Policy Rules in Times of Prolonged Crisis: Quantitative Easing Abroad and Fiscal Adjustment at Home

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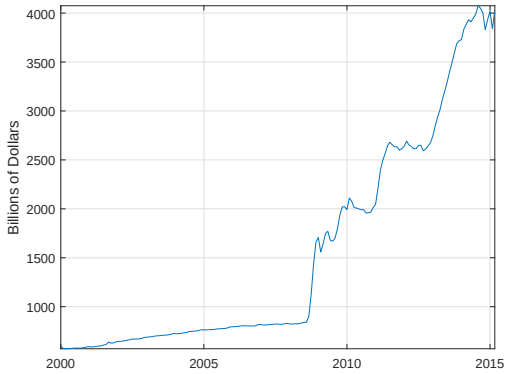
Figure 1: US Base Money, 2000-2015



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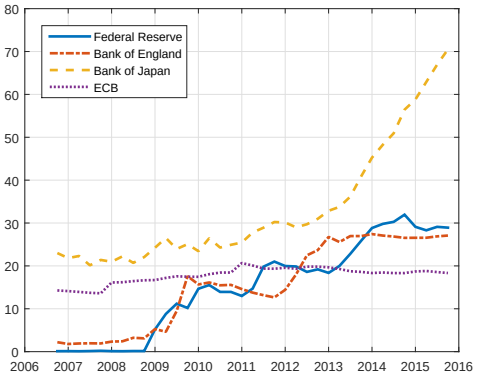
1 Introduction

- US, Euro Area, and Japan: massive expansions of liquidity
- US Monetary base rose from $600 billion in 2000 to $4 trillion in 2014
- Balance sheets have rises to skyrocket proportions. Credit growth in emerging markets has also risen.

Figure 2: Central Bank Net Asset/GDP Ratios, 2006-2016



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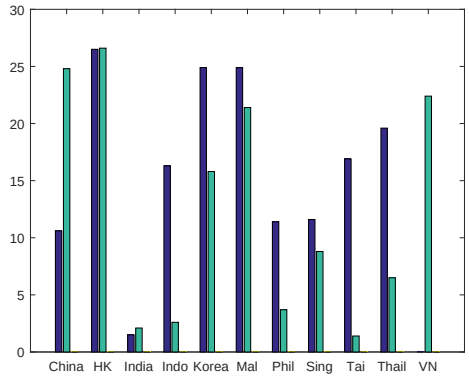
- Sims calls these interventions "quasi-fiscal" monetary policies.
- First time that the central bank intervened in non-bank financial institutions.
- Appreciation of exchange rates and asset price increases in emerging market

Figure 3: Credit Growth/GDP Ratios in 1990's and the Recent Surge



- Captial controls and macro-prudential regulation?
- Rey argues that monetary trilemma is now a dilemma.
- Yes how effective are CFM (Capital flow management) measures? Forbes contests their effectiveness.
- Domestic tax rate instruments can be used to offset crises coupled with QE policies abroad.
- Correia, Teles et al have shown that tax-rate rules can be used as substitutes for monetary policy at the lower bound.
- Lim and McNelis have show that such quasi-monetary fiscal instruments be be effective substitute for quasi-fiscal monetary instrumetns.
- This means tax-rate rules for consumption rather than capital controls or macro-prudential regulation.
- We use a two country model of Dedola-Karradi-Lombardo to examine effects of crisis and QE policy in one country (stressed) on another non-stressed country
- We assume that the non-stressed country does not have the option of QE policies: its currency does not enjoy the ehoribitant privilege as the Dollar, Yen or Euro.
- We examine stochastic properties of key variables, as well as respone of both countries during crisis periods, following Mendoza (2010).

2 The Model

- Model has households, who supply labor to firms and engage in financial services
- Government responsible for monetary and fiscal policy.
- Real frictions in terms of habit persistence and adjustment costs for investment.
- Financial friction is in the banking sector, not in the form of a firm-level collateral constraint, used by Mendoza.
- Villa (2014): banking sector friction more accurate for replicating propagation of shocks in Euro Area and USA.

Households.

- Objective function with budget constraint

$$\max E_t \sum_{\iota=0}^{\infty} \beta^{\iota} U(C_t, L_t) \tag{1}$$

$$U(C_t, L_t) = \frac{(C_t - hC_{t-1})^{1-\sigma}}{1-\sigma} - \chi \frac{L_t^{1+\varphi}}{1+\varphi} \tag{2}$$

$$(1+\tau_t^c)C_t + (B_t + D_t) = (1-\tau_t^w)W_t L_t + \Pi_t + R_{t-1}(D_{t-1} + B_{t-1}) \tag{3}$$

- Euler equations for the household

$$\varrho_t(1+\tau_t^c) = (C_t - hC_{t-1})^{-\sigma} - \beta h E_t \left(C_{t+1} - hC_t\right)^{-1} \tag{4}$$

$$\chi L_t^{\varphi} = \varrho_t(1-\tau_t^w)W_t \tag{5}$$

$$1 = \beta R_t E_t \frac{\varrho_{t+1}}{\varrho_t} = \beta R_t E_t \Lambda_{t,t+1} \tag{6}$$

- Same equations apply to both economies

1. Firms

- Two types of producers, for goods and capital
- Productivity follows an AR(1) process with normally distributed innovation term
- Law of motion for capital is multiplied by an efficiency term

The production sector contains two types of firms - goods producers and capital producers. The production function has A_t as a productivity term, α is a share parameter, L_t is labor and K_t is capital. The productivity term follows a stochastic autoregressive process with a normally-distributed innovation term, $\varepsilon_{A,t}$, with variance σ_A^2 , with persistence parameter ρ_A.

$$Y_t = A_t K_t^{\alpha} L_t^{1-\alpha} \tag{7}$$

$$K_{t+1} = \xi_{t+1}((1-\delta)K_t + I_t) \tag{8}$$

$$ln(A_t) = \rho_A ln(A_{t-1}) + \varepsilon_{A,t} \tag{9}$$

$$\varepsilon_A \sim N(0, \sigma_A^2) \tag{10}$$

- Real wages and real return on capital

$$W_t = (1-\alpha)\frac{Y_t}{L_t} \tag{11}$$

$$Z_t = \alpha\frac{Y_t}{K_t} \tag{12}$$

- Capital producers: Price of capital Q_t is equal to marginal cost of producing these goods

$$Q_t = 1 + f_t(.) + \frac{\partial f_t(.)}{\partial I_t} I_t + \beta E_t \Lambda_{t,t+1} \frac{\partial f_t(.)}{\partial I_t} I_{t+1} \tag{13}$$

- The aggregate resource constraint for the two countries

$$Y_t + Y_t^* = C_t + C_t^* + G_t + G_t^* + (1 + f_t(.))I_t + (1 + f_t^*(.))I_t^* \tag{14}$$

- G_t is determined by the government budget constraint, with the debt balanced stabilized at zero with lump-sum taxes T_0

$$G_t = T_0 \tag{15}$$

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- Law of one price is assumed in this model. Flexible price model with real and financial frictions
- Obviate Taylor rule: we compare optimal QE rules with optimal tax-rate rules and capital-flow management policies.

Financial intermediaries

- Banks borrow from households D_t and pay a gross rate R_{t+1},
- The lend to domestic and foreign firms, with total value $Q_t s_t^h + Q_t^* s_t^f$
- s is the number of state contingent claims
- Expected returns in each country:

$$R_t^k = \xi_t \left(\frac{Z_t + (1-\delta)Q_t}{Q_{t-1}} \right) \tag{16}$$

$$R_t^{k*} = \xi_t^* \left(\frac{Z_t^* + (1-\delta)Q_t^*}{Q_{t-1}^*} \right) \tag{17}$$

- **Objective function is to maximize expected terminal wealth subject to constraint** $V_t \geq \lambda_t \mathcal{W}_t$,
- λ_t**is the fraction of funds which banks are able to divert,** $\mathcal{W}_t$ **is the value of the banks balance sheet.**
- The financial sector shock we model is precisely to this ratio, λ_t, the fraction of funds which banks are able to divert:

$$\lambda_{N,t} = \rho_\lambda \lambda_{N,t-1} + \varepsilon_{\lambda,t} \tag{18}$$

$$\varepsilon_{\lambda,t} \sim N(0, \sigma_\lambda^2 \tag{19}$$

- This terminal wealth condition is important, because households will only lend to a bank if the terminal value exceeds a fraction λ of total lending.
- Bankers represent a subset of the householders.
- The present value of the bankers is given by the following objective function:

$$V_t = \max \beta \boldsymbol{E}_t \{\Lambda_{t,t+1}[(1-\theta)N_{t+1} + \theta V_{t+1}]\} \tag{20}$$

- A fraction $(1-\theta)$ of the bankers become extinct each period. The parameter θ is the survival probability of the banking sector at time t.
- With a conjectured linear solution:

$$V_t = \nu_t \mathcal{W}_t, + \eta_t N_t$$

- Assuming a continuously binding incentive compatibility constraint, the leverage ratio has the following form:

$$\phi_t = \frac{\mathcal{W}_t}{\mathcal{N}_t} = \frac{\eta_t}{\lambda_t - \nu_t}$$

- The time-varying leverage ratio yields the Law of motion for net worth of the banking sector in each country: :

$$\mathcal{N}_t = \theta \left(\left[\left(R_t^k - R_{t-1}\right) - \frac{Q_{t-1}^* s_{t-1}^f}{\mathcal{W}_{t-1}} \left(R_t^k - R_t^{k*}\right) \right] \phi_{t-1} + R_{t-1} \right) \mathcal{N}_{t-1} + \omega \mathcal{W}_{t-1} + \lambda_{N,t} \tag{21}$$

$$\mathcal{N}_t^* = \theta \left(\left[\left(R_t^{k*} - R_{t-1}^*\right) - \frac{Q_{t-1} s_{t-1}^{h*}}{\mathcal{W}_{t-1}^*} \left(R_t^{k*} - R_t^k\right) \right] \phi_{t-1}^* + R_{t-1}^* \right) \mathcal{N}_{t-1}^* + \omega \mathcal{W}_{t-1}^* + \lambda_{N,t}^* \tag{22}$$

ω : proportion of balance sheet used as start up capital for new banks

- Aggregate value of installed capital:

$$Q_t(s_t^h + s_t^{h*}) = Q_t S_t = Q_t((1-\delta)K_t + I_t) \tag{23}$$

$$Q_t^*(s_t^f + s_t^{f*}) = Q_t^* S_t^* \tag{24}$$

Application of the Model

QE in the stressed economy

- Rule for the QE parameter :

$$\psi_t = \psi + \nu^{\mathbf{m}} \mathbf{E}_t \left(R^k_{t+1} - R_t \right) \tag{25}$$

where ρ_m is the policy parameter, and ψ is the steady-state QE parameter.

- Market clearing for private and publically owned assets and balanced-budget condition:

$$(1 - \psi_t) Q_t S_t = Q_t (s^h_t + s^{h*}_t) \tag{26}$$

$$G_t = T_0 + (R^{k^*}_t - R_t) \psi_{t-1} Q_{t-1} S_{t-1} \tag{27}$$

Consumption tax-rate policy rule in the non-stressed country

- The policy response of the non-stressed country is to change its tax rates on consumption and labor income:

$$\tau^c_t = \upsilon^c \mathbf{E}_t \left(R^{k^*}_{t+1} - R_{t+1} \right) \tag{28}$$

- The government budget constraint for the non-stressed country is given by the following equation:

$$G^*_t = T^*_0 + \tau^c_t C^*_t \tag{29}$$

- As is the stressed country, the government budget is balanced at all times, with no debt expansion or contraction. When tax rates fall, government spending is reduced below its steady state, and when tax rates rise, spending increases below its steady state.

- The policy rules for the quantitative easing parameter and the tax rate, to be sure, are not meant to mimic the actual policies adopted in the USA, Japan, or the Euro Area. We are evaluating the adjustment of key variables in the model, during a prolonged crisis, with and without optimal rules for unconventional monetary and unconventional fiscal policy. The goal of our analysis is to examine how different optimal rules affect outcomes, not how the actual policies were implemented.

Tax Rate on the Interest Rate on the International Bond

- The policy response of the non-stressed country is to tax the interest earnings or payments on the net foreign assets:

$$NFA^*_t = [1 + R_{t-1}(1 - \tau^{cap}_t)] NFA^*_{t-1} + [Y^*_t - C^*_t - (1 + f^*_t(.)) I^*_t - G^*_t]$$

$$\tau^{cap}_t = \upsilon^{cap} \mathbf{E}_t \left(R^{k^*}_{t+1} - R_{t+1} \right)$$

- In this case the budget constraint has the following form:

$$G^*_t = T^* + \tau^w_t W^*_t L^*_t + \tau^c_t C^*_t + \tau^{cap}_t R_t NFA_{t-1}$$

Optimal Parameters

Table 1: Optimal Policy Parameters for QE and Tax-Rate Regimes

Regime:	
QE	Quantitative Easing Rule
ν^m	333.784
CTR	Consumption Tax Rule
ν^r	-1025.91
CFM	Interest Tax Rate Rule
υ^{cap}	-2.887

- We obtained the optimal parameters under separate optimization in the stressed home country and in the non-stressed country.
- Thus we are not talking about cooperative fiscal policy between countries
- The stressed country chooses the parameters of the QE rule for minimization of the volatility of financial sector net worth as well as welfare, not taking into account any response in policy rules in the non-stressed country,
- The non-stressed country optimizes welfare, given that the QE rule was in place in the stressed country.
- DKL examine the differences between cooperative and non-cooperative rules for QE, in two countries. We assume that the central bank in the stressed home country, due to information asymmetries, does not take into account policy responses in the non-stressed foreign country.
- However, the non-stressed foreign country can observe the policy responses in the stressed country.
- We make this assumption to capture the stressed country to be a center country such as the United States, where information about monetary policy is transparent, while the non-stressed country represent a collection of emerging market areas of the world where information is less transparent about policy reaction.

Table 2: Parameters

Discount factor	β	0.99
Risk aversion	σ	1
Habit persistence	h	.815
Relative utility weight of labor	χ	3.40
Inverse Frisch elasticity of labor supply	φ	0.276
Capital share	α	.33
Depreciation rate	δ	.025
Inverse elasticity. of I to Q	η_i	1.728
Government share of GDP	G/Y	0.2
Start-up transfer	ω	.002
Divertible fraction	λ	.382
Banker continuation probability	θ	.972
Std. Deviation: financial Shock	σ_λ	.01
Std. Deviation: productivity Shock	σ_A	.01
Persistence: financial shock	ρ_λ	.90
Persistence: productivity shock	ρ_A	.90
Steady-state leverage	ϕ	4
Steady-state premium	$(R_k - R)400$	1.00

Solution Method and Simulation Strategy

- The model was solved with a second-order perturbation method put forward by Dynare. For a robustness check, we also simulated the model with the extended-path method originally developed by Fair and Taylor
- **Foure types of experiments:**

1. **Base,**
2. **QE in Stressed Country**
3. **Given QE in stressed, Consumption Tax Regime in Non-Stressed Country**
4. **Given QE in stressed, Captial Flow Management Regime in Non-Stressed Country**

- **Properties based on stochastic means of long simulations with Distributions**
- **Crisis-event analysis and Dark Corner Dynamics: we are interested in the behavior of key variables during a sequence of adverse shocks**
- Following Kaminski, Vegh, we are interested in the adjustment process not just when it rains but when it pours, and not just at home but the contagion on the rest of the world, even if such contagion does not take the form of an unholy trinity

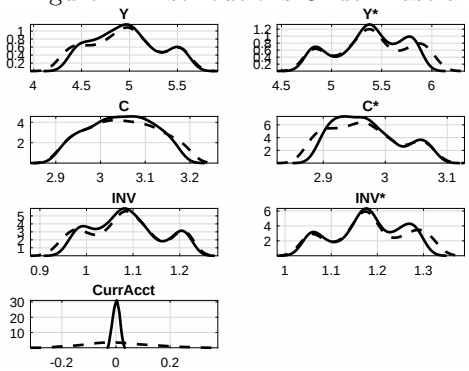
- We identify the bust episodes when output gap falls two standard-deviations below its stochastic mean, for recurring productivity shocks, and Net worth by the same amount, for recurring financial-sector shocks,
- We trace the adjustment of key variables in the home (stressed) and foreign (tranquil) country for five years before and five years after this low point. We normalize each variable at an index of 1 for the period $t^* - 4$ (where t^* is the dating of the crisis).
- We also examine the case of recurring real and financial shocks. In this case, crisis events take place when both the output gap and net worth in the stressed country are two standard deviations below their respective stochastic means.
- We then obtain the paths from t-5 to t+5 of the crisis events. From these sets of paths, we obtain the median values of these variables.
- Our purpose is to find out, not how the QE or tax-rate rules perform in normal times, but how these rules affect the behavior of key variables when the economy is undergoing stress.
- The merits of these rules should be judged by how they shield key variables from sharp drops in crisis periods,
- As noted by Mendoza, looking at welfare measures over the full period of simulation, based on averages, will not help us see how these rules perform when things get bad, as they do, for all economies, some of the time.

3 Simulation Results: Base and QE Regimes

- T = 10000
- Distributions and Mendoza Crisis Event Methodology

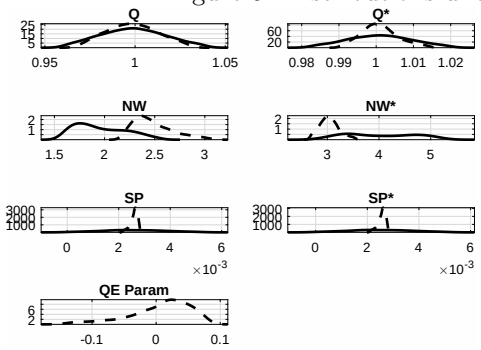
Distributions: Base and QE Regime

Figure 4: Distributions Under Base and QE Regimes: GDP Components and Current Account



___Base Regime _ _ _ QE Regime

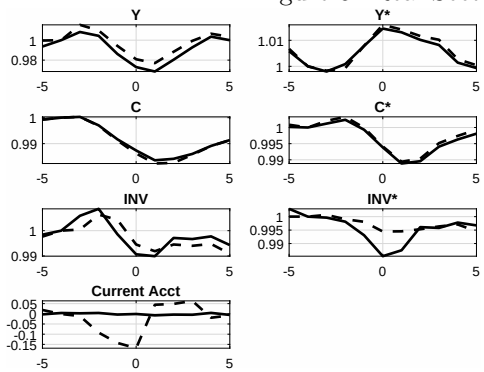
Figure 5: Distributions under Base and QE Regimes: Financial Sector



___Base Regimes _ _ _QE Regime

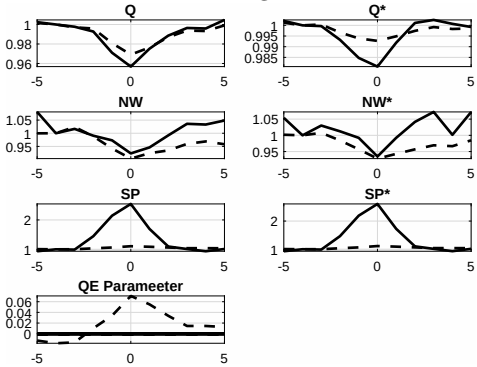
Dark Corner Dynamcis: Base and QE Regime

Figure 6: Real Sector Response: Base and QE Regimes



____Base Regime - - - -QE Regime

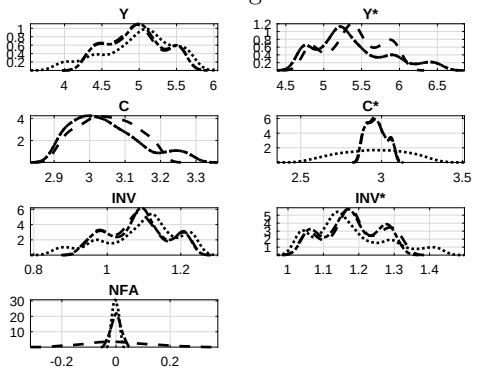
Figure 7: Financial Sector Response:Base and QE Regimes



____Base Regime - - - -QE Regime

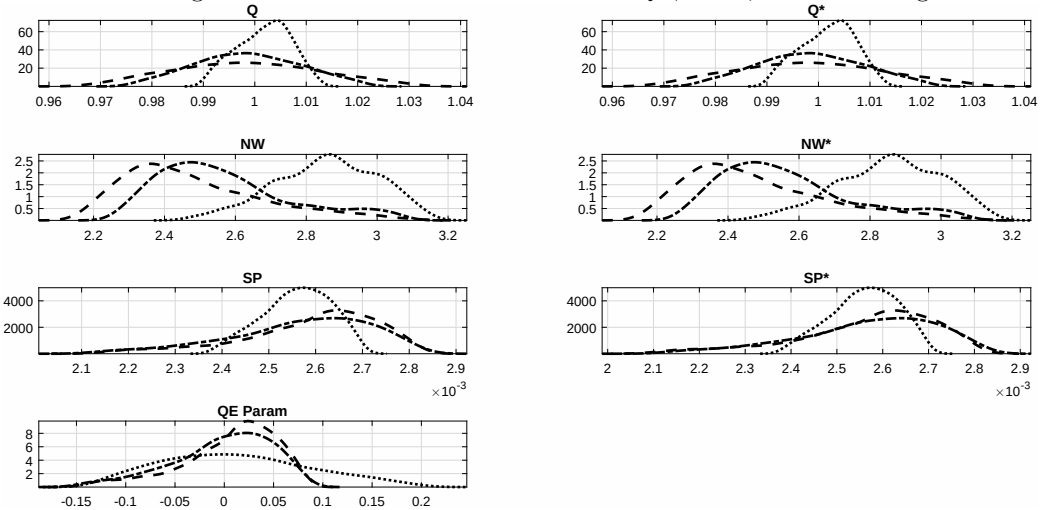
Distributions: QE, CTR and CFM Regimes

Figure 8: Real Distribtutions: QE, CTR, and CFM Regimes



_ _ QE Regime
.....CTR Regime
_._.CFM Regime

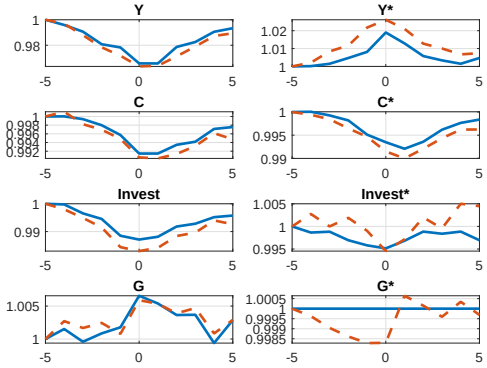
Figure 9: Financial Distributions under QE, CTR, and CFM Regimes



_ _ _QE Regime
..... CTR Regime
_._.CFM Regime

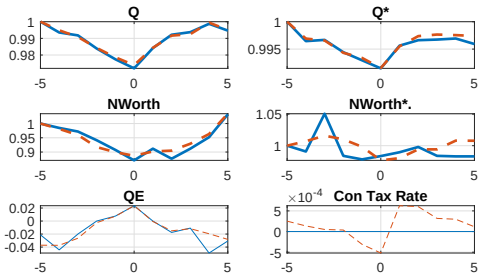
Dark Corner Dynamics: QE and CTR Regimes

Figure 10: Real Sector Response to Crisis: QE and CTR Regimes



____QE Regime - - - -CTR Regime

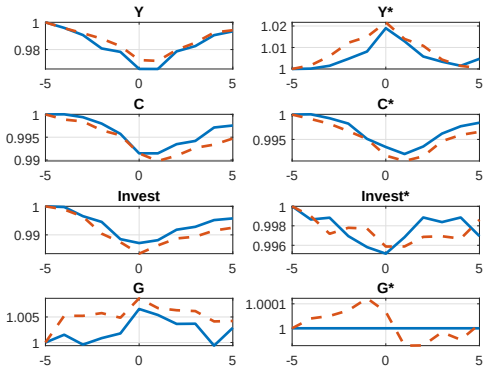
Figure 11: Financial Sector Response to Crisis: QE and CTR Regimes



____QE Regime - - - -FR Regime

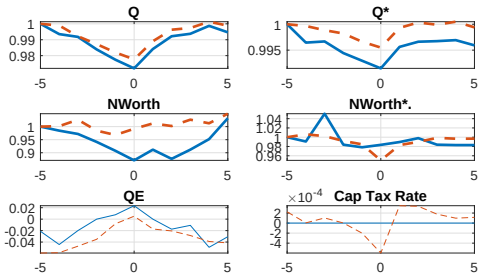
Dark Corner Dynamcis: QE and CFM Regimes

Figure 12: Real Sector Response to Crisis: QE and CFM Regimes



____QE Regime - - - -CFM Regime

Figure 13: Financial Sector Response to Crisis: QE and CFM Regimes



____QE Regime - - - -CFM Regime

4 Conclusion

- The results of this analysis show that in the wake of recurring negative shocks to one country, in net wealth or productivity or both, there will be repercussions in the rest of the world.
- QE policies can help stabilize the level of investment, asset prices and net worth world wide, but they will have negative pressures on consumption elsewhere.
- Adopting a fiscal rule at home, in the wake of the bust shocks elsewhere, will stimulate more investment and consumption at home, and, in the case of pure productivity shocks, more consumption abroad.
- In this model with real and financial frictions, but no price stickiness. the tax-rate regime acts as a quasi-exchange rate shock-absorger.
- The tax rates in the non-stressed country change the relative prices of the traded consumption goods and real labor costs. While we have both recurring productivity and net worth shocks, the QE policy in the stressed country transforms these shocks, at least for the rest of the world, into monetary shocks.
- Recalling the work of Vegh and Lahiri: our result is another example of turning the Mundell-Fleming conventional wisdom on its head.
- As these authors point out, monetary shocks under financial frictions, with full flexibility in wages and prices, call for a flexible exchange-rate regime, rather than the fixed-rate regime.
- The tax-rate regime emulates such a quasi-monetary flexible-rate regime, just as the QE policy represents a quasi-fiscal regime.
- Of course, this is a simple model, with full price flexibility, no zero lower bound and no form of firm-level collateral constraints on investment in either country.

- Such additional frictions would open the scope for more effective use of fiscal policy in both boom and bust periods. We also limited QE policies to be purchases by the central bank of private-sector assets.
- We stabilized the evolution of government debt in a radical way, by imposing a balanced budget rule for government spending.
- There are varieties of non-traditional monetary policies, involving forward guidance, as well as purchases of long-term government securities, reminiscent of the famous "Operation Twist" in the 1960's, which are ripe for further analysis within this framework [see, for example, Swenson, for a closed-economy analysis of this issue].
- Left unsaid in this paper, of course, is the political feasibility of implementing a system of a flexible tax-rate policy for stabilization.
- Capital controls, while at best only temporarily effective, can be administered by financial authorities, without the political overhead of enacting tax-rate changes on labor income or consumption spending.
- In most parliamentary democracies, tax-rate changes involve a long and cumbersome process, often called the legislative lag, while monetary policy can be administered quickly.
- For the endogenous tax-rate rules to work effectively, limited control of tax rates would have to be transferred to a stabilization board, perhaps made up of members of the monetary and fiscal authorities.
- Since most legislative bodies, quite naturally, would be quite reluctant to cede significant authority to an outside body, the scope for such tax-rate changes would most likely be limited, and subject to a high degree of legislative supervision.
- It could function much like a target zone for an exchange rate, with the authority to move rates a few percentage points above or below a target rate.
- As noted above, the firewall separating monetary and fiscal policy decisions has become more porous. Just as QE policies have ushered in a world of quasi-fiscal monetary policy, we can move into a world of quasi-monetary fiscal policy with such endogenous tax-rate policy rules.
- Of course, the results of this study leave aside the question of debt.
- In our simulations we imposed a balaned-budget rule on both economies. In the stressed-country, goverment spending rose when the QE policies went into effect and declined when the QE policies were removed.
- Similarly in the non-stressed country, government spending fell when the tax-rates fell in the fiscal regime. A richer framework would be less restrictive and allow risk premia to emerage as public debt increases, thus differentiating public-sector from private-sector risk-free deposits.
- Another drawback is that we assumed that the exogenous shocks originated in the stressed country and had spillover effects on the non-stressed country through trade and capital flows. We left aside the possibility of common global shocks, in which the two countries would adjust with different policy rules, one a quasi-fiscal monetary policy and the other a quasi-monetary fiscal framework.