC_t\ \Xi_t\right] \tag{A.15}$$

Market clearing and accounting

(2.45): goods market $$Y_t = \left[h(Q_t)\right]^{\eta}\left[(1-\alpha)\,C_t\ +\ \alpha\ \left[h(Q_t)\right]^{\gamma-\eta}\ Q_t^{\gamma}\ Y^*_t\right] + G_t \tag{A.16}$$

(2.46): aggregate labor $$N_t = \lambda\check{N}_t + (1-\lambda)\widehat{N}_t \tag{A.17}$$

(2.36): aggregate consumption $$C_t = \lambda\check{C}_t + (1-\lambda)\widehat{C}_t \tag{A.18}$$

(2.51): trade balance $$NX_t = \left[h(Q_t)\right]^{-1}\ (Y_t - G_t) - C_t \tag{A.19}$$

Fiscal policy block

$$\text{(2.32): government budget} \quad T_t + \frac{b_t^g}{1+i_t} = [h(Q_t)]^{-1} G_t + \frac{b_{t-1}^g}{\Pi_t} \tag{A.20}$$

$$\text{(2.33): fiscal rule} \quad T_t - T = \phi_B \left(b_{t-1}^g - \bar{b}^g\, Y\right) - Y\left[\lambda \check{\varepsilon}_t^T + (1-\lambda)\widehat{\varepsilon}_t^T\right] \tag{A.21}$$

$$\text{(2.34): HtM taxes} \quad \check{T}_t - \frac{\phi}{\lambda} T = \frac{\phi}{\lambda}\, \phi_B \left(b_{t-1}^g - \bar{b}^g\, Y\right) - \check{\varepsilon}_t^T Y \tag{A.22}$$

$$\text{(2.35): aggr. taxes} \quad T_t = \lambda\, \check{T}_t + (1-\lambda)\, \widehat{T}_t \tag{A.23}$$

Others

$$\text{(2.20): CPI-PPI wedge} \quad \frac{P_t}{P_t^H} = h(Q_t) = \left[\frac{1-\alpha}{1-\alpha\, Q_t^{1-\eta}}\right]^{\frac{1}{1-\eta}} \tag{A.24}$$

$$\text{(2.19): REER definition} \quad Q_t = \frac{e_t P_t^*}{P_t} \tag{A.25}$$

$$\text{(2.29): monetary policy} \quad \frac{1+i_t}{1+i} = \left(\frac{\Pi_t^H}{\bar{\Pi}^H}\right)^{\phi^\pi} \left(\frac{Y_t}{\bar{Y}_t}\right)^{\phi^y} \left(\frac{e_t}{e_{t-1}}\right)^{\phi^e} v_t \tag{A.26}$$

$$\text{(??): CPI inflation} \quad \Pi_t = \frac{P_t}{P_{t-1}} \tag{A.27}$$

$$\text{(??): PPI inflation} \quad \Pi_t^H = \frac{P_t^H}{P_{t-1}^H} \tag{A.28}$$

Exogenous processes

$$\text{(2.30): monetary policy shock} \quad \ln v_t = \rho_R \ln v_{t-1} + \epsilon_t^R \tag{A.29}$$

$$\text{(2.56): sudden stop} \quad \zeta_t = (1-\rho_\zeta)\zeta + \rho_\zeta \zeta_{t-1} + \epsilon_t^\zeta \tag{A.30}$$

$$\text{(??): government spending} \quad \ln G_t = (1-\rho_g)\ln(\Gamma\, Y) + \rho_g \ln G_{t-1} + \epsilon_t^g \tag{A.31}$$

$$\text{cost push shock} \quad \ln \xi_t = \rho_\xi \ln \xi_{t-1} + \epsilon_t^\xi \tag{A.32}$$

$$\text{TFP process} \quad \ln A_t = \rho_A \ln A_{t-1} + \epsilon_t^A \tag{A.33}$$

$$\text{foreign output} \quad \ln Y_t^* = (1-\rho_{Y^*})\ln Y^* + \rho_{Y^*} \ln Y_{t-1}^* + \epsilon_t^{Y^*} \tag{A.34}$$

$$\text{foreign prices} \quad P_t^* = 1 \tag{A.35}$$

$$\text{tax shocks} \quad \check{\varepsilon}_t^T, \qquad \widehat{\varepsilon}_t^T$$

which is (A.1)-(A.28) 28 equations for 28 endogenous variables, plus 7 exogenous processes (and 8 shocks):

- quantities: $Y_t, C_t, N_t, NX_t, b_t, \Omega_t, T_t, b_t^g$ (8)
- domestic prices: $\Pi_t, \Pi_t^H, rMC_t, \frac{W_t}{P_t}, \Xi_t, \Theta_t, \Delta_t$ (7)
- international prices: Q_t, e_t (2)
- interest rates: i_t, i_t^*, ψ_t (3)
- disaggregated variables: $\check{C}_t, \widehat{C}_t, \check{N}_t, \widehat{N}_t, \check{T}_t, \widehat{T}_t$ (6)
- definitions: P_t, P_t^H (2)
- exogeneous variables: $v_t, \zeta_t, G_t A_t, \xi_t, Y_t^*, P_t^*$ (7)

With FX debt use the following BoP and premium functions:

$$\text{(??): risk premium FCY} \quad \psi_t = e^{-\delta\left(b_t^* \frac{h(Q_t)}{Y_t} - \chi_t\right)} \tag{A.36}$$

$$\text{(2.54): balance-of-payments FCY} \quad NX_t = \frac{b_t^*}{(1+i_t^*)\psi_t} - b_{t-1}^* \frac{Q_t}{Q_{t-1}} \tag{A.37}$$

B Steady state

Supply side

- zero inflation steady state: from the Taylor rule (A.26) we get $\Pi^H = \bar{\Pi}^H = 1$ (by setting the inflation target parameter $\bar{\Pi}^H = 1$)
- using the above $\Pi^H = 1$ in the 4 equations describing the optimal firm decision (A.9)-(A.12) (and substituting out rMC, Δ, Θ) we get the **firm's labor demand** equation:

$$\begin{aligned} \Theta &= \widehat{C}^{-\sigma} Y \, rMC \, \mathcal{M} \; + \; \theta \, \beta \, \Theta \\ \Delta &= \widehat{C}^{-\sigma} Y \; + \; \theta \, \beta \, \Delta \\ \frac{\Theta}{\Delta} &= \left[\frac{1-\theta}{1-\theta} \right]^{\frac{1}{1-\varepsilon}} \\ rMC &= \frac{w}{A} \, h(Q) \\ \Rightarrow \qquad w &= \frac{A}{\mathcal{M}} \left[h(Q) \right]^{-1} \end{aligned} \tag{AS}$$

  - I.e. real marginal costs are the inverse of the desired markup $rMC = 1/\mathcal{M}$
- via (A.14) price dispersion in the steady state $\Xi = 1$ (which also implies via (A.13) the steady state aggregate production $Y = A \, N$
- firm profits from (A.15) are then:

$$\begin{aligned} \Omega &= \frac{Y}{h(Q)} \left[1 - \; rMC \; \Xi \right] = \\ &= \frac{Y}{h(Q)} \left[1 - \frac{1}{\mathcal{M}} \right] \end{aligned}$$

Demand side

- government expenditures are exogenous from (A.31), $G = \Gamma \, Y$
- the **goods market clearing** condition (A.16) captures domestic and external demand

$$Y = \left[h(Q) \right]^{\eta} \Big[(1-\alpha) \, C \; + \; \alpha \, \left[h(Q) \right]^{\gamma - \eta} \, Q^{\gamma} \, Y^{*} \Big] + \Gamma \, Y \tag{AD}$$

International risk-sharing

- the **imperfect intrenational risk-sharing condition** (A.5) gives us the steady state risk-premium (since discount factors are the same at home and abroad $\beta = \beta^*$, and provided that we want to avoid steady state real depreciation/appreciation $\Delta Q \neq 0$)

$$\psi = 1$$

- $\psi = 1$, together with the risk premium function (A.7) pins down the steady state NFA position

$$\begin{aligned} \psi = 1 &= e^{-\delta \left(b \frac{h(Q)}{Y} - \zeta \right)} \\ \Rightarrow \qquad b &= \zeta \, Y \left[h(Q) \right]^{-1} \end{aligned}$$

- that, in turn can be used in the **balance-of-payments** equation (A.8) (together with the $\Pi^H = 1$ result, the CPI-PPI wedge (A.24) giving us steady state CPI inflation, the LCY Euler (A.4) pinning down nominal interest rates, and the trade balance definition (A.19))

$$\frac{\Pi}{\Pi^H} = \frac{h(Q)}{h(Q)} = 1 \qquad \Rightarrow \qquad \Pi = \Pi^H = 1$$
$$\frac{1}{1+i} = \beta \left\{ \frac{1}{\Pi} \right\}$$
$$NX = \left[h(Q)\right]^{-1} (Y - G) - C$$
$$\frac{b}{1+i} - \frac{b}{\Pi} = NX$$
$$\Rightarrow \qquad \frac{C}{Y}\left[h(Q)\right] = (1 - \Gamma) + (1-\beta)\,\zeta \tag{BoP}$$

Fiscal block

- the fiscal rule (A.21) pins down the steady state government debt (via the debt target parameter $\bar{b}^g\, Y$): $b^g = \bar{b}^g\, Y$
- the government budget constraint (A.20) is used to back out aggregate taxes (using previous results)

$$T + \frac{b^g}{1+i} = [h(Q)]^{-1} G + \frac{b^g}{\Pi}$$
$$T = Y\left[[h(Q)]^{-1}\Gamma + (1-\beta)\,\bar{b}^g\right]$$

- HtM taxes from (A.22) are then:

$$\check{T} = \frac{\phi}{\lambda} T = \frac{\phi}{\lambda} Y\left[[h(Q)]^{-1}\Gamma + (1-\beta)\,\bar{b}^g\right] \tag{F}$$

Household heterogeneity

- Without HtM households $\lambda = 0$ the 3 steady state relationships (AS), (AD) and (BoP) pin down the steady state of Y, C, Q (after substituting out w with the Ricardian (= aggregate) labor supply (A.3) and the production function (A.13)).
- However, with HtM households $\lambda \neq 0$ we will need to account for household heterogeneity.
- In particular, plugging in the characterization of fiscal redistribution (F) into the steady state **HtM budget** (A.2) (and using steady state profits from above):

$$\check{C} = w\,\check{N} + \frac{\tau^D}{\lambda}\Omega - \check{T} =$$
$$= w\,\check{N} + Y\left\{ \frac{1}{h(Q)}\frac{\tau^D}{\lambda}\frac{\mathcal{M}-1}{\mathcal{M}} - \frac{\phi}{\lambda}\left[\frac{\Gamma}{h(Q)} + (1-\beta)\,\bar{b}^g\right] \right\} \tag{HtM}$$

  - some of the profits potentially get redistributed to HtM households – provided there *are* steady state profits (i.e. $\tau^w \neq \frac{1}{\epsilon} \Rightarrow \mathcal{M} \neq 1$) and the government decides so ($\tau^D \neq 0$, i.e. endogenous redistribution)
  - HtM households must also pay their share ϕ of agrgegate taxes financing government expenditures and the interest expenditures on steady state government debt ($\phi \neq \lambda$ corresponds to exogenous redistribution)

The resulting minimal steady state system to solve is the following:

$$\text{(A.12)} \Rightarrow \text{(AS)}: \quad w = \frac{A}{\mathcal{M}}\big[h(Q)\big]^{-1} \tag{B.1}$$

$$\text{(A.16)} \Rightarrow \text{(AD)}: \quad (1-\Gamma)\,Y = \big[h(Q)\big]^{\eta}\Big[(1-\alpha)\,C \;+\; \alpha\,\big[h(Q)\big]^{\gamma-\eta}\,Q^{\gamma}\,Y^*\Big] \tag{B.2}$$

$$\text{(A.8)} \Rightarrow \text{(BoP)}: \quad \frac{C}{Y}\big[h(Q)\big] = (1-\Gamma) + (1-\beta)\,\zeta \tag{B.3}$$

$$\text{(A.17)}: \quad N = \lambda\check{N} + (1-\lambda)\widehat{N} \tag{B.4}$$

$$\text{(A.18)}: \quad C = \lambda\check{C} + (1-\lambda)\widehat{C} \tag{B.5}$$

$$\text{(A.2)} \Rightarrow \text{(HtM)}: \quad \check{C} = w\,\check{N} + Y\left\{\frac{1}{h(Q)}\,\frac{\tau^D}{\lambda}\,\frac{\mathcal{M}-1}{\mathcal{M}} - \frac{\phi}{\lambda}\left[\frac{\Gamma}{h(Q)} + (1-\beta)\,\bar{b}^g\right]\right\} \tag{B.6}$$

$$\text{(A.1)}: \quad w = \check{C}^{\sigma}\,\check{N}^{\varphi} \tag{B.7}$$

$$\text{(A.3)}: \quad w = \widehat{C}^{\sigma}\,\widehat{N}^{\varphi} \tag{B.8}$$

$$\text{(A.13)}: \quad Y = A\,N \tag{B.9}$$

which is a system of 9 equations in 9 variables: $Y, C, Q, w, N, \check{N}, \widehat{N}, \check{C}, \widehat{C}$

Normalize $Q = 1$ (implying $h(Q) = 1$ via (A.24)) and endogenize Y^* instead (which only shows up at (B.2)).

- from AS (B.1) + ($Q = 1$)

$$w = \frac{A}{\mathcal{M}} \tag{B.10}$$

- from BoP (B.3) + ($Q = 1$)

$$C = Y\,\Big[(1-\Gamma) + \zeta(1-\beta)\Big] \tag{B.11}$$

- from HtM budget (B.6) + HtM labor supply (B.7) + ($Q = 1$):

$$\check{N} = \left[\frac{w}{\check{C}^{\sigma}}\right]^{\frac{1}{\varphi}} \tag{B.12}$$

$$\begin{aligned}\check{C} &= w\left[\frac{w}{\check{C}^{\sigma}}\right]^{\frac{1}{\varphi}} + Y\left\{\frac{\tau^D}{\lambda}\,\frac{\mathcal{M}-1}{\mathcal{M}} - \frac{\phi}{\lambda}\,\big[\Gamma + (1-\beta)\,\bar{b}^g\big]\right\} = \\ &= w^{\frac{1+\varphi}{\varphi}}\check{C}^{-\frac{\sigma}{\varphi}} + Y\left\{\frac{\tau^D}{\lambda}\,\frac{\mathcal{M}-1}{\mathcal{M}} - \frac{\phi}{\lambda}\,\big[\Gamma + (1-\beta)\,\bar{b}^g\big]\right\}\end{aligned} \tag{B.13}$$

- from production fcn (B.9) + aggregate labor (B.4) + (B.12):

$$\frac{Y}{A} = \lambda\left[\frac{w}{\check{C}^{\sigma}}\right]^{\frac{1}{\varphi}} + (1-\lambda)\widehat{N}$$

$$\widehat{N} = \frac{Y/A - \lambda\left[\frac{w}{\check{C}^{\sigma}}\right]^{\frac{1}{\varphi}}}{1-\lambda} \tag{B.14}$$

- from aggregate consumption (B.5) + (B.11):

$$\widehat{C} = \frac{Y\,\Big[(1-\Gamma) + \zeta(1-\beta)\Big] - \lambda\check{C}}{1-\lambda} \tag{B.15}$$

- from Ricardian labor supply (B.8) + (B.15) + (B.14):

$$w = \left[\frac{Y\left[(1-\Gamma)+\zeta(1-\beta)\right]-\lambda\check{C}}{1-\lambda}\right]^{\sigma}\left[\frac{Y/A-\lambda\left(\frac{w}{\check{C}^{\sigma}}\right)^{\frac{1}{\varphi}}}{1-\lambda}\right]^{\varphi} \tag{B.16}$$

- given (B.10) $w = A/\mathcal{M}$, we can solve (B.13) and (B.16) for $\check{C}, Y$ which then can be used to recover all the other variables

The **full steady state solution** can be recovered as:

normalization (endog. Y^*)	$Q = 1$
	$\mathcal{M} = \frac{\varepsilon(1-\tau^w)}{\varepsilon-1}$
(A.12) ⇒ (B.10) AS	$w = \frac{A}{\mathcal{M}}$
(A.3) ⇒ (B.16) Ricardian labor supply – `numerical`:	$Y = \bar{y}$
(A.2) ⇒ (B.13) HtM budget – `numerical`:	$\check{C} = \bar{c}$
(A.1) ⇒ (B.12) HtM labor supply	$\check{N} = \left[\frac{w}{\check{C}^{\sigma}}\right]^{\frac{1}{\varphi}}$
(A.13) ⇒ (B.9) production fcn	$N = \frac{Y}{A}$
(A.17) ⇒ (B.14) aggregate labor	$\widehat{N} = \frac{N-\lambda\check{N}}{1-\lambda}$
(A.8) ⇒ (B.11) BoP	$C = Y\left[(1-\Gamma)+\zeta(1-\beta)\right]$
(A.18) ⇒ (B.15) aggregate consumption	$\widehat{C} = \frac{C-\lambda\check{C}}{1-\lambda}$
(A.16) ⇒ (B.2) AD	$Y^* = \frac{(1-\Gamma)\,Y-(1-\alpha)C}{\alpha}$

(A.31) exog G	$G = \Gamma Y$
(A.19) trade balance	$NX/Y = (Y - C - G)/Y$
(A.5) int'l risk sharing	$\psi = 1$
(A.7) risk premium fcn	$b = \zeta Y$
(A.26) Taylor rule	$\Pi^H = \bar{\Pi}^H = 1$
(A.28) + normalization	$P^H = 1$
(A.24) CPI-PPI wedge	$P = 1$
(A.35) exog foreign prices	$P^* = 1$
(A.25) REER definition	$e = \frac{Q\,P}{P^*} = 1$
(A.27) inflation definition	$\Pi = 1$
(A.4) LCY Euler	$1+r = \frac{1+i}{\Pi} = \frac{1}{\beta} \quad \Rightarrow \quad i = \frac{1-\beta}{\beta}$
(A.6) real UIP	$\frac{1+i^*}{\Pi^*} = \frac{1+i}{\Pi} = \frac{1}{\beta} \quad \Rightarrow \quad i^* = \frac{1-\beta}{\beta}$

(A.21) fiscal rule	$b^g = \bar{b}^g\, Y$
(A.20) gov. budget	$T = G + (1-\beta)\, b^g$
(A.22) HtM tax rule	$\check{T} = \frac{\phi}{\lambda} T$
(A.23) aggregate taxes	$\widehat{T} = \frac{T - \lambda\check{T}}{1-\lambda}$
(A.10)	$\Delta = \frac{\widehat{C}^{-\sigma} Y}{1-\theta\beta}$
(A.11)	$\Theta = \Delta$
(A.9)	$rMC = \frac{1}{\mathcal{M}}$
(A.14)	$\Xi = 1$
(A.15)	$\Omega = Y\left[1 - \frac{1}{\mathcal{M}}\right]$

which is 30 equations to pin down the steady state of 28 endogenous variables (with the steady state versions of (A.1)-(A.28)), plus 2 exogenous processes G, P^*.

Check if Walras' Law holds, i.e. whether aggregating budget constraints yields the BoP equation:

$$\text{(A.2):} \qquad \lambda \left\{ \check{C} = w\,\check{N} + \frac{\tau^D}{\lambda}\Omega - \check{T} \right\}$$

$$\text{(2.3):} \qquad (1-\lambda) \left\{ \widehat{C} + \frac{\widehat{b}}{1+i} = \widehat{b} + w\,\widehat{N} + \frac{(1-\tau^D)}{(1-\lambda)}\Omega - \widehat{T} \right\}$$

$$\text{(A.20):} \qquad G + b^g = \frac{b^g}{1+i} + T$$

$$\Rightarrow \qquad \underbrace{\left[\lambda\check{C} + (1-\lambda)\widehat{C}\right]}_{C} + (\beta-1)\left[(1-\lambda)\widehat{b} - b^g\right] + G =$$

$$= \underbrace{w\,\underbrace{\left[\lambda\check{N} + (1-\lambda)\widehat{N}\right]}_{N} + \Omega}_{Y} - \underbrace{\left[\lambda\check{T} + (1-\lambda)\widehat{T}\right]}_{T} + T$$

$$(\beta-1)\underbrace{\left[(1-\lambda)\widehat{b} - b^g\right]}_{b} = \underbrace{Y - C - G}_{NX}$$

$$b = -\frac{NX}{1-\beta}$$

which is indeed consistent with (B.11): $C = Y\left[(1-\Gamma) + \zeta(1-\beta)\right]$, i.e. $\underbrace{C + G - Y}_{-NX} = (1-\beta)\underbrace{\zeta Y}_{b}$

C Further figures

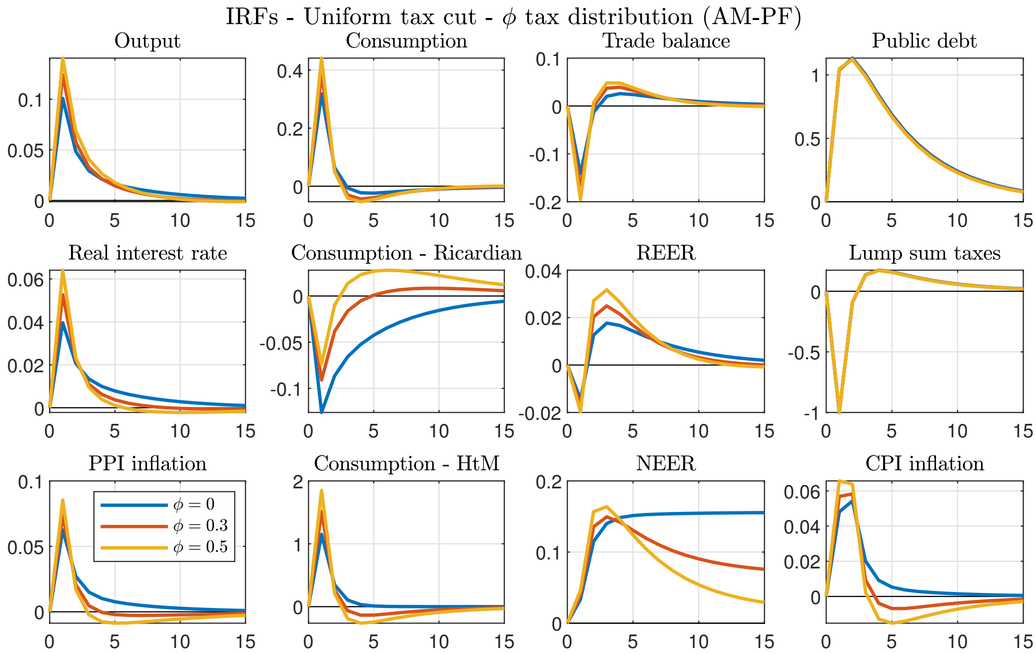

Figure 12: Impulse responses to a uniform tax cut, for different tax distribution ϕ (AM-PF policy mix with $\phi_B = 0.2$)

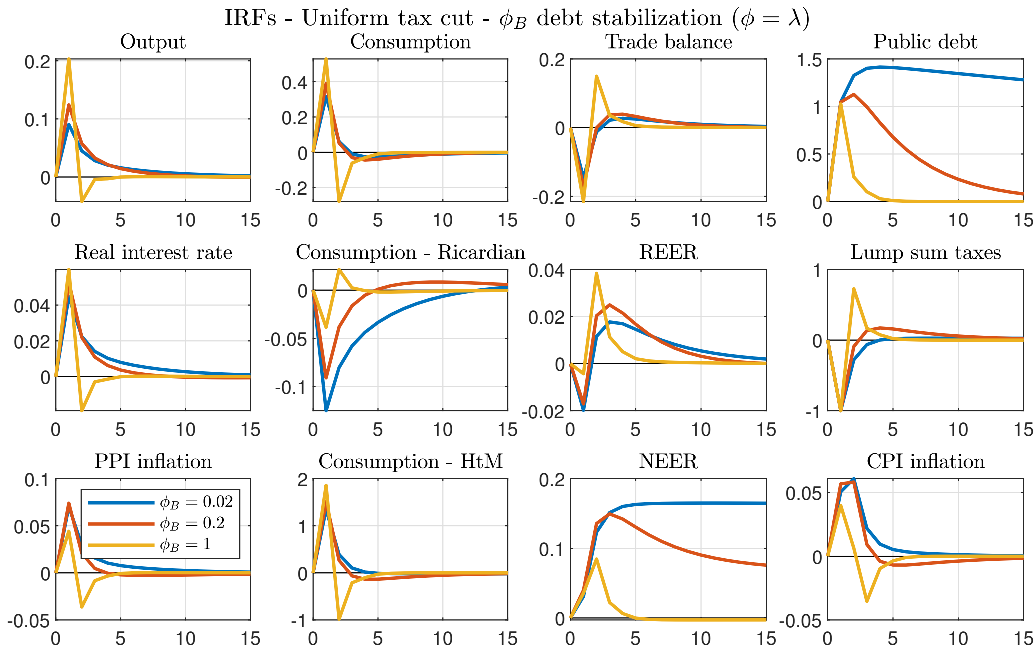

Figure 13: Impulse responses to a uniform tax cut, for different debt stabilization ϕ_B (AM-PF policy mix, with uniform tax distribution $\phi = \lambda$)

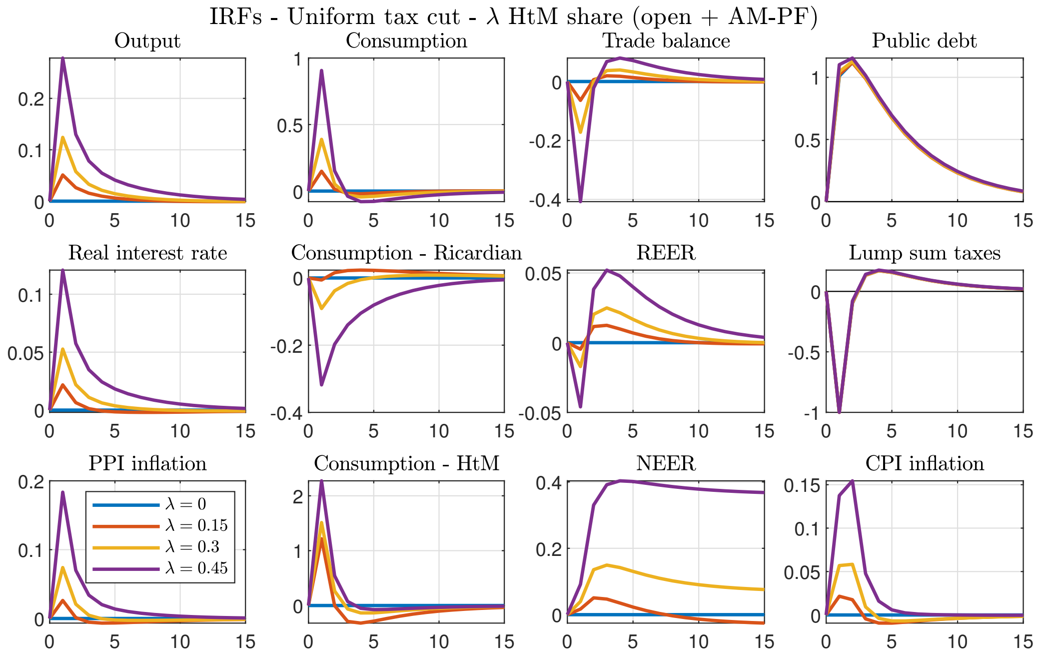

Figure 14: Impulse responses to a debt-financed uniform tax cut, for different HtM shares λ (AM-PF policy mix)

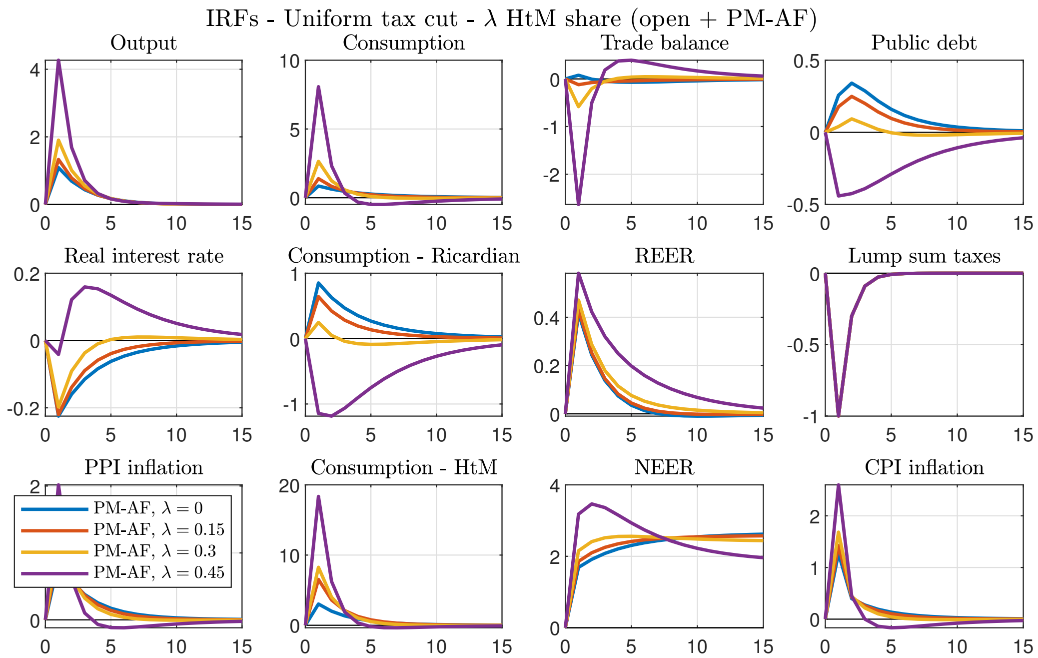

Figure 15: Impulse responses to a debt-financed uniform tax cut, for different HtM shares λ (PM-AF policy mix)

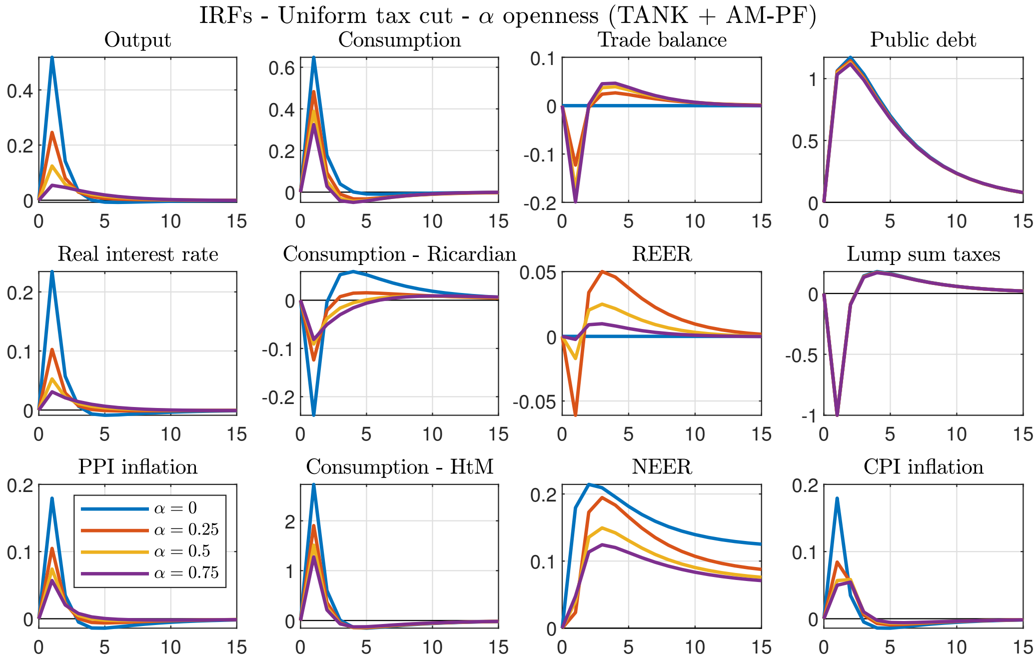

Figure 16: Impulse responses to a debt-financed uniform tax cut, for different openness α (AM-PF policy mix)

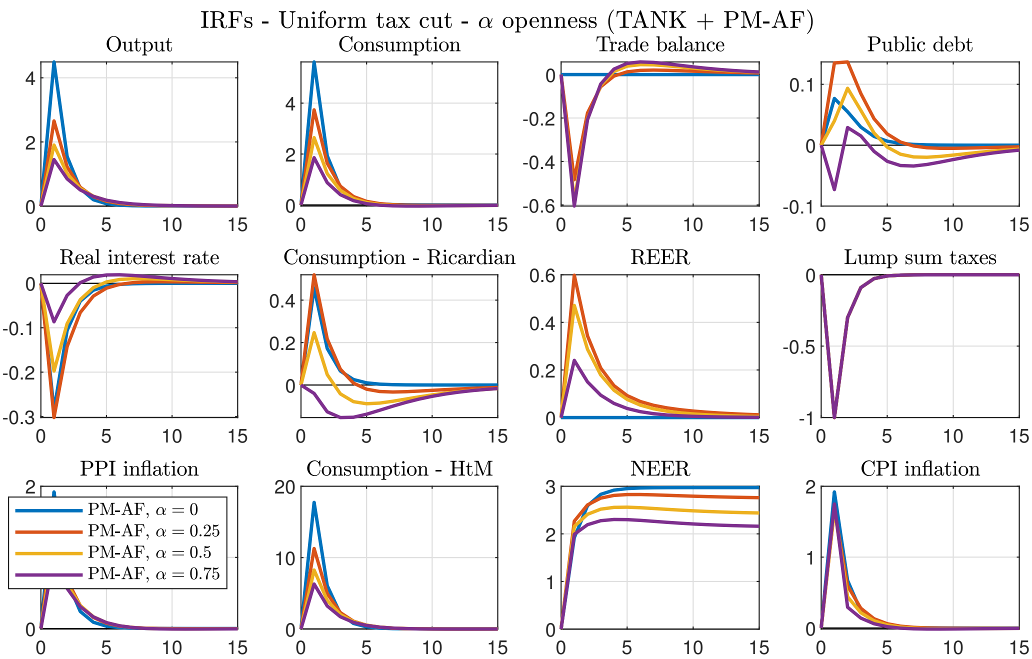

Figure 17: Impulse responses to a debt-financed uniform tax cut, for different openness α (PM-AF policy mix)

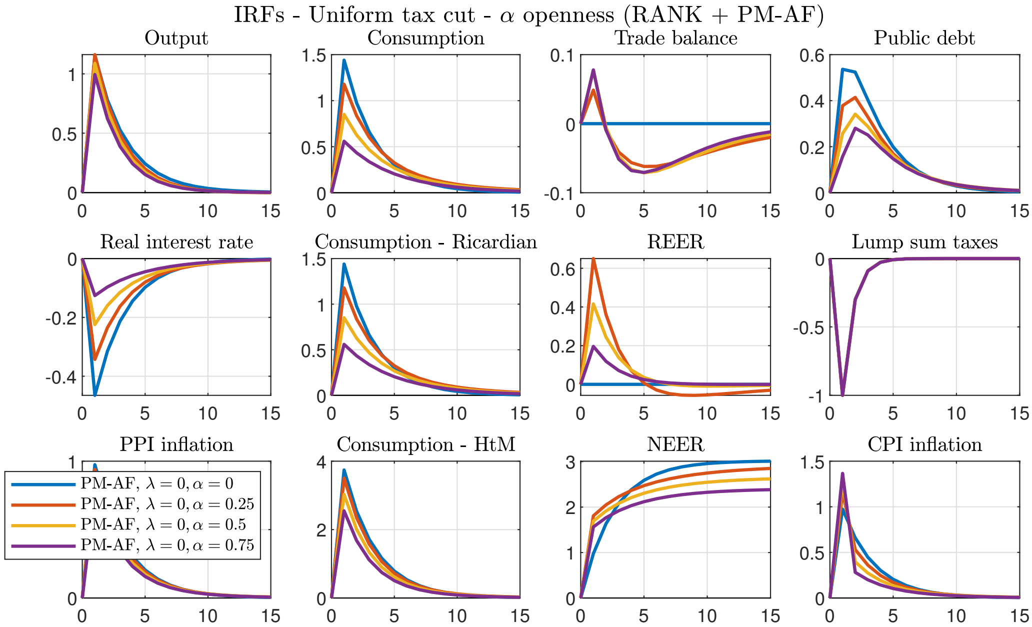

Figure 18: Impulse responses to a debt-financed uniform tax cut, for different openness α (RANK model $\lambda = 0$, PM-AF policy mix)

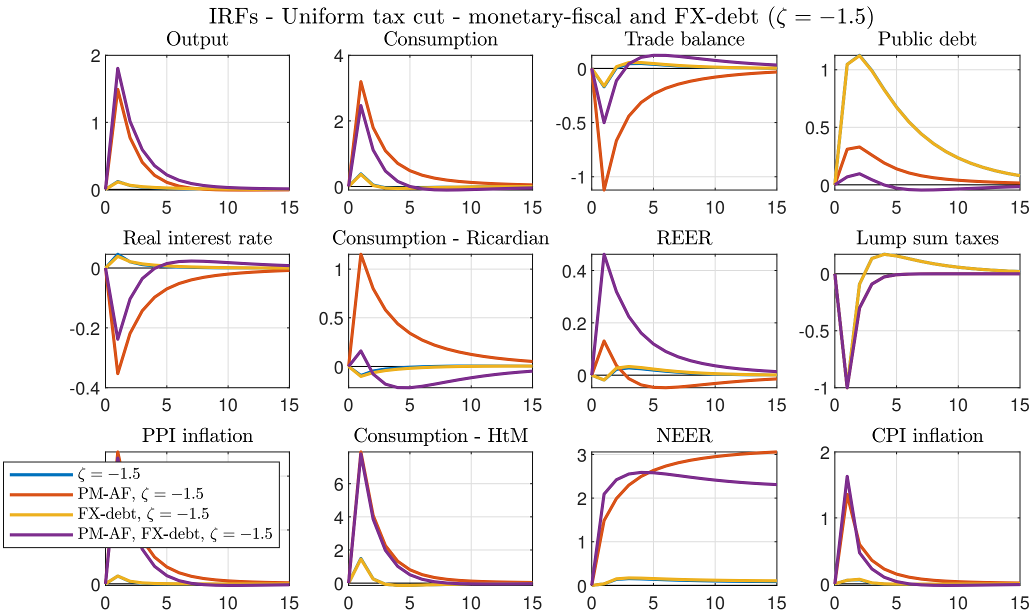

Figure 19: Impulse responses to a debt-financed uniform tax cut, for different policy regimes and external debt denomination (NFA $\zeta = -1.5$)

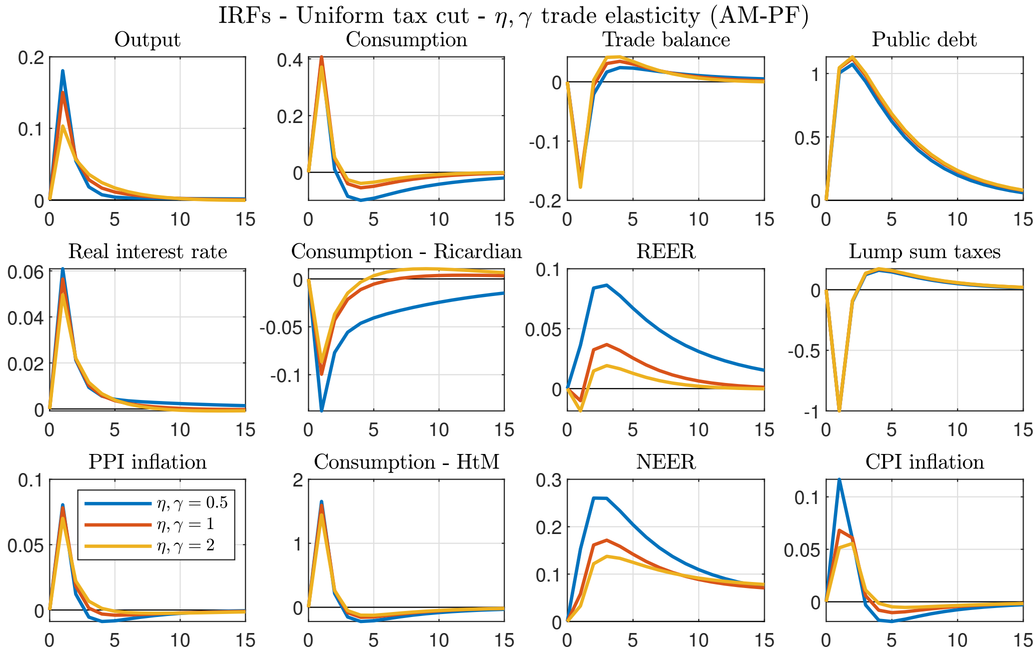

Figure 20: Impulse responses to a debt-financed uniform tax cut, for different trade elasticities η, γ (AM-PF policy mix)

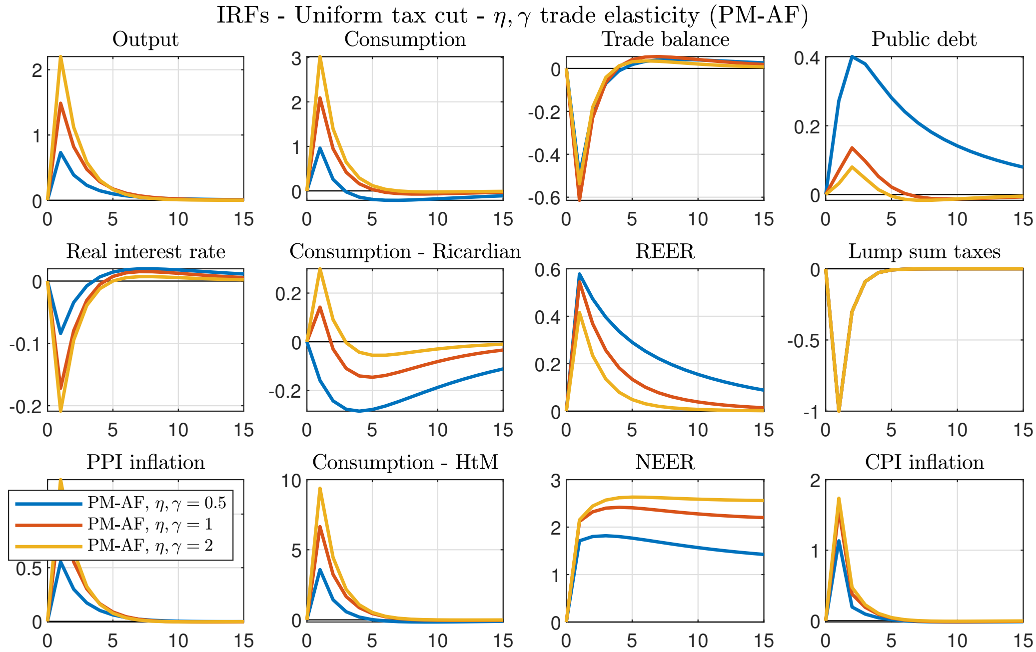

Figure 21: Impulse responses to a debt-financed uniform tax cut, for different trade elasticities η, γ (PM-AF policy mix)

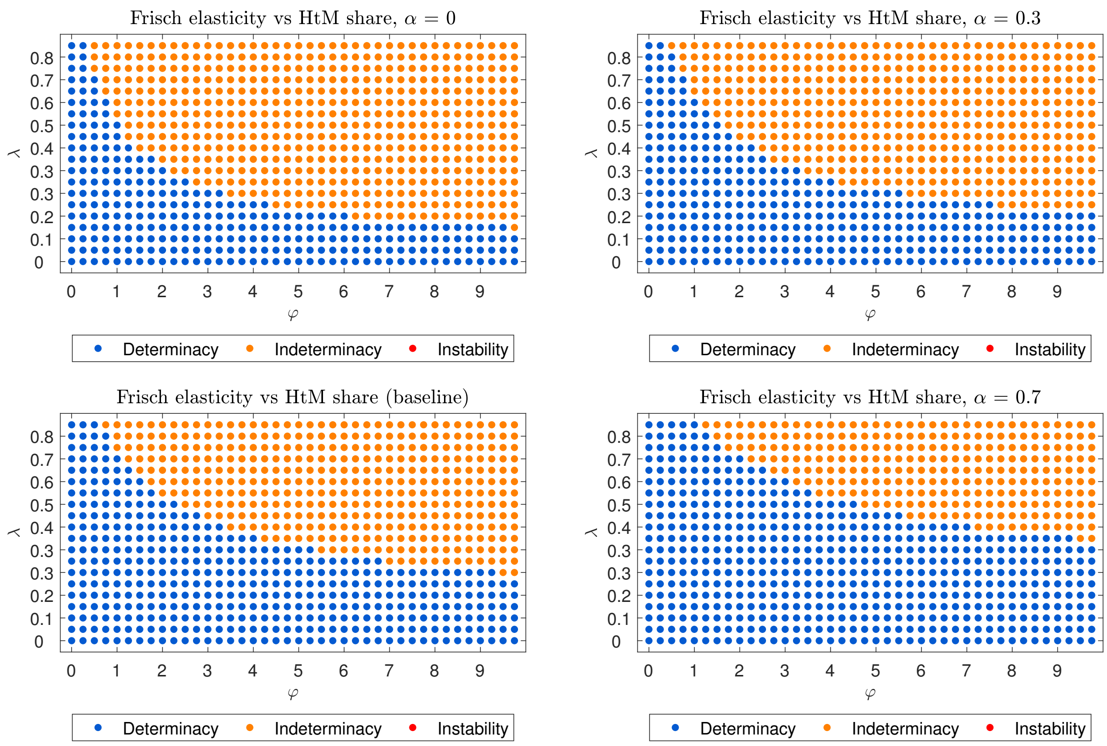

Figure 22: Inverted Aggregate Demand frontier in the (φ, λ) plain, given differing degrees of openness α (baseline is $\alpha = 0.5$, with baseline policy specification (i.e. $\phi^{\pi} = 1.5$ and $\phi_B = 0.2 > 1 - \beta$.) and symmetric external steady state $\zeta = 0$).

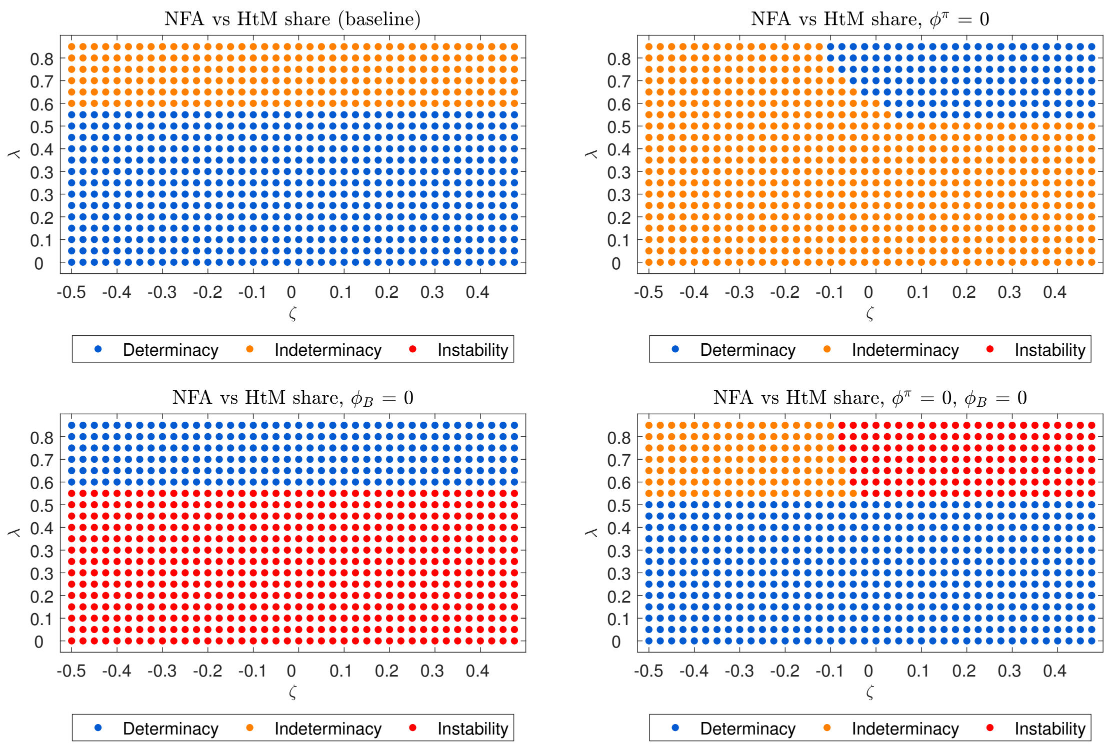

Figure 23: Model determinacy properties in the (ζ, λ) plain, for different policy regimes. Unless otherwise indicated, baseline parameters are $\phi^{\pi} = 1.5$ and $\phi_B = 0.2 > 1 - \beta$ and we have $\alpha = 0.5$.

	HtM tax cut	uniform tax cut	Ricardian tax cut	BB redistribution
HtM shock: $\check{\varepsilon}_t^T$	ε	ε	0	ε
Ricardian shock: $\hat{\varepsilon}_t^T$	0	ε	$\varepsilon/(1-\lambda)$	$\frac{-\lambda}{1-\lambda}\varepsilon$
TOTAL: $(1-\lambda)\hat{\varepsilon}_t^T + \lambda\,\check{\varepsilon}_t$	$\lambda\,\varepsilon$	ε	ε	0

Table 4: Description of tax cut shocks for different scenarios (with HtM tax shock $\check{\varepsilon}_t^T$ kept the same)

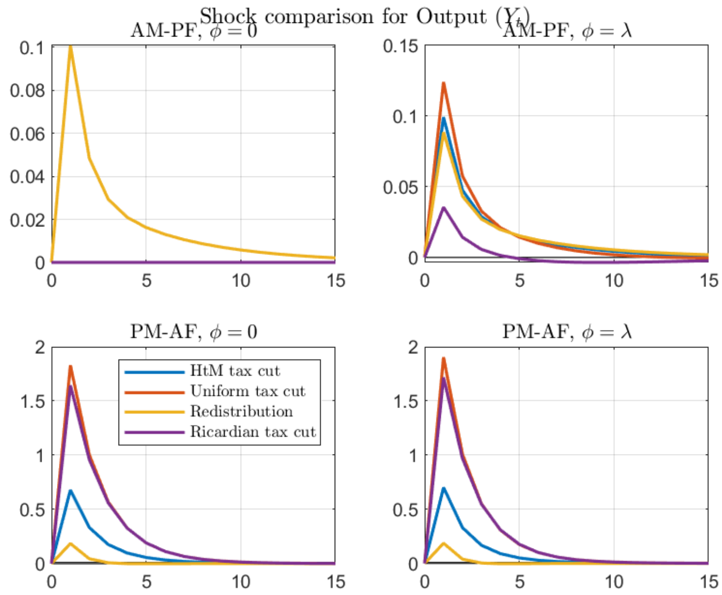

Figure 24: Shock comparison for output, across policy regimes and tax distribution ϕ (with HtM tax shock $\check{\varepsilon}_t^T$ kept the same) as in Table 4