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Optimal policy rules at home, crisis and quantitative easing abroad

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Optimal Policy Rules at Home, Crisis and Quantitative Easing Abroad

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Abstract

This paper examines the international transmission of financial shocks which originate in, and are partially offset by, quantitative easing in a large financially-stressed country. Using a two-country model, we evaluate the adjustment in the non-stressed home country, following recurring negative shocks to productivity and banking-sector balance-sheet/terminal wealth ratios. We first examine the application of QE policies in the stressed foreign country. Coupling quantitative easing with crisis events abroad magnifies the financial instability transmitted to the rest of the world. Our results show that the non-stressed home country can make effective use of tax-rate rules for consumption, or taxes to stabilize financial-sector net worth in times of prolonged crisis abroad.

Key words: Quantitative easing, financial frictions, unconventional monetary policy.

JEL Codes: E44, E58, F38, F41

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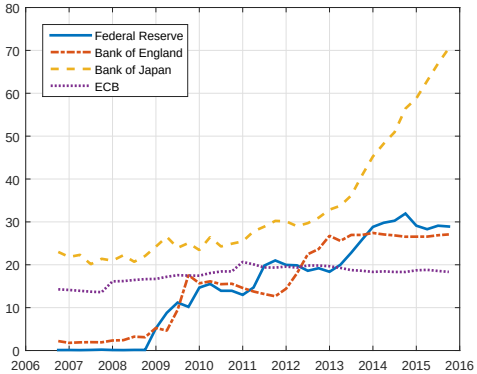
1 Introduction

Four major advanced economies, the United States, the United Kingdom, the Euro Area and Japan, have engaged in massive expansions of domestic liquidity. In the US, for example, the expansion came in various waves after the onset of the financial crisis in 2008, with the monetary base, rising from just over $600 billion in 2000, to nearly $4 trillion in 2014. These liquidity injections have been labeled as Quantitative Easing (QE) policies, then as Large Scale Asset Purchases (LSAP). In the Euro Area such injections took the form of Long Term Refinancing Operations (LTRO), as well as the Securities Market Programme and the Outright Monetary Transactions. The first wave of QE in Japan was in 2001 in an effort to stimulate its economy, it was re-implemented in 2010 and even more aggressively in 2013, in order to generate an uptick in inflation, as noted by Andolfatto and Li (2014).

Figure 1 pictures the central bank balance sheets relative to GDP of the United States Federal Reserve (FED), the Bank of England (BOE), the European Central Bank (ECB), and the Bank of Japan (BOJ). While the US and UK increases took place after the onset of the global crisis in 2008, the sharpest increase took place in Japan, starting in late 2013.

These liquidity operations went beyond the usual form of monetary policy since they involved purchases of assets not just from banks but from non-bank financial intermediaries by the central bank, which Sims (2010)has called "quasi-fiscal"policies. Normally, interventions in non-bank private sector enterprises come from the Treasury or Finance Ministry, with legislative approval, not from the monetary authority.

Figure 1: Central Bank Net Asset/GDP Ratios, 2006-2016



Needless to say, there has been much discussion of the effectiveness of QE policies both within the domestic country implementing QE and in the economies experiencing the spillover effects of the QE policies, in terms of surging capital inflows. This paper examines policy responses in these countries.

Balakrishnan et al. (2013) documented the surge in capital flows to Asia since 2010. These capital inflows are on average slightly more than four percent of GDP, with Hong Kong and Korea experiencing larger inflows of eight percent of GDP. They also note that now, on average, more than half of the inflows are in the form of relatively risky bank-related and other private flows, with Hong Kong have an extraordinarily high share of bank-related inflows, due to its status as an international financial center. A natural concern of policy makers, of course, is about the volatility of such flows, since more than 60 percent of capital inflow surges in emerging Asia have ended up in sudden stops. However in the recent surge, there is one important difference, from previous surges such as the Asian Crisis of 1997. This time interest rates have fallen. They also point out that buffers, in terms of current account surpluses and reserve levels, in Asian countries, are much higher now, relative to past surges. [1]

However, Balakrishnan et al. (2013) point out one important similarity linking the current surge in capital flows to the 1990's surge, prior to the onset of the Asian crisis of 1997. Figure 2 pictures the annualized growth of credit relative to GDP for eleven Asian countries, for the 1990's and the current period (with the exception of Vietnam, for which data were unavailable for the 1990's). For Hong Kong, the credit expansion is almost identical in the two periods, and the current growth in Vietnam is quite similar to the HK growth. For China, the current surge generated higher credit expansion than in the previous period, while for Korea, Malaysia and Singapore, the current credit expansions are almost as high as in the pre-1990 crisis period. The exceptions are Indonesia, Philippines and Taiwan, where the current credit growth measures are only a fraction of the growth rates in the 1990's.

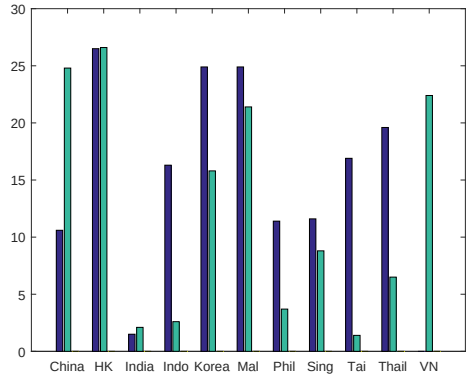
The focus of this paper is to consider the policy options for the non-stressed open economy having a high degree of financial integration with the large stressed economy, when massive QE policies are implemented, during periods of prolonged stagnation. Since QE policies have effects, near and far, what type of policies are best for dealing with these liquidity expansions abroad, due to the negative shocks to productivity or to their financial sector?

From a modeling perspective, Gertler and Karadi (2011) have examined quantitative easing policies in models with financial frictions. Dedola et al. (2013) extended this model to an open-economy two-country framework with flexible prices, with each economy of equal size. They found that unconventional policies work best if the policies between the two country aim at optimization of a joint utility function and thus are based on Ramsey cooperative arrangements. In further work, Kolasa and Lombardo (2014) explore the implications of such cooperative policies for price-stability targets of the monetary authorities in each country.

Capital controls have been suggested as a way to manage capital flows to contain these unintended bubble-thy-neighbor credit effects. This simple means

[1] Yiu et al. (2013) have documented the appreciation of exchange rates and rise in asset prices in emerging economies in the financially open Asia-Pacific region. They note a weak but positive correlation in capital movements and argue for multifaceted policy responses in the countries of this region.

Figure 2: Credit Growth/GDP Ratios in 1990's and the Recent Surge



Source: Balakrishnan et al. (2013)

that rapid credit expansion in one country leads to asset-price inflation in foreign countries. Forbes et al. (2012), Benigno et al. (2013), Bianchi et al. (2012), Brunnermeier and Sannikov (2015), Devereux and Yetman (2014), among many others, examined the costs and benefits of various forms of capital controls in this context. Rey (2013) goes even further and argues that the monetary "trilemma" is now a "dilemma", since monetary independence in any regime is only possible with capital controls.

By contrast, Devereux et al. (2015) found the use of capital controls to be inferior from a welfare point of view to an optimal but time-inconsistent monetary policy, and that an optimal policy regime will never use such controls as precaution against the risk of future crises (with or without commitment). Their framework was that of a small open economy. More recently, Heathcote and Perri (2016) examined the desirability of capital controls in a two-country framework. They argue in favor of such controls, since they can dampen the increase in investment in a country experiencing higher productivity shocks, and lessen the effects on terms of trade.

In more recent work, Banerjee et al. (2015) took up the question of the use of "self-oriented" monetary policy, generating large surges in capital flows, and the possible need for cooperative policy measures. Using a two-country model, found that the use of optimal policies, which go beyond simple inflation targeting, obviate the need for coordinated policies across countries.

While models with financial frictions may show the beneficial effects of various forms of capital controls, taking the form of taxes or subsidies, they ignore one important fact. The effectiveness of such controls, in practice, is usually very short-lived. Browne and McNelis (1990) showed how the Irish use of exchange controls in the 1980's proved to be ineffective for keeping interest rates below the German levels. More recently, Forbes et al. (2014) conducted a multi-country panel study and concluded that most capital-flow management

measures (termed CFM policies) did not accomplish their stated goals.

The purpose of this paper is to show that domestic tax-rate instruments, in particular, changes in the consumption rates, can be used as effective instruments, as substitutes for CFM measures, for offsetting the effects of QE policies from financially stressed countries, on domestic asset prices. The reason for using these instruments, rather than CFM measures, is that they are more broadly based in the economy, more transparent and easier to enforce and implement, rather than taxes and subsidies on capital inflows or outflows.

We do not examine the use of similar QE policies in the non-stressed country, as done by Dedola et al. (2013). The reason is that we wish to focus on the "non-stressed" country as representative of countries which do not have "privileged" currencies, such as the US Dollar, Japanese Yen, the UK Sterling, or the Euro. Thus the non-stressed "country" does not have the option of such unconventional monetary policies, to the extent that these national currencies do not have the the same status as the currencies in the stressed countries, namely, the Euro Area, the UK, Japan, and the USA. It does have tax policies, to be sure, and we examine these options as alternatives to unconventional policies. Correia et al. (2013) have shown how "unconventional fiscal policy" in the form of tax-rate rules, can be effective substitutes for monetary policy when the interest rate is at the zero lower bound. More recently, Lim and McNelis (2016) compared the unconventional fiscal-policy rules with quantitative easing using the closed-economy framework of Gertler and Karadi (2011). They found that the fiscal rules can be as effective as the quasi-fiscal unconventional monetary-policy rules. We ask if the same holds true in an open economy, two-country model, when one country is stressed and the other is not.

We adopt the Dedola et al. (2013) model, but allow for the adoption of fiscal options, following Correia et al. (2013) and Lim and McNelis (2016), as well as CFM measures, taking the form of interest-rate taxes on traded risk-free assets..

We first examine the distribution of key variables in the base crisis scenario with no policy response, neither in the stressed nor the non-stressed country, and then we examine distributions with a QE policy rule in place in the stressed country. The results show that the QE policy rule does indeed generate a surge in capital flows, and a jump in net worth of the financial sector, in the non-stressed country, but it is a "beggar thy neighbor" policy, since GDP and investment fall in the non-stressed country, when the QE policy is in place in the stressed country.

We examine the response of key variables in each country, with two methods. Using a long simulation, we compare the overall distributions in each country under the base "no policy" response regime and under the QE regime in the stressed country. However, in order to capture better the "disparate confounding dynamics" noted by Faust and Leeper (2015) , and overlooked in conventional monetary analysis, we also adopt a variant of the Mendoza (2010) approach for the analysis of crisis events. The model is simulated for recurring shocks and simulated for a very long run of T = 10000. We then isolate sub-periods when the GDP is at its minimum point in the base case of no policy response. We examine the adjustment of key variables for five years before and five years

after this worst case. Then, for the same shocks, we examine the adjustment process pre-crisis and post-crisis under the QE policy rule. Our goal is to capture not only the overall volatility of key variables, but their adjustment during the worst-case crisis scenarios.

We then calculate optimal rules for tax rates for consumption as well as for interest-earnings on the risk free asset, in both countries, as an alternative to the QE policy implemented in the stressed country.

The next section describes the model specification as well as its calibration. This section also describes the optimal rules for the tax rates for consumption and labor income in the non-stressed country, and for quantitative easing in the stressed country. The third section contains an analysis of the simulation results for recurring productivity and financial-sector shocks. The last section concludes

2 The Model

The model is fully described in Dedola et al. (2013), henceforth denoted at DKL. This paper is an open-economy extension of the model developed in Gertler and Karadi (2011), which we denote by GK. It is a two-country economy model with households, firms and financial intermediaries (bankers). There is also a government which is responsible for monetary and fiscal policies with different behavior in the stressed and non-stressed countries. We have modified the DKL model to allow for taxes on wage income and on consumption. The model is described briefly in the next section and includes only the key aggregate equations. For further elaboration of the model see Dedola et al. (2013).

The model incorporates many of the real frictions used by Smets and Wouters (2003, 2007) in their models for the Euro Area and the USA. As noted by Villa (2014),the DKL and GK models incorporate financial frictions appearing in the banking sector, rather than at the firm level, in the form of collateral constraints, adopted by Mendoza (2010), and more recently by Devereux et al. (2015) for the analysis of sudden stops. Villa pointed out that the banking sector friction, in the form of incentive-compatibility constraints linking banking balance sheets with terminal wealth, rather than the firm-level collateral constraint, was more effective for replicating the propagation of real shocks, with Bayesian model estimation, for the Euro Area and the USA.

2.1 Households

The household sector consumes C_t, which is subjected to a consumption tax $(1+\tau_t^c)$, provides labor services L_t at wage $(1-\tau_t^w)W_t$ and lends or borrows an international risk-free bond B_t as well as makes deposits D_t to financial intermediaries, both of which earn a gross risk-free rate of R_t. Returns on these assets are also subject to a time-varying tax rate of τ_t^c. This tax rate as well as the tax rates on consumption and wages, given by τ_t^c, τ_t^w respectively, are set to zero in normal times.

The household maximizes the intertemporal welfare function (1) with utility function defined in (2) subject to the budget equation (3).

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

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

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

where β $(0 < \beta < 1)$ is a discount factor, σ is a risk-aversion parameter, h $(h > 0)$ is a habit persistence coefficient, χ $(\chi > 0)$ is the disutility of labor, and φ $(\varphi > 0)$ is the Frisch labor-supply elasticity. Π_t is net profits from ownership of financial and non-financial firms, while D_t, B_t represent riskless assets in the form of deposits and government bonds.

The Euler equations appear below. The variable ϱ_t is the marginal utility of consumption

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

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

$$1 = \beta R_t(1-\tau_t^{cap})E_t\frac{\varrho_{t+1}}{\varrho_t} = \beta R_t(1-\tau_t^{cap})\boldsymbol{E}_t\Lambda_{t,t+1} \tag{6}$$

The same equations apply to both economies. We assume that the crisis takes place in the economy without the asterisk, and we evaluate the adjustment in the country denoted with the asterisk (*). The tax rates, τ_t^c, τ_t^w, and τ_t^{cap}, represent time-varying state-contingent tax rates on consumption, wages, and interest income. These tax-rate rules, discussed below, are policy options for the non-stressed county, facing the consequences of crisis and quantitative easing abroad.

2.2 Firms

The production sector contains two types of firms - goods producers and capital producers. The production function is described in (7) where A_t is 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.

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

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

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

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

The law of motion of capital is described in equation (8), which is the sum of un-depreciated capital (with depreciation rate, δ) plus investment, I_t, multiplied by an efficiency term ξ_{t+1}. Factor inputs are chosen such that the unit cost of labor W_t and the unit cost of capital Z_t are equal to their respective marginal products.

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

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

The capital producers build new capital, and they maximize their discounted profits subject to an adjustment cost function $f_t(.)$ (see DKL for details). This

yields an equation relating the price of capital goods Q_t to the marginal cost of producing investment goods:

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

These equations also apply to the other $*$ economy. The aggregate resource constraint for the two countries is given by the following equation

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

where the government expenditure G_t is financed by lump-sum taxes, in the absence of quantitative easing or endogenous tax-rate rules.

$$G_t + T_t + (1 + R_t)B_{t-1} = B_t \tag{15}$$

The model is a flexible price model.[2] The focus is on the interactions of unconventional monetary policy rule in the stressed economy and fiscal tax-rate rules in the non-stressed economy in a highly integrated world of trade and finance. Given that we assume flexible prices we do not examine Taylor rules and the issue of the zero lower bound. The focus is on the propagation of the real or net worth shocks due to financial frictions, with the use of QE policies in one country and tax-rate rules in the other country. Correia et al. (2013) have noted that such tax-rate rules, unlike Taylor rules, do not rely on the assumption of sticky prices or wages to be effective. In one sense, the implementation of these tax-rate rules is a form of "quasi-monetary" fiscal policy, since the tax-rate changes affect the Euler equations in the same way that interest rates would in a sticky-price Taylor-rule world.

2.3 Financial intermediaries

The financial intermediaries borrow domestically from households D_t and pay a gross rate R_{t+1}, but they lend to both domestic and foreign firms. Superscripts h and f are used to denote the loans in the home country to the home and foreign firms. The value of these loans is the sum of $Q_t s_t^h + Q_t^* s_t^f$ where s is the number of state contingent claims. For the foreign country, the total value of loans is given by $Q_t^* s_t^{h^*} + Q_t s_t^{f^*}$ and the respective gross returns per unit of loans, R_t^k, R_t^{k*} in the home and foreign countries:

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

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

As in the GK model, DKL also present a discussion about a bank's objective to maximize expected terminal wealth V, subject to the incentive-compatibility condition :

[2]The law of one price is assumed in this model, so that the expected real exchange rate is unity.

$$V_t \geq \lambda_t \mathcal{W}_t, \tag{18}$$

where λ_t is the fraction of funds which banks are able to divert, and $\mathcal{W}_{\mathbf{t},t}$ is the value of the bank's balance sheet. This incentive-compatibility constraint, relating the balance sheet of the bank to terminal wealth, is the key financial friction.

The financial sector shock in the stressed country is precisely a shock to this ratio, λ_t, the fraction of funds which banks are able to divert:

$$\lambda_t = \bar{\lambda} exp(\lambda_t)$$

$$\lambda_t = \rho_\lambda \lambda_{t-1} + \varepsilon_{\lambda,t}$$

The shock to the ratio follows an autoregressive process with persistence parameter $\rho_\lambda$and innovation term ε_λ, which is normally distributed with mean zero and variance σ^2_λ.

In this model, bankers represent a subset of the householders. The present value of the bankers is given by the following objective function:

$$V_t = \max \beta \boldsymbol{E}_t \{\Lambda_{t,t+1}[(1-\theta)N_{t+1} + \theta V_{t+1}]\} \tag{19}$$

With a conjectured linear solution for terminal wealth:

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

as well as assuming a continuously binding incentive-compatability constraint, one obtains the following expression for the leverage ratio ϕ_t:

$$\begin{aligned} \phi_t &= \frac{\mathcal{W}_t}{\mathcal{N}_t} \\ &= \frac{\eta_t}{\lambda_t - \nu_t} \end{aligned} \tag{20}$$

Given the binding constraint, the law of motion for aggregate net worth $\mathcal{N}_t$ is:

$$\mathcal{N}_t = \theta \left(\left[\left(R^k_t - R_{t-1} \right) - \frac{Q^*_{t-1} s^f_{t-1}}{\mathcal{W}_{t-1}} \left(R^k_t - R^{k*}_t \right) \right] \phi_{t-1} + R_{t-1} \right) \mathcal{N}_{t-1} + \omega \mathcal{W}_{t-1} \tag{21}$$

where ω is the proportion of $\mathcal{W}_{t-1}$ used as start-up capital of new banks.[3] Equation (21) is important as it highlights the role played by spreads. The symbol $\lambda_{N,t}$ represents a shock which affects the amount of divertible funds in the banking sector, which in turn affects the evolution of net worth.

[3]Note that, in general, net-worth is: $Q_t s_t + Q^*_t s^*_t - D_t = \mathcal{W}_t - D_t = R^k_t Q_{t-1} s_{t-1} + R^{k*}_t Q^*_{t-1} s^*_{t-1} - R_{t-1} D_{t-1}$

In the symmetric case, the **aggregate** net worth of the foreign country, $\mathcal{N}_t^*$, is given by the following relation:

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

where s^{h*} is the amount of loans extended by the foreign bank to the home firms. The corresponding shock to foreign financial wealth is given by the term $\lambda_{N^*,t}^*$. As in the home country, this shock follows a stochastic autoregressive process.

For completeness, the aggregate value of installed capital is equal to the funds provided by the home and foreign-country banks:

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

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

.As noted in DKL, by making different assumptions about the possibility of lending outside the home country, the model allows for complete autarky to complete integration with two equal sized economies. We assume complete financial integration, and assess tax-rate rules rather than CFM policies aimed at financial fragmentation.

2.4 Application of the Model

Our particular interest is to evaluate the policy options for the non-stressed economy when the other major economy implements QE in response to a recurring negative productivity or financial-sector net worth shocks. The equations describing household and firm behavior are identical (with the same parameter values) in all scenarios, but behavior in the financial sector and the policy rules are different in each scenario.

2.5 QE in the stressed economy

As in GK, during crisis periods, the government buys private sector debt $\psi_t Q_t S_t$ where ψ_t is a function of the risk premium, described below:

$$\psi_t = \psi + \nu^m E\left(R_{t+1}^k - R_t \right) \tag{25}$$

where ν^m and $\rho_m$are policy parameters, and ψ is the steady-state QE parameter. The market clearing equation and government budget equations now become

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

$$G_t^* + \psi_t Q_t^* S_t - T^* = R_t^k \psi_{t-1} Q_{t-1}^* S_{t-1} \tag{27}$$

Note, $s_t^{h*} \neq 0$ because we allow financial institutions in the stressed QE country to hold assets in the non-stressed foreign country. We assume that the

government uses the revenue from expansionary QE policies, with $\psi_t > 0$, to increase government spending above its steady-state, and during "tapering", when $\psi_t < 0$, government spending is reduced below its steady state. Thus there is no debt expansion or contraction, since the government budget is in balance. We denote this regime the QE regime.

2.6 Policies in the non-stressed country

The policy response of the non-stressed country is to impose a tax on interest earnings on foreign assets (or payments on foreign debt), in the capital-flow management regime (CFM), or change its tax rates on consumption and labor income in the fiscal regime (FR).

In the CFM regime, interest earnings or payments on foreign assets/liabilities are taxed at the variable rate τ_t^{cap}. The foreign asset position of the non-stressed country has the following law of motion:

$$NFA_t^* = [1 + R_{t-1}(1 - \tau_t^{cap})]NFA_{t-1}^* + [Y_t^* - C_t^* - (1 + f_t^*(.))I_t^* - G_t^*] \quad (28)$$

The time-varying tax-rate on interest earnings or payments to the spreads between the return on capital and the risk-free return:

$$\tau_t^{cap} = \upsilon^{cap}\mathbf{E}_t\left(R_{t+1}^{k^*} - R_{t+1}\right) \quad (29)$$

The tax rate on consumption is also based on the spreads in the non-stressed country

$$\tau_t^{c} = \upsilon^{c}\mathbf{E}_t\left(R_{t+1}^{k^*} - R_{t+1}\right) \quad (30)$$

Government spending for the non-stressed country is determined by the following budget constraint:

$$G_t^* = T^* + \tau_t^w W_t^* L_t^* + \tau_t^c C_t^* + \tau_t^{cap}(R_t - 1)NFA_{t-1}^* \quad (31)$$

As is the stressed country, the government budget is balanced at all times, with neither debt expansion nor contraction, so that $B_t^* = 0$. When tax rates fall or rise on income, consumption, or net foreign asset receipts (or payments on net debt), 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 rates, 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

Table 1: 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	.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	.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

analysis is to examine how different optimal rules affect outcomes, not how the actual policies were implemented.

We obtained the optimal parameters under separate optimization in the stressed home country and in the non-stressed country. 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, while 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 1, replicated from DKL, gives the parameter calibration for the model. These parameter values closely follow the earlier closed economy setup of GK. The calibration of the leverage ratio, the start-up transfer, and the fraction of divertible funds are set to deliver a premium of 100 basis points based on an annual rate of return.

Table 2 displays the optimal policy parameters for the QE, CFM and FR

rules. The optimal coefficients are based on minimizing volatility of financial sector wealth as well as optimizing welfare, in the stressed home country, for the QE rule, while the non-stressed country optimizes welfare, given the policy parameters in the stressed country. Unlike GK and DKL, we incorporate a smoothing parameter in each of these rules. The optimal rules for both countries show a high degree of smoothing for QE and the FR rules. In the tranquil country, the optimal rule calls for subsidies to both income and consumption when the premium or difference between the return on equity and the risk-free rate is positive, during times of stress.

Table 2: Optimal Policy Parameters for QE, CFM and FR Regimes

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

2.7 Solution Method and Simulation Strategy

The model was solved with a third-order perturbation method put forward by Adjemian et al. (2014). For a robustness check, we also simulated the model with the extended-path method originally developed by Fair and Taylor (1983).

Following Heathcote and Perri (2016), we note that the use of the third-order approximation allows us to incorporate the effects of uncertainty on optimal choices, as well as to capture how uncertainty varies with the levels of the state variables. As these authors note, as one country becomes more leveraged, due to capital inflows, the precautionary saving motive increases, pushing the negative net foreign asset position back to zero. With this approximation, the net foreign asset process is stationary, so that here is no need to introduce ad-hoc devices for closing open economies, suggested by Schmitt-Grohe and Uribe (2003).

As noted above, we first examine the distributions of key variables under the base regime, the QE regime and the FR regime, given the QE regime in the stressed country.

Following the methodology of Mendoza (2010) we then use a crisis-event analysis, rather than impulse-response functions, since we are interested in the dynamic behavior of key variables, pre-, during and post- crisis events, where the crisis events have been generated by a sequence of adverse shocks in the home country. Following Kaminsky et al. (2005), we are interested in the adjustment process not just when it rains but when it pours, and not just in the stressed country but in the rest of the world, even if such contagion does not take the form of an unholy trinity [see Kaminsky et al. (2003)].

Following this approach, we first examine the adjustment for five years before and five years after the worst crisis event in the long simulation, when GDP is at its absolute minimum value. We then examine the mean values of key variables for all of the instances when GDP is two standard deviations below its stochastic mean.[4]

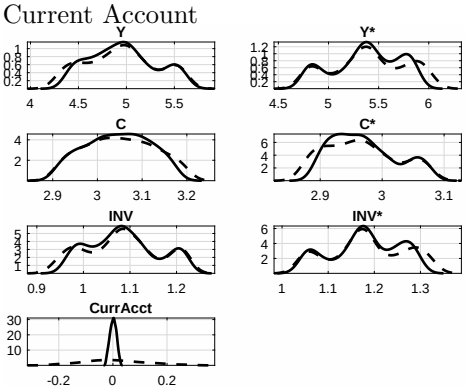
The merits of the alternative QE and RE rules should be judged by how they shield key variables from sharp drops in crisis periods, As noted by Mendoza (2010), looking at welfare measures over the full period of simulation, based on averages, will not help us see how these rules perform when things get bad, as they do, for all economies, some of the time.

We simulate the model with recurring productivity and net-worth shocks in the foreign country, first without a QE policy in place and then with a QE policy in place. Then we evaluate the performance of key variables with CFM and FR rules in place in the non-stressed country.

Our interest is how key variables behave in down times or crisis periods, and how their adjustment changes with respect to the use of unconventional monetary policies and the use of CFM and tax-rate rules for consumption.

[4] Note that the stochastic means are different from the steady state values of the endogenous variables, due to higher order approximation methods.

Figure 3: Distributions Under Base and QE Regimes: GDP Components and Current Account



___Base Regime _ _ _ QE Regime

3 Simulation Results: Base Scenario and QE Regime

We first assess the stochastic simulation results for T = 10000, in terms of the distributions. Then we take up the event dynamics before and during a crisis event in the stressed country.

We compare the adjustment under the base regime with no quantitative easing, with QE in place in the stressed country and then with the fiscal regime in place in the tranquil non-stressed country, when QE is in use in the stressed country.

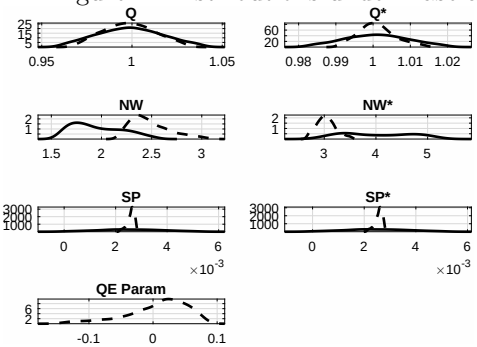
3.1 Stochastic simulation statistics

Figure 3 pictures the distribution of GDP, denoted by Y, as well as two components, Consumption (C) and Investment (INV), as well as the Current Account (for the stressed country). The non-starred variables correspond to the stressed country experiencing the recurring productivity and financial shocks, while the starred variables represent the corresponding variables in the non-stressed country. The solid curves represent the distributions under the Base Regime, with no policy responses, neither in the stressed country nor the non-stressed country. The broken curves represent the distributions under the QE regime in the stressed country.

We see that the adoption of the QE regime in the stressed country has its main effect on the current account, and this on capital flows, between the two countries. There appears to be little or no effect on the overall distributions of real GDP, consumption and investment, after the implementation of the QE regime.

Figure 4 pictures the distributions of the financial-sector variables. These variables are Tobin's Q, net worth of the financial sector (NW), the spread

Figure 4: Distributions under Base and QE Regimes: Financial Sector



Base Regime QE Regime

between the return on capital and the risk-free rate (WP) and the QE parameter ψ_t, denoted by QE Param. As above, the starred variables represent the distributions in the non-stressed country while the non-starred represent the distributions in the stressed country. This is where we see significant differences emerging with the adoption of the QE policy.

We see that the main consequence of adopting the QE policies is to tighten the distributions of Q in the non-stressed country, and the spreads and net worth in both countries. The QE parameter shows high volatility, with high positive vales reaching .2 and low negative values, representing periods of tapering, going to much lower values of .4.

Even though the shocks originate in the stressed country, it should not come as a surprise that these shocks generate variability in financial variables in both countries, given the complete financial integration.

Of course, as noted by Mendoza (2010), what matters more is the adjustment of key variables during crisis period events or dark corners. Comparisons based on overall distributions, over long simulation intervals, do not pick up how different policy regimes affect key variables during extreme events. We then examine how the effects of the QE policy in the stressed country may be offset by policy rules in the non-stressed country, when the economy is in a dark corner.

3.2 Crisis Scenario: Base and QE Regimes

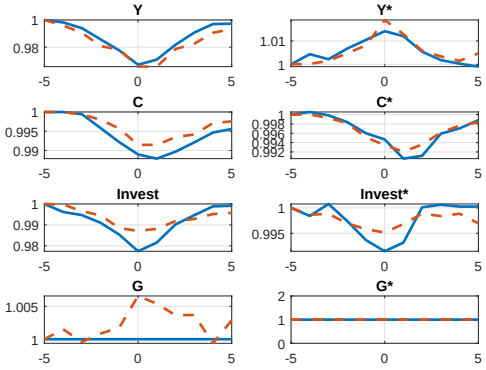
We isolate the crisis periods when the output gap and the net worth index in the stressed country are two standard deviations below its stochastic mean. We then obtain the values of these variables for four years before and four years after the "crisis period" points. We then take each of these variables and normalize them at values of unity for time t*-4 for each crisis episode taking place at time t=t*. The only exception is for the QE parameter and the tax rate parameters. In this case we picture the actual values of these policy parameters before and after the crisis. Blanchard (2014) would call these episodes dark corners. The

adjustment before and after thus represent dark-corner dynamics.

Figure 5 pictures the adjustment of the mean values of GDP, Consumption, Investment, Government Spending. Adjustment under the base policy is shown with the solid curves, while the broken curves represent adjustment with the QE policy rule in place.[5]

What emerges is that the implementation of the QE regime stabilizes consumption slightly in the stressed country, and investment in both countries. It makes little difference for consumption in the non-stressed country. The use of the expansionary QE policy, of course, implies an increase in government spending in the stressed country.

Figure 5: Real Sector Response to Productivity/NW Crisis: Base and QE Regimes



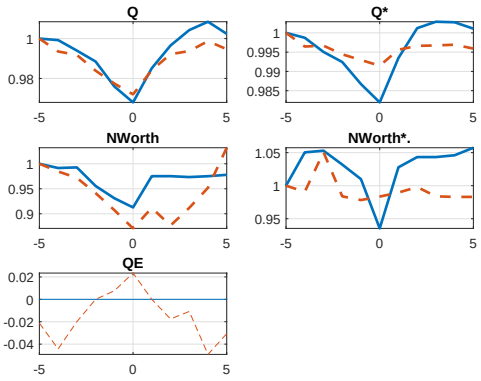
____Base Regime - - - -QE Regime

Figure 6 compares the adjustment of the financial-sector variables, under the Base and QE regimes, for the same set of recurring productivity and incentive-compatibility shocks. As above, the solid curves represent the base case, while the broken curves show the case of the QE policies. We see that the adoption of the QE rule has a stronger effect on Q in the non-stressed country than in the stressed country. The fall in net worth in both countries is curtailed by the use of the QE policy in the stressed country

The overall assessment is that the onset of a crisis coupled with QE policies has quick effects on investment as well as on financial variables in the rest of the world. However, in times of crisis, these policies do little to help consumption in the rest of the world. The benefits are confined to the financial sector in the rest of the world.

[5]The adjustment of each of these variables is relative to the initial position at t-4, not relative to the stochastic mean.

Figure 6: Financial-Sector Response to Crisis: Base and QE Regimes



___ Base Regime - - - -QE Regime

3.3 Crisis Scenario: QE and CFM Regimes

Figure 7 pictures the adjustment of key real-sector variables under the QE regime in the stressed country with no policy rule in non-stressed country, given by the solid curves, and the adjustment with a CFM regime in place in the non-stressed country. The adoption of CFM policies are marginally better at stabilizing investment in the non-stressed country, and the revenue generated by these policies lead to a marginal increase in government spending.

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Figure 8 pictures the adjustment of financial-sector variables under the two regimes. We see that the net effect of the CFM rule is to stabilize net worth in both countries. Not surprisingly, the CFM rule in the non-stressed country is more effective in stabilizing Q in the non-stressed country than in the stressed country.[6] The use of the CFM rule slightly reduces the expansion in QE in the stressed country, since its own net worth is stabilized by the CMF rule abroad.

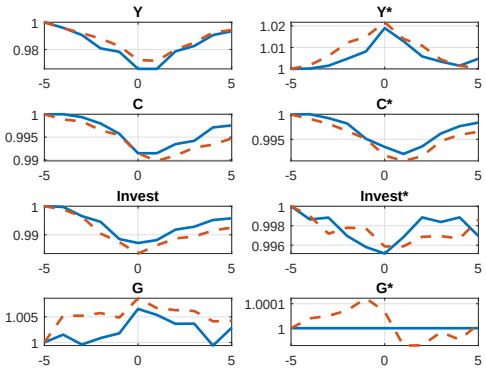
3.4 Crisis Scenario: QE and FR Regimes

Figure 9 pictures the effects of a FR rule for consumption taxes in the non-stressed country. The solid curves, as above, represent the regime with a QE rule in the stressed country without a policy rule in the non-stressed country. We see that the use of consumption subsidy boosts output in the non-stressed country, while its own government spending falls (due to the balanced-budget assumption). The adjustment in the real sector variables in the stressed country remain unchanged.

Figure 10 pictures the adjustment of the financial-sector variables under the

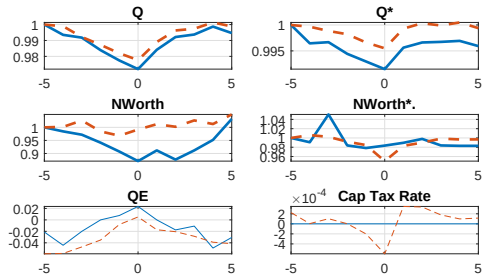
[6]The interest rate is negative, but generates revenue since the capital inflows are negative, and thus represent a fall in net foreign asset position of the non-stressed country.

Figure 7: Real Sector Response to Crisis: QE and CFM Regimes



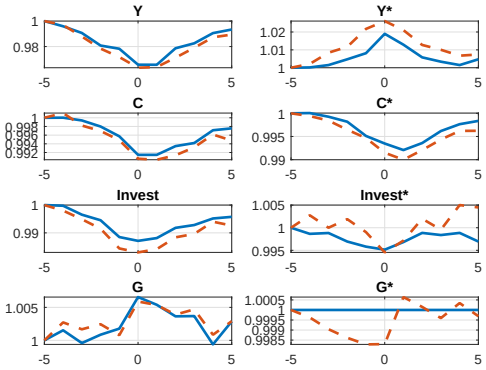
____QE Regime - - - -CFM Regime

Figure 8: Financial Sector Response to Crisis: QE and CFM Regimes



____QE Regime - - - -CFM Regime

Figure 9: Real Sector Response to Crisis: QE and FR Regimes



____QE Regime - - - -FR Regime

two regimes. We see that the use of the consumption tax/subsidy rule makes little or no difference for the stressed-country financial variables, nor for Q in the non-stressed country. The primary effect of the consumption tax-rate rule is to stabilize the financial-sector net worth in its own country. The boom in net worth is curtailed as the consumption subsidy begins. The consumption rule allows the households to hold more deposits in the banking sector, thus stabilizing its net worth.

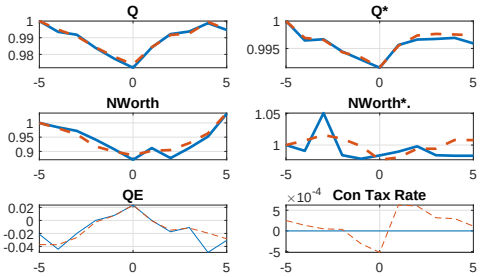
4 Conclusion

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, and lead to expansions in the net worth of the financial sector in the rest of the world. Adopting capital flow management measures in the non-stressed country stabilizes financial sector net worth in both countries in these times of crisis.

In this model with real and financial frictions, but no price stickiness, the CFM regime acts as a real interest-rate rule, affecting intertemporal decisions in both countries. The FR, with a rule on consumption in the non-stressed country, has more limited effects in its own economy.

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 net-worth shocks. Recalling the work of Lahiri et al. (2007a),Lahiri et al. (2007b) our result is another example of turning the Mundell-Fleming conventional wisdom on its head. As these authors point

Figure 10: Financial Sector Response to Crisis: QE and FR Regimes



____QE Regime - - - -FR Regime

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 CFM 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, Swanson (2011), 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 CFM or consumption tax-rate policy rule for stabilization. Capital controls, while at best only temporarily effective, can be administered by financial authorities, without the political overhead of a legislature enacting tax-rate changes r consumption spending. In most parliamentary democracies, tax-rate changes involve a long and cumbersome process, often called the legislative lag, while monetary policy, taking the form of ad-hoc capital controls, can be administered quickly.

For the endogenous tax-rate rules to work effectively, with their limited effects, 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, leading to expansions in financial sector expansion across the world, we can move into a world of quasi-monetary fiscal policy with such endogenous CFM and tax-rate policy rules.

Of course, the results of this study leave aside the question of debt. In our simulations we imposed a rule for balanced budgets on both economies. In the stressed-country, 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 emerge 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.

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