Global implications of national unconventional policies*

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April 2012

1 Introduction

The recent financial crisis has witnessed governments and monetary authorities around the world engage in a number of unprecedented and unconventional policy interventions. Central banks in particular acted aggressively, deploying traditional tools, for instance lowering interest rates, but also introducing extraordinary measures geared towards redressing malfunctioning of financial markets and cushioning national economies from recessionary consequences. These measures included various kinds of credit facilities to ease credit conditions. In some cases, central banks acted directly as intermediaries in dysfunctional markets. For instance, Kosicki, Santor and Suchanek (2011) look at the international record of central bank asset purchases by comparing the dynamics of the balance sheets of major central banks. The Federal Reserve and the Bank of England conducted sizable asset purchases, totalling close to 18 and 12 percent of GDP, respectively, and leading to a dramatic expansion of their balance sheets. The Bank of Japan and the European Central Bank implemented more modest purchase programs. The ECB however greatly expanded its provision of liquidity to the banking sector, far beyond standard short-term maturities, especially after the second half of 2011.

Given the unusual size and scope of these unconventional policies, a fast growing literature has been invaluable in providing an early assessment of their effectiveness, and of their underpinnings in theoretical models (see e.g. the chapter in the Hanbook of Monetary Economics by Gertler and Kiyotaki (2011) and references therein). However, most positive and especially normative analyses of unconventional policy measures have been framed in terms of closed economies, thus neglecting a key aspect of the financial and economic crisis that triggered

*We thank participants in seminars at the Bank of England, the Federal Reserve Bank of Dallas, HEC Montreal and Michigan State. The views expressed here are our own and do not reflect those of the ECB and the Eurosystem.

them: its global reach.[1] At the center of the crisis and its universally widespread repercussions were arguably highly leveraged financial intermediaries: unable to raise funds in money markets to finance their global asset portfolios they were instrumental in the propagation of the collapse in asset prices and the increase in credit spreads (see e.g. Milesi-Ferretti and Tille (2011), Shin (2011)). Recent work e.g. by Perri and Quadrini (2011) and Mendoza and Quadrini (2010) has shown that the combination of financial frictions with international financial integration results in very strong cross-border spillovers especially of financial shocks, in line with the experience of the Great Recession.

In this paper we study the international dimension of unconventional policies in economies featuring financial frictions. We introduce the latter in the form of balance sheet constraints à la Gertler and Karadi (2011, henceforth GK) on financial intermediaries. Financial intermediaries raise funds from households domestically and abroad, and allocate them to domestic and foreign assets, subject to time varying endogenous balance sheet constraints. When the markets for banks' assets (e.g. loans to firms) and liabilities (e.g. short term deposits) are integrated across countries, credit spreads become highly correlated: a shock that brings about a tightening of the balance sheet constraint in one country generates endogenously a tightening of the balance sheet constraint in the other country too. By the same token, a national policy that aims at mitigating the consequences of such an adverse shock, for instance by trying to relax the balance sheet constraint faced by domestic financial intermediaries through purchases of domestic assets, will inevitably benefit foreign intermediaries too. This positive spillover has the potential to generate a free-riding behavior, especially when the unconventional policy measures entail domestic costs, with the risk of a globally suboptimal under-reaction.

In this version of the paper, we first document the international propagation of country-specific real and financial shocks in a flexible price version of the model. We confirm previous results in the literature that with a high degree of financial integration, country specific shocks with a financial origin result in a much greater deal of macroeconomic synchronization across countries than real shocks (such as shocks to capital quality studied by GK).

The differences in macroeconomic volatility and international transmission documented so far may have important implications for the desirability of unconventional policies, and for the optimal degree of international coordination of these policies. We turn to the analysis of these policy implications in the next section.

We then study a set of unconventional policies similar to those analyzed by GK and Gertler, Kiyotaki and Queralto (2011, henceforth GKQ). Government financial intervention is modeled as direct puchases of private assets. Purchases are assumed to be a function of prevailing credit spreads. We study both cooperative and noncooperative policies. Under cooperation, purchases are set to jointly maximize the equally weighted sum of Home and Foreign households life-

[1] The international financial market effects of the US Large-Scale Asset Purchases have been recently documented by Neely (2010). In addition, major central banks established swap lines in foreign currency (see e.g. Goldberg et al. ()).

time utility. Noncooperative (Nash) policies are the result of each government maximizing the domestic agent lifetime utility while taking as given the rule followed by the other country. We find that unconventional policies are generally welfare decreasing against capital quality shocks under both cooperation and Nash. While surprising in light of earlier results in the literature, we argue that such a finding should not be unexpected on the basis of standard second-best reasoning. Conversely, financial shocks should be aggressively offset under cooperation, for the range of cost of intervention that we consider. The Nash outcome features a suboptimal amount of financial market intervention. Due to the positive spillovers generated by the policy, stabilization by one country will also benefit the other one, reducing its incentive to intervene (at a cost) in a classic free-riding problem. However, the resulting welfare losses relative to cooperation are not generally very large, in line with standard results in the literature (see e.g. Obstfeld and Rogoff (2002)).

The structure of the paper is as follows. The next section presents a two-country version of the GK model of financial frictions, under flexible prices. Section 3 documents some properties of the model in terms of the international propagation of real and financial shocks. Section 4 reports on the policy experiments, while the last section concludes.

2 An open-economy version of Gertler and Karadi (2011)

In this section we describe our two-country model economy with financial frictions. The core framework is a standard open-economy model such as Backus et al. (1991), to which we add financial intermediation of fund transfers between households and nonfinancial firms. Intermediation is constrained by an agency problem which limits the ability to raise funds from households. We will focus on the implications of different assumptions about international capital markets for the international transmission of country-specific shocks to the quality of capital and to the financial sector. Absent financial frictions the first shock only causes a small output fall, while the second is obviously inconsequential. Conversely, when financial intermediaries face binding constraints to their activity, both shocks induce a tightening of credit supply and bring about a domestic recession. As we show, when intermediaries operate in integrated deposit and loan markets, both country-specific shocks spillover abroad, causing a global slump. It is against the background of these inefficiencies that there is a potential role of coordinated government interventions in the credit markets. We now proceed to outline the basic ingredients of the model.

2.1 The baseline model

Before introducing financial frictions, we present the basic environment, which is not too different from standard IRBC models with intermediate homogenous goods and investment adjustment costs, such as Backus et al. (1991). The world economy comprises two entirely symmetric countries producing a homogeneous good, and populated by a continuum of infinitely-lived households. Therefore, we abstract from the role of international relative prices. A key difference from Backus et al. (1991), is that we consider incomplete market environments, similarly to Baxter and Crucini (1998), with the obvious difference that we also add financial frictions. In addition to households, there are three types of firms in the model: goods and capital producers, and banks.

Preferences Focusing on the Home country (we will denote with an asterisk '*' the variables in the other, Foreign country), households preferences are quite standard:

$$E_t \sum_{\tau=t}^{\infty} \beta^{\tau-t} \frac{\left[\frac{(C_t - hC_{t-1})}{1-\gamma}^{1-\gamma} - \chi \frac{L_t^{1+\varphi}}{1+\varphi}\right]^{1-\sigma}}{1-\sigma}, \tag{1}$$

where E_t is the expectation operator conditional on date t information and $\beta, \gamma, \sigma, h, \varphi, \chi$ are all positive parameters, with $0 < \beta < 1, 0 < h < 1$. Preferences feature consumption habit formation to enhance consumption dynamics. The above functional form is general enough that, when $\gamma = 0$, preferences are quasi-linear in hours and thus rule out wealth effects on labor supply as in Greenwood, Hercowitz and Huffman (GHH, 1988). Conversely, for $\sigma = 0, \gamma > 0$ the standard utility separable in consumption and labor obtaines.

Technology and production In each country there are a continuum of perfectly competitive firms of unity mass. Each firm produces a homogeneous output using an identical constant returns to scale production function with capital and local labor as inputs. While labor is immobile across countries, we will explore how different degrees of capital markets integration affect the transmission of country specific shocks and the design of cooperative and unilateral unconventional policies.

Output Y_t is a Cobb-Douglas function of capital times its utilization rate $u_t K_t$, and labor hours L_t as follows:

$$Y_t = A_t \left(u_t K_t\right)^{\alpha} L_t^{1-\alpha} \quad 0 < \alpha < 1 \tag{2}$$

where A_t is TFP, which is potentially stochastic following a (country-specific) stationary Markov process.

Let S_t be the aggregate capital stock at the end of period t that could be used for production in period t+1. This capital stock "in process" at t for t +1 is the sum of current investment I_t and the stock of undepreciated capital, $(1 - \delta(u_t))K_t$:

$$S_t = (1 - \delta(u_t))K_t + I_t, \tag{3}$$

where the depreciation rate is allowed to depend on capacity utilization u_t as follows:

$$\delta(u_t) = \delta + \frac{b}{1+\zeta} u_t^{1+\zeta}.$$

Capital in process for period t +1 is transformed into capital for production after the realization of a country-specific multiplicative shock to capital quality, ψ_{t+1};

$$K_{t+1} = \psi_{t+1} S_t \tag{4}$$

The random variable ψ_{t+1} could be thought of as capturing some form of economic obsolescence, as opposed to physical depreciation (Appendix B in Gertler, Kyiotaki and Queralto (2011) working paper version provides microfoundations). Following the finance literature (e.g., Merton (1973)), Gertler and Karadi (2011) consider the capital quality shock as a simple way to introduce an exogenous source of asset price dynamics. Because of adjustment costs, the market price of capital will be endogenous and will respond to the random variable ψ_{t+1}.

Goods producers purchase new capital from capital goods producers. In order to introduce a Tobin's Q motive to obtain a time varying price of capital, as in GK we assume convex adjustment costs in the rate of change in investment goods output. Aggregate world output thus comprises world household consumption $C_t + C_t^*$, world investment expenditures including adjustment costs, and world government consumption $G_t + G_t^*$:

$$\begin{aligned} Y_t + Y_t^* \quad = \quad & C_t + C_t^* + G_t + G_t^* + \\ & I_t + f\left(\frac{(I_t - \delta(u_t) K_t) + I_{ss}}{(I_{t-1} - \delta(u_{t-1}) K_{t-1}) + I_{ss}}\right)(I_t - \delta(u_t) K_t + I_{ss}) + \\ & I_t^* + f\left(\frac{(I_t^* - \delta(u_t^*) K_t^*) + I_{ss}}{\left(I_{t-1}^* - \delta\left(u_{t-1}^*\right) K_{t-1}^*\right) + I_{ss}}\right)(I_t^* - \delta(u_t^*) K_t^* + I_{ss}), \end{aligned} \tag{5}$$

where $f(\cdot)$ reflects convex physical adjustment costs of investment net of depreciated capital, $I_t - \delta(u_t) K_t$, with $f(1) = f'(1) = 0$ and $f"(\cdot) > 0$.

In the absence of financial frictions and with complete international asset markets, the competitive equilibrium would correspond to a solution of the planner's problem that involves choosing aggregate quantities in the two countries $\{(Y_t; L_t; C_t; I_t; S_t; u_t);\ (Y_t^*; L_t^*; C_t^*; I_t^*; S_t^*; u_t^*)\}$ as a function of the aggregate state $\left\{(C_{t-1}; I_{_{t-1}}; S_{t-1}; \psi_t; A_t); (C_{t-1}^*; I_{_{t-1}}^*; S_{t-1}^*; \psi_t^*; A_t^*)\right\}$ in order to maximize the equally weighted sum of the expected discounted utility of the representative households in the two countries, subject to the aggregate resource constraints. This frictionless economy is a useful welfare benchmark against which we may compare the implications of introducing financial frictions and incomplete international markets. In what follows we will introduce financial intermediation of funds between households and non financial firms. We will also introduce financial frictions that may impede credit flows from households to firms within and across countries.

2.2 Households

Following GK, the household sector is modeled in a way that allows to introduce a substantive role for financial intermediation while keeping the tractability of the representative agent approach. Households consume, supply labor and save. They save by lending funds to financial intermediaries (domestically and possibly abroad), and to the government. In particular, there is a representative household with a continuum of members of measure unity. Within the household there are two types of members: $1-f$ "workers" and f "bankers", who pool consumption risk perfectly. Workers supply labor and bring the wage they earn back to the household every period. Each banker manages a financial intermediary (dubbed a "bank") and returns nonnegative profits back to the household subject to its flow of fund constraint. The household thus owns the banks managed by its bankers. It is convenient to assume that households supply funds to domestic (and depending on the degree of international financial integration also foreign) banks other than the the ones they own. Banks can raise funds from households other than their own only by offering noncontingent riskless short term debt ("deposits" D_t). This assumption is important as banks will face constraints in obtaining this kind of external funds. In addition, households may acquire short-term (riskless) government debt (B_t). Both bank deposits and government debt are one period real riskless bonds and thus are perfect substitute, hence paying the same gross real return R_t from t to $t+1$. Furthermore, without loss of generality, we may assume that only domestic residents hold their own government bonds. Clearly, when there is an integrated bank deposit market so that the risk free rate is the same across countries, households can absorb more government debt by reducing their holdings of equivalent domestic and foreign deposits.

The representative household in the Home country chooses consumption, labor supply, riskless debt $(C_t; L_t; D_t + B_t)$ to maximize expected discounted utility subject to the budget constraint,

$$C_t + D_t + B_t = (1+\tau_t)\, w_t L_t + \Pi_t + R_{t-1}\,(D_{t-1} + B_{t-1}) - T_t \qquad (6)$$

Here w_t is the real wage rate, T_t is lump sum taxes, Π_t is net profit distributions from ownership of both banks and capital producing firms, and τ_t is a tax/subsidy on labor (depending on whether it is negative or positive). Let u_{C_t} and u_{L_t} denote the marginal utility of consumption and labor, respectively, and $\Lambda_{t;t+1}$ the household's stochastic discount factor. Then the quite standard household's first order conditions for labor supply and consumption/saving are given by:

$$w_t\,(1+\tau_t) = \frac{u_{L_t}}{u_{C_t}}$$

$$\begin{aligned} E_t\,(\beta \Lambda_{t;t+1})\, R_t &= 1 \\ \Lambda_{t;t+1} &= \frac{u_{C_{t+1}}}{u_{C_t}}. \end{aligned}$$

We want to rule out the possibility that over time bankers do not accumulate enough internal funds that they do not need to borrow to finance their investments. In this case, the financial constraint they face will not be binding anymore. In order to limit bankers' ability to save to overcome financial constraints, GK assume they face a finite horizon. GK assume that with i.i.d. probability $1-\theta$ a bank shuts down next period. This probability is thus independent of the length of tenure as a banker. Despite the fact that the expected survival time $\frac{1}{1-\theta}$ may be quite long, the finite expected horizon induces payouts while the financial constraints are still binding. While every period $(1-\theta)f$ bankers exit and become workers, a similar number of workers randomly become bankers, keeping the fraction of each type constant. Bankers who exit pay out accumulated retained earnings to their respective households. On the other hand, each new banker receives from the household "start up" funds necessary to be able to operate and raise deposits from the other households. As anticipated earlier, Π_t includes net funds transferred to the household, namely dividends payed by exiting bankers minus the funds transferred to new bankers (aside from profits of capital producers).

2.3 Nonfinancial firms

Here we describe the program of the two types of nonfinancial firms: goods producers and capital producers.

Goods producers Firms producing goods for consumption and investment operate a Cobb-Douglas production function (discussed earlier) with capital and labor inputs, under perfect competition. Conditional on their choice of capital, goods producers choose labor and capacity utilization to satisfy

$$W_t = (1-\alpha)\frac{Y_t}{L_t} \tag{7}$$

$$\alpha\frac{Y_t}{u_t} = b u_t^{\zeta} K_t. \tag{8}$$

At the end of period t, a goods producer acquires capital S_t for use in production in the subsequent period in the amount $\psi_{t+1}S_t$. After production, the firm has the option of selling the (depreciated) capital stock on the open market. There are no adjustment costs at the firm level, thus the capital choice problem is static. It follows that we may express *gross* profits per unit of capital Z_t as:

$$Z_t = \alpha\frac{Y_t}{K_t}. \tag{9}$$

Goods producers finance capital purchases each period by obtaining funds from intermediaries against perfectly state-contingent securities.. They face no frictions in obtaining these funds. Banks are efficient at evaluating and monitoring goods producers and also at enforcing contractual obligations with these borrowers. On the other hand, goods producers can commit to pay all the future gross profits to the creditor bank. That is why they rely exclusively on banks to obtain funds. The producer then uses the funds to buy new capital goods from capital goods producers. Each unit of the security issued by the latter is a state-contingent claim to the future returns from one unit of investment (which is best thought of as equity or perfectly state-contingent debt). Through perfect competition, the price of new capital goods is equal to Q_t, the price of the state-contingent securities, and goods producers earn zero net profits. This frictionless funding contrasts with the process of intermediaries in rasing funds from households as they face funding constraints. These constraints, in turn, affect the supply of funds available to nonfinancial firms and hence the required rate of return on capital these firms must pay.

Capital producers Competitive capital producers use final output as input in their activity. On the one hand, they purchase the end-of- period capital stock from goods producers, and then refurbish depreciated capital at a unity cost and sell it back to goods producing firms. On the other hand, they also build new capital, subject to adjustment costs in terms of output, which is sold to goods producers at the price Q_t, as described above. Households are assumed to own capital producers. The objective of a capital producer is to choose I_t to maximize discounted profits:

$$\max E_t \sum_{\tau=t}^{\infty} \beta^{\tau-t} \Lambda_{t;\tau} \left[(Q_\tau - 1)(I_\tau - \delta(u_\tau) K_\tau) - f\left(\frac{(I_\tau - \delta(u_\tau) K_\tau) + I_{ss}}{(I_{\tau-1} - \delta(u_{\tau-1}) K_\tau) + I_{ss}} \right) ((I_\tau - \delta(u_\tau) K_\tau) + I_{ss}) \right].$$

The price of capital goods is thus equal to the marginal cost of investment goods production:

$$\begin{aligned} Q_t &= 1 + f(\cdot) + f'(\cdot) \frac{(I_t - \delta(u_t) K_t) + I_{ss}}{(I_{t-1} - \delta(u_{t-1}) K_{t-1}) + I_{ss}} + \\ &\quad - E_t \beta \left[\Lambda_{t;t+1} \left(\frac{(I_{t+1} - \delta(u_{t+1}) K_{t+1}) + I_{ss}}{(I_t - \delta(u_t) K_t) + I_{ss}} \right)^2 f'(\cdot) \right]; \end{aligned} \tag{10}$$

clearly in the nonstochastic steady state the price of capital will be equal to 1. Note that all capital producers choose the same net investment rate. Because of the flow adjustment costs, capital producers may earn profits outside of the steady state. As explained above, these profits are redistributed lump sum to households.

2.4 Financial intermediaries

Financial intermediaries lend funds obtained from domestic (and possibly foreign) households to domestic (and possibly foreign) goods producers. In doing so they engage in maturity and liquidity transformation, holding long-term, risky assets whose valuation is subject to market fluctuations, against short-term, risk-free liabilities redeemable at face value. They also act as specialists in channeling funds from savers to investors. Thus, financial intermediaries in this model are meant to capture in a stylized way investment banks as well as commercial banks.

In addition to obtaining deposits from households, banks raise funds also internally. The bank has its own net worth — accumulated from retained earnings. The bank then uses all its available funds to make loans to goods producers. As noted above, banks finance goods producers by purchasing state-contingent securities as there are no frictions in dealings between intermediaries and firms. The total value of loans for a bank is equal to the the price Q_t times the number of state-contingent claims s_t^h ($Q_t^* s_t^f$ for loans abroad) on the future returns of a unit of capital at the end of period t in process for $t+1$.

Ignoring at this stage any supply of funds from the government, for an individual bank the value of loans funded within a given period (i.e. $Q_t s_t^h + Q_t^* s_t^f$ when banks can lend to both domestic and foreign firms) must equal the sum of bank net worth (N_t), and deposits raised from households (D_t). The intermediary balance sheet is then given by:

$$\mathcal{W}_t \equiv Q_t s_t^h + Q_t^* s_t^f = N_t + D_t \tag{11}$$

We assume it is prohibitively costly for incumbent bankers to issue equities to bring in new ones with sufficient wealth. Thus, bank's net worth N_t is the gross payoff from loans extended in the previous period, net of interest payments to depositors. Let $R_{k,t}$ ($R_{k,t}^*$) denote the gross rate of return on a unit of the bank's domestic (foreign) loans from $\mathbf{t-1}$ to $\mathbf{t}$:

$$\begin{aligned} R_{k,t} &= \psi_t \frac{[Z_t - \delta(u_t) + Q_t]}{Q_{t-1}}, \\ R_{k,t}^* &= \psi_t^* \frac{[Z_t^* - \delta(u_t^*) + Q_t^*]}{Q_{t-1}^*}. \end{aligned}$$

As described above, since the cost of replacement of depreciated capital is unity, the value of the leftover capital stock is $(Q_t - \delta(u_t))\,\psi_t$. In general returns on loans are country specific, as they depend on the price of capital and on the payoffs, including the quality shocks ψ_t and ψ_t^* and the (potentially) endogenous depreciation rates $\delta(u_t), \delta(u_t^*)$. Then we can express net worth as the difference between earnings on assets and interest payments on deposit liabilities:

$$\begin{aligned} N_t &= \left[Q_{t-1} s_{t-1}^h R_{k,t} + Q_{t-1}^* s_{t-1}^f R_{k,t}^* - R_{t-1} D_{t-1}\right] \\ &= \left[(R_{k,t} - R_{t-1}) - \frac{Q_{t-1}^* s_{t-1}^f}{\mathcal{W}_{t-1}}\left(R_{k,t} - R_{k,t}^*\right)\right]\mathcal{W}_{t-1} + R_{t-1} N_{t-1}, \end{aligned}$$

Any growth in net worth above the deposit rate R_{t-1} depends on the spread over it that the intermediary earns on domestic and foreign assets, as well as the total value of assets $\mathcal{W}_{t-1}$. Recalling that $\beta\Lambda_{t,t+1}$ is the (household) discount factor, due to the assumption of risk pooling within each family, for the intermediary to be profitable to operate in any period it must be that the following hold:

$$\begin{aligned} E_t \beta \Lambda_{t,t+1} \left(R_{k,t+1} - R_t \right) &\geq 0 \\ E_t \beta \Lambda_{t,t+1} \left(R^*_{k,t+1} - R_t \right) &\geq 0. \end{aligned}$$

The bank will not fund assets with a (discounted) rate of return below the borrowing cost. With frictionless capital markets, the above relations holds with equality and the risk-adjusted spreads are always zero. With financial frictions, however, the spread may be positive due to limits on the intermediary ability to borrow.

Given a bank facing financing constraints and thus positive spreads, it is in its interest to invest all its funds and thus retain all earnings until the time it exits. Upon exit, the banker pays out accumulated retained earnings as dividends. Accordingly, the objective of the bank at the end of period t is the expected present value of the future terminal dividends,

$$\begin{aligned} V_t &= \max E_t \sum_{i=0}^{\infty} (1-\theta)\, \theta^i \beta^{i+1} \Lambda_{t,t+1+i} \left(N_{t+i+1} \right) \qquad (12) \\ &= \max E_t \sum_{i=0}^{\infty} (1-\theta)\, \theta^i \beta^{i+1} \Lambda_{t,t+1+i} \Big[\left(R_{k,t+1+i} - R_{t+i} \right) \mathcal{W}_{t+i} - Q^*_{t+i} s^f_{t+i} \left(R_{k,t+1+i} - R^*_{k,t+1+i} \right) \\ &\quad + R_{t+i} N_{t+i} \big] \end{aligned}$$

where θ is the probability of surviving into the next period.

To the extent that the (discounted) spread is positive, the intermediary will want to borrow additional funds from households to expand its assets indefinitely. To motivate an endogenous constraint on the bank's ability to obtain funds, following GK we introduce the following simple agency/moral hazard problem. After a banker obtains funds, he or she may transfer a fraction of assets to his or her family, e.g. by paying out large bonuses or dividends. It is the recognition of this possibility that has (other) households limit the funds they lend to banks. Specifically, at the end of each period a (potentially stochastic) fraction λ_t of available funds can be diverted by the banker. If a banker diverts assets, it is forced into bankruptcy and is shut down. The creditors may re-claim the fraction $(1-\lambda_t)\,\mathcal{W}_t$ of assets. However, it is too costly to recover the remaining fraction of assets $\lambda_t \mathcal{W}_t$.

Concretely, in order for lenders to be willing to supply funds the following incentive-compatibility constraint must be satisfied for each bank

$$V_t \geq \lambda_t \mathcal{W}_t.$$

The right hand side is the gain from absconding with a fraction λ_t of bank assets. The left hand side is what the banker would lose by having to shut down operations as a consequence. The banker's decision over whether to divert funds must be made at the end of the period t but before the realization of aggregate uncertainty in the following period. Here the idea is that if the banker is going to divert funds, it takes time to position assets and this must be done between the periods (e.g., during the night).

Define

$$V_{1,t} = E_t \sum_{i=0}^{\infty} (1-\theta)\,\theta^i \beta^{i+1} \Lambda_{t,t+1+i} \left[(R_{k,t+1+i} - R_{t+i})\, \mathcal{W}_{t+i} - Q^*_{t+i} s^f_{t+i} \left(R_{k,t+1+i} - R^*_{k,t+1+i} \right) \right],$$

or recursively

$$V_{1,t} = E_t \beta \Lambda_{t,t+1} \left\{ (1-\theta) \left[(R_{k,t+1} - R_t)\, \mathcal{W}_t - Q^*_t s^f_t \left(R_{k,t+1} - R^*_{k,t+1} \right) \right] + \theta V_{1,t+1} \right\}$$

Divide through by $\mathcal{W}_t$ and define $v_t = \dfrac{V_{1,t}}{\mathcal{W}_t}$

$$v_t = E_t \beta \Lambda_{t,t+1} \left\{ (1-\theta) \left[(R_{k,t+1} - R_t) - \frac{Q^*_t s^f_t}{\mathcal{W}_t} \left(R_{k,t+1} - R^*_{k,t+1} \right) \right] + \theta x_{t+1} v_{t+1} \right\}$$

where $x_{t+1} = \dfrac{\mathcal{W}_{t+1}}{\mathcal{W}_t}$.

Then, as for the second part of (12) define

$$V_{2,t} = E_t \beta \Lambda_{t,t+1} \left\{ (1-\theta)\, R_t N_{t+1} + \theta V_{2,t+1} \right\}$$

Divide through by N_{t+1} and define $z_{t+1} = \dfrac{N_{t+1}}{N_t}$ and $\eta_t = \dfrac{V_{2,t}}{N_{t+1}}$ and get

$$\eta_t = E_t \beta \Lambda_{t,t+1} \left\{ (1-\theta)\, R_t N_{t+1} + \theta z_{t+1} \eta_{t+1} \right\}$$

Then we can write

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

The incentive constraint becomes (assuming it is binding)

$$v_t \mathcal{W}_t + \eta_t N_t = \lambda_t \mathcal{W}_t$$

or

$$\mathcal{W}_t = \frac{\eta_t}{\lambda_t - v_t} N_t = \phi_t N_t, \tag{13}$$

where ϕ_t is the ratio of bank intermediated assets to bank net worth, which we will refer to as the banking/financial sector leverage. This expression is a key equilibrium feature of the banking sector: It indicates that when the borrowing constraint binds, the total quantity of private assets that a bank can intermediate is limited by its net worth. The relation is intuitive: holding net worth constant, an increase in bank's assets through raising more deposits will reduce the franchise value of the bank and increase the incentives to divert funds.

For positive levels of net worth, the constraint binds only if $\lambda_t > v_t > 0$. When this occurs, the leverage ratio is increasing in two factors which raise the charter value of the bank: v_t, namely the discounted excess value of bank (domestic and potentially foreign) assets; and η_t, the saving in borrowing costs from another unit of net worth. Because both these factors raise the bank's charter value, they reduce the incentives to divert funds, making depositors willing to lend more. Conversely, ϕ_t is decreasing in λ_t, the fraction of funds banks are able to divert. If v_t increases above λ_t the incentive constraint does not bind as the value from intermediation exceeds the gains from absconding with funds. In the equilibria we study the constraint always binds in a neighborhood of the nonstochastic steady state.

We can derive the aggregate evolution of net worth considering that a fraction $(1-\theta)$ exits the banking sector and an equal fraction of bankers enters the banking sector with starting capital of $N_{n,t} = \omega \mathcal{W}_{t-1}$.[2] Aggregate net worth in each country then follows:

$$N_t = \theta \left[\left[(R_{k,t} - R_{t-1}) - \frac{Q^*_{t-1} s^f_{t-1}}{\mathcal{W}_{t-1}} \left(R_{k,t} - R^*_{k,t} \right) \right] \phi_{t-1} + R_{t-1} \right] N_{t-1} + N_{n,t},$$

and

$$N^*_t = \theta \left[\left[\left(R^*_{k,t} - R^*_{t-1} \right) - \frac{Q_{t-1} s^{h*}_{t-1}}{\mathcal{W}^*_{t-1}} \left(R^*_{k,t} - R_{k,t} \right) \right] \phi^*_{t-1} + R^*_{t-1} \right] N^*_{t-1} + N^*_{n,t},$$

where s^{h*}_{t-1} (s^{f*}_{t-1}) represents the amount of loans extended by foreign banks to domestic (foreign) firms.

Finally, market clearing in the loan markets requires that the value of installed capital be equal to funds provided by banks:

$$\begin{aligned} Q_t S_t &= Q_t \left(s^h_t + s^{h*}_t \right) \\ Q^*_t S^*_t &= Q^*_t (s^f_t + s^{f*}_t) \end{aligned}$$

2.4.1 Cross-border financial integration in banking

Here we spell in detail the possible configurations of banking integration across countries we consider in our analysis. On the bank liability side, there are only two possible cases: i) country specific deposit rates, when households are restricted to autarky holding only national deposits (and also governement bonds); ii) a common interest rate, when households can hold deposits with foreign and domestic banks, implying that $R_t = R^*_t$.

On the bank asset side, we can consider the following two cases: i) banks can only lend to firms in their own country; ii) banks can directly lend to firms in either country. In this latter case we can also introduce the possibility that the agency problem could be more severe in case of assets held abroad. This would be the case if the fraction of the latter asset class that can be recovered

[2] Alternatively if want to take into account the change in value, could define the transfer as $\omega \frac{\mathcal{W}_{t-1}}{Q_{t-1} K^D_{t-1} + Q^*_{t-1} K^{D*}_{t-1}} \left(Q_t K^D_{t-1} + Q^*_t K^{D*}_{t-1} \right)$.

by depositors in case of default (say, $1-\lambda_t^f$) is lower than the fraction that can be recovered for assets held domestically (i.e. $1-\lambda_t^h$, with $\lambda_t^f > \lambda_t^h$). As we show below, when assets are symmetric in this dimension (i.e. $\lambda_t^f = \lambda_t^h = \lambda_t$), the composition banks assets is determined according to a standard portfolio choice problem.[3]

Clearly, under complete autarky on both assets and liabilities sides, there will be no linkage across countries, whereas the strength of cross-country interdependence will vary with the other configurations. The closest integration will occur when banks have access to the same funding and lending markets. It is then worthwhile to briefly consider each case in more detail.

Autarky In this case loans to firms abroad are zero by assumption, $s_t^{h*} = s_t^f = 0$. Thus, in terms of the above notation this implies that

$$\begin{aligned} \mathcal{W}_t &= s_t^h Q_t = Q_t S_t \\ \mathcal{W}_t^* &= Q_t^* s_t^{f*} = Q_t^* S_t^*. \end{aligned}$$

Cross-border loans and bank portfolio choice When the incentive constraint for the bank is the same as above,

$$V_t \geq \lambda_t \left(Q_t^* s_t^f + s_t^h Q_t \right) = \lambda_t \mathcal{W}_t,$$

namely it does not differentiate between assets held domestically and abroad, the problem of the Home representative banker can be re-written as follows

$$\max E_t \sum_{i=0}^{\infty} (1-\theta)\,\theta^i \beta^{i+1} \Lambda_{t,t+1+i} \left[\left[(R_{k,t+1+i} - R_{t+i}) - \alpha_{t+i}^P \left(R_{k,t+1+i} - R_{k,t+1+i}^* \right) \right] \phi_{t+i} + R_{t+i} \right] N_{t+i},$$

[3] We could also consider an intermediate case, in which banks in the two countries can trade capital claims at a unique price (similarly to the setting in e.g. Mendoza and Quadrini (2010)). In this case banks can buy and sell to each other capital claims, so that capital is effectively perfectly mobile across countries. Therefore, its price will be equalized across countries ($Q_t = Q_t^*$), and the market clearing condition would be:

$$Q_t (S_t + S_t^*) = \mathcal{W}_t + \mathcal{W}_t^* = Q_t (s_t + s_t^*).$$

However, as the capital purchased by each bank can only be rented out to domestic firms, returns will be country specific. Namely, domestic and foreign banks earn respectively:

$$\begin{aligned} R_{k,t} &= \psi_t \frac{[Z_t - \delta(u_t) + Q_t]}{Q_{t-1}}, \\ R_{k,t}^* &= \psi_t^* \frac{[Z_t^* - \delta(u_t^*) + Q_t]}{Q_{t-1}}. \end{aligned}$$

While the price of capital is the same, returns are different as in general $Z_t \neq Z_t^*$ and $\psi_t^* \neq \psi_t$.

where $\alpha_t^P = \dfrac{Q_t^* s_t^f}{\mathcal{W}_t}$ is the share of foreign assets in the bank's portfolio. Then the FOC with respect to the portfolio share is

$$\alpha_t^P : E_t \left\{ -(1-\theta)\beta\Lambda_{t,t+1}\left(R_{k,t+1} - R_{k,t+1}^*\right)\phi_t N_t + \right.$$
$$(1-\theta)^2 \beta^2 \left(\Lambda_{t,t+1}\right)^2 \frac{\eta_t}{\left(\lambda_t - v_t\right)^2}\left(R_{k,t+1} - R_{k,t+1}^*\right)\left[\left(R_{k,t+1+i} - R_{t+i}\right) - \alpha_{t+i}^P\left(R_{k,t+1+i} - R_{k,t+1+i}^*\right)\right] N_t = 0$$

or

$$\alpha_t^P : E_t \left\{ \Omega_{t+1}\left(R_{k,t+1} - R_{k,t+1}^*\right)\right\} = 0 \tag{14}$$

where

$$\Omega_{t+1} \equiv \left((1-\theta)\beta\Lambda_{t,t+1}^2 \phi_t \eta_t^{-1}\left[\left(R_{k,t+1} - R_t\right) - \alpha_t^P\left(R_{k,t+1} - R_{k,t+1}^*\right)\right] - \Lambda_{t,t+1}\right)$$

can be thought of as the intermediary discount factor, which will differ from the household one because of the presence of financial frictions.

From (14) we have that up to first order:

$$E_t\left(R_{k,t+1} - R_{k,t+1}^*\right) \simeq 0$$

so that the portfolio is indeterminate. Notice that the foreign country will have an equivalent condition, i.e.

$$E_t\left\{\Omega_{t+1}^*\left(R_{k,t+1} - R_{k,t+1}^*\right)\right\} = 0.$$

By taking the difference between home and foreign asset-pricing equation we have

$$E_t\left\{\left(\Omega_{t+1} - \Omega_{t+1}^*\right)\left(R_{k,t+1} - R_{k,t+1}^*\right)\right\} = 0 \tag{15}$$

We can find the steady-state portfolio by choosing α^P that makes condition (15) hold true, up to second order of approximation (see Devereux and Sutherland (2007) and Tille and van Wincoop(2008)). The first order dynamics of the model are affected only by this constant portfolio.

Finally, notice that from the bank first order conditions we have that:

$$\begin{aligned} E_t\left\{\Omega_{t+1}\left(R_{k,t+1} - R_t\right)\right\} &= v_t \\ E_t\left\{\Omega_{t+1}^*\left(R_{k,t+1}^* - R_t^*\right)\right\} &= v_t^*, \end{aligned}$$

as v_t and v_t^* represent the discounted excess value of bank assets, and

$$\begin{aligned} E_t\left\{\Omega_{t+1}\right\} R_t &= \eta_t \\ E_t\left\{\Omega_{t+1}^*\right\} R_t^* &= \eta_t^*, \end{aligned}$$

as η_t and η_t^* represent the saving in deposit costs from another unit of net worth. Therefore, when domestic and foreign banks face the same deposit rate $R_t = R_t^*$ and can lend across borders ($E_t\left(R_{k,t+1} - R_{k,t+1}^*\right) \simeq 0$), we will have that up to first order, $v_t \simeq v_t^*$ and $\eta_t \simeq \eta_t^*$. In turn this implies that also leverage ϕ_t and ϕ_t^* will be equalized up to first order, net of variations in λ_t and λ_t^*. As we illustrate in the next section, this equalization of the endogenous leverage ratio is a crucial cross-border propagation mechanism in this model of financial frictions. As already argued by Dedola and Lombardo (2012), this property is not unique of this specific framework of financial frictions but it is shared by many others (see e.g. Devereux and Yetman (2011), Perri and Quadrini (2011)).

2.5 Government

Government expenditures, denoted G_t, include (constant) government consumption G and the potential resource costs Γ_t incurred in undertaking unconventional policies such as government purchases of private assets. We denote the outflow due to unconventional policies with AP_t. These outflows are financed through one-period riskless bonds (B_t) held by domestic households, and (lump-sum and potentially distortionary) tax revenues T_t and $\tau_t\left(1-\alpha\right)Y_t$:

$$G+\Gamma_t+R_{t-1}B_{t-1}+\tau_t\left(1-\alpha\right)Y_t+AP_t=T_t+B_t+\mathcal{L}_t, \tag{16}$$

where recall that $\tau_t \lesseqgtr 0$, depending on whether it is a labor tax or a subsidy. A further source of (net) revenues, L_t, denotes gains or losses from unconventional policies. In Section 4 we will specify functional forms for AP_t, L_t and Γ_t depending on the kind of financial market policy we will consider.

3 The international transmission of real and financial shocks

In this section we present impulses responses from the model log-linearized around the steady state, focusing on two kinds of country-specific shocks to the Home country: a real negative shock to the quality of capital, and an unexpected increase in the agency cost parameter λ_t. The first kind of shock is used in a closed economy setting by GK and GKQ to mimick the effects of a "financial crisis"; financial shocks are studied in two-country models by Perri and Quadrini (2011) and Dedola and Lombardo (2012) — the latter look at net-worth and premium shocks in a financial accelerator model) to generate a global recession similar to that observed in 2008-2010 (see Imbs (2011).

The stories relating the two shocks to the genesis of the recent financial crisis are as follows. The quality shock can be interpreted as implying that the crisis was really precipitated by the sudden realization that much of the capital (e.g. housing) installed before its inception was of lower quality and much less productive than previously thought. Interestingly, this view implies that because the shock is "efficient" as it shifts inwards the production function, potential output in the aftermath of the crisis is also lower, although not as low as actual output because of financial frictions. Any policy intervention should not result in complete output and employment stabilization in this case.

Conversely, the shock to the recoverability of bank assets λ_t could be viewed as involving a loss of confidence in the financial sector, for depositors believe that it is more attractive for bankers to abscond funds and thus default — Perri and Quadrini (2011) actually show how to obtain a sunspot shock to the loan-to-value ratio in a related setting when financing constraints are occasionally binding. Banks respond by restricting both the amount of deposits and loans that they issue out of a fear that depositors would lose confidence and take their money elsewhere. Depositors would do so in the (correct) anticipation that too high a level of bank leverage would cause bankers to abscond with bank assets. From this perspective, a sharp cut in loans that lowers current asset prices and increases banks' expected returns to some extent allays the fears of depositors by raising banks' expected profits and providing bankers with an incentive to continue doing business normally. However, the contraction in deposits and loans (often referred to as *deleveraging*) precipitates a credit crunch, a contraction in investment and a recession. Clearly, this shock is totally inefficient, and it could turn out to be optimal to stabilize output and employment, particularly if this policy course involved no other cost.

The implications for the international propagation of the shocks of different degrees of financial and banking integration are stark. The key point is that while the idiosyncratic capital quality shock cannot generally induce a truly global recession, the financial shock instead does bring about a very high degree of macroeconomic synchronization across countries when both deposits and loans markets are integrated. On the other hand, under the latter shock financial flows such as bank assets and deposits always display negative international comovements. These variables instead can be highly correlated across countries in the wake of capital quality shocks when banks hold diversified asset portfolios with a sizable amount of loans abroad. These results thus confirm those in Dedola and Lombardo (2012) and Perri and Quadrini (2011) for TFP shocks vis-á-vis financial shocks, and extend them to capital quality shocks.

3.1 Parameterization

In this subsection we first present our first pass parameterization of the economy and of the shocks, shown in Table 1. Most are quite standard preference and technology parameters, for which we use fairly common values in line with the values used in GK. Indeed a feature of our model is that, assuming a steady state with zero net foreign assets, we do not need to use any open-economy information to calibrate it. However, when we introduce the possibility for banks to hold a diversified portfolio of assets, we can in principle compare the proportion of domestic and foreign assets held by the banking sector in its portfolio with its counterpart in the data.

We set $\sigma = 0$ and $\gamma = 1$, implying that at this stage we use a standard separable utility function with logarithmic consumption, rather than one with GHH preferences. Moreover, in this version we assume that utilization and thus depreciation are constant, departing from GK. Parameters for Frisch elasticity, time rate preference, and for the capital share in production and investment adjustment costs are standard.

The parameters specific to the model are those shaping financial frictions and the properties of the two shocks we consider. Following GK, we first set the survival probability θ so that the implied average banker's tenure is around 8 years. Second, the values of λ in the nonstochastic steady state, and the value of ω, determining the start up transfer to new bankers are set to target the following values: the spread earned by banks on their assets over deposits is set to be 100 basis points per year, whereas the leverage ratio ϕ is set to 4. Moreover, in the steady state the incentive constraint is binding with equality. Finally, the two shocks to ψ and λ are assumed to follow country-specific, uncorrelated AR(1) processes with autoregressive coefficients equal to 0.66 and 0.8, respectively, and the same standard deviation of innovations, set to 0.05. The parameterization for the capital quality shock is the same as in GK. The parameterization for the lambda shock is such that a one standard deviation shock yields a similar impact response of the spread as the capital quality shock. Notice that the empirical evidence seems to attribute most of the variation in credit spreads to shocks specific to the financial sector and unrelated to the rest of the economy (e.g. see Gilchrist et al. (2009)).

3.2 Impulse response analysis

In this version we focus on results for the case of full financial integration, in which both loan and in deposit markets are integrated. As a result, there is a common risk-free rate and returns on loans are equalized ex-ante, up to first order of approximation, as explained above. However, at this stage we set the bank portfolio weight of loans abroad arbitrarily close to 0, implying a high degree of home bias, rather than at its optimal level. Therefore, all the propagation will stem from return equalization. As it will be clear below, this choice has no implications for the financial shock, which acts as a common shock. Moreover, at this stage we only look at one shock at the time, for which the optimal portfolio choice would not be particularly meaningful. In future versions we plan to document more extensively the features of international transmission under different degrees of financial integration and with optimal portfolio shares.

Figure 1 and 2 present responses of selected variables to one standard deviation shocks to capital quality ψ and to the financial friction parameter λ. Importantly, in these experiments we assume there is no policy in place to stabilize financial markets in response to the shocks. This is exemplified by the zero response of the share of government intermediation.

Capital quality shock Starting first with the negative ψ shock in the Home country in Figure 1, it is clear that this shock brings about a deep and persistent recession, in line with earlier results in GK and GKQ. Highly leveraged banks are quite susceptible to the effects on their net worth of the declines in domestic asset values (Tobin's Q) and returns caused by the unexpected decline in capital quality. As a consequence, in the wake of the shock, the spread jumps by over (annualized) 200 basis points and their total loans (assets) fall dramatically. This in turn increases the cost of capital, which leads to a sharp contraction in domestic investment , output and employment . The trough contraction in domestic output is in excess of 5 percent, that in investment over 10 percent, both much larger than it would be in the case without financial frictions. The difference of course is due to the sharp widening of the spread that arises in the model with financial frictions. The spread further is slow to return to its steady state value as it takes time for banks to repair their balance sheets and rebuild their net worth — with the latter dropping by almost a half on impact. As net worth falls more than bank assets, leverage has to increase. The economy is thus recovers slowly: after 12 quarters output is still around 4 per cent below its steady state value. The decline in output and investment is accompanied by a fall in consumption . Also the risk-free rate falls, contributing to widening the spread over the return on investment.

Concerning the spillover to the foreign country (F), the forces of financial integration bring about an increase in the spread which, has explained above, has to be the same as in the Home country (and thus it is not shown in the chart). Note that as result leverage is also endogenously equalized across countries. However, the same increase in the spread transpires into a smaller fall in investement, as the Foreign economy is not experiencing any exogenous reduction in the capital stock. Moreover, employment and output instead rise persistently, while the increase in asset prices is short lived. Foreign consumption mimicks the fall in domestic consumption, implying that the Home country runs a current account deficit. This allows it to cushion the negative consequences of the shock in the Home country, in comparison to what would happen in closed economy. As Foreign bank are assumed to lend essentially to local firms only, their net worth and thus their assets increase, to some extent thus replacing Home banks in lending to Home firms. It is important to stress that the different behavior of Home and Foreign net worth and bank assets is a direct consequence of the assumed cross-border composition of their assets. The more diversified internationally their loans portfolios, the more similar the behavior across countries of these financial quantities would be, with little impact however on macroeconomic outcomes. Therefore, while the price effects due to financial integration result in synchronization of credit spreads regardless of the share of assets held abroad, the latter mainly affects the international synchronization in financial quantities, when the shock has asymmetric effects across countries.

This version of the model with financial frictions thus displays an international transmission remarkably similar to frictionless models, particularly concerning the so-called "quantity" puzzle (see Backus, Kehoe and Kydland (1994). Namely, output and employment comove negatively across countries conditonal on the capital quality shock, whereas they tend to be positively (unconditionally) correlated in the data. The correlation in cross-country consumption has the right sign but is counterfactually stronger than correlation of output. Notably, this result occurs in a model with incomplete markets and financial frictions, in contrast with the standard result obtained in frictionless, complete-market economies. The introduction of financial frictions result in a deeper recession in the country experiencing the negative capital quality shock, yet this is not enough to generate a global recession despite the global increase in the credit spreads.

Financial shock Figure 2 reports the impulse responses for an adverse (positive) shock to λ_t in the Home country. In contrast with the results above, this idiosyncratic shock now brings about a recession perfectly synchronized across countries. As discussed above, the confidence loss in the Home intermediaries due to the perceived increase in their incentives to run away with assets sets in motion a process of reduction of intermediation, leading to a fall in the amount of deposits and thus also of loans that they can issue. While the spread they require has to go up to restore the viability of their business, the disintermediation process puts downward pressure on the price of domestic capital. However, because of the tendency to equalization due to financial integration, the climb in the Home spread has to be matched by an equivalent climb abroad. This requires a fall in Foreign asset prices and the result is a global slump in investment, employment, consumption and output which are all perfectly synchronized across countries. However, while the spread is equalized, the (ϕ measure of) bank leverage differs across countries, reflecting the (exogenous) difference in λ_t and λ_t^*, as discussed in the previous section. Foreign leverage has to increase by more than Home leverage, and this can only occur if Foreign banks raise deposits and loans abroad. Since there is no current account deficit, these flows are completely offset by reductions in deposits and loans of Home banks to Home firms. Therefore, the perfect synchronization in credit spreads and macroeconomic variables is not associated with an equally perfect synchronization in banks asset and liabilities, as argued by Perri and Quadrini (2011). These results are independent of the composition of banks assets between domestic and foreign loans. As it should be clear from the above results concerning their transmission, financial shocks effectively act as a global factor, implying that the bank portfolio composition is irrelevant, including for welfare. The assets in our world economy provide no hedge against this kind of aggregate risk.

Finally, it is important to stress also the different magnitude of the responses to the capital quality shock relative to the financial shock: despite the similar dynamics in credit spreads, the latter have smaller macroeconomic repercussions — Gilchrist et al. (2009) obtain similar results in an estimated DSGE model á la BGG when comparing the effects of shocks to the premium with those of shocks to net worth. The differences in macroeconomic volatility and international transmission documented so far may have important implications for the desirability of unconventional policies, and for the optimal degree of international coordination of these policies. We turn to the analysis of these policy implications in the next section.

4 Cooperative and self-oriented unconventional policies

We present (preliminary) numerical experiments with a view to illustrate how unconventional policies might work to mitigate consequences of shocks in open economies, depending on their degree of international coordination. Intuitively, the presence of financial frictions transpire into two inefficiencies which can be consequential for welfare. First, fluctuations in the spread in response to both financial and capital quality shocks may induce excessive volatility relative to the efficient equilibrium without financial frictions, depressing welfare. Second, the long run level of key variables such as the capital stock, consumption and hours could be distorted because of the presence of financial frictions. In particular, we know that the level of these variables in the nonstochastic steady state is inefficient as we assume that the financial constraint is binding. However, what is relevant for (unconditional) welfare is the level of variables in the *stochastic* steady state, and this will also be affected by volatilities. Consistent with the binding incentive constraint, we restrict policies to be ineffective in the nonstochastic steady state, so that benevolent policymakers cannot do anything directly about this source of distortions. On the other hand, the policy tools we consider will affect second moments, and thus in the stochastic steady state they can impinge on both the level and the volatility of variables. In doing so policymakers will face a trade-off to the extent that a reduction in volatility of endogenous variables may result in higher average distortions, such as the average credit spread in the stochastic economy. But in our second-best environment, the opposite could also happen, namely that volatility-reducing policies also reduce the average level of distortions. Therefore, there is no ground to a priori expect that unconventional policies are desirable, making our analysis somehow nontrivial.

Finally, some discussion about the welfare metric we use is in order. We measure welfare consequences of the different policies looking at unconditional measures, as in GKQ.[4] This approach represents an important difference from GK, who instead consider welfare *conditional* on the realization of an adverse shock under perfect foresight. This means that the class of policies we consider should be thought of as being in place regardless of the sign and size of the shocks and their effects on credit spreads. Therefore, if one is interested in the welfare consequences of unconventional policies in response to adverse shocks that increase credit spreads, our results would give a lower bound. Therefore, they will be useful to the extent that we find that these policies are unconditionally welfare improving.

[4] While we share the same unconditional welfare measure with GKQ, we differ in the way we compute it. We use a standard second order approximation around the *nonstochastic* steady state, as e.g. in Benigno and Woodford (2003), which is valid for the small shocks we consider. GKQ instead use a different approach and compute a second order approximation around the *stochastic* steady state (see the appendix in their working paper version).

4.1 Asset purchases

Here we analyze the impact of outright public asset purchases (or direct lending to nonfinancial firms) as a mean to mitigate the negative consequences of shocks. Following GK and GKQ, we assume that governments in each country can intermediate a fraction φ_t of the overall *domestic* funding needs: in terms of the flow budget constraint in Section 2.5, at each point in time government net asset purchases are set so that $AP_t = \varphi_t Q_t S$. This implies that we need to amend the market clearing conditions for capital as follows:

$$\begin{aligned} (1-\varphi_t) Q_t S_t &= Q_t \left(s_t^h + s_t^{h*}\right) \\ (1-\varphi_t^*) Q_t^* S_t^* &= Q_t^* (s_t^f + s_t^{f*}). \end{aligned}$$

in turn, the fraction φ_t of private assets intermediated by the government is adjusted as a function of the difference between the spread $E_t\left(R_{k,t+1} - R_{t+1}\right)$ and its steady state value. Namely in the Home country we assume that:

$$\varphi_t = \kappa \left[E_t \left(R_{k,t+1} - R_{t+1}\right) - (R_k - R)\right].$$

On the one hand, this policy rule is consistent with the presumption that fluctuations in the spread brought about by financial shocks are inefficient in the model. Moreover, a large increase in the credit spread between the expected return on capital and the riskless interest rate is an indicator of financial distress in response to adverse shocks. On the other hand, the rule captures the fact that central banks took action carrying out unconventional policies in response to the emergence of abnormal credit spreads in various financial market segments.

Given our interest in evaluating the consequences from coordinated vs unilateral unconventional policies, we model the policy decision making about the intensity of the reaction to spread fluctuations as follows. In the cooperative equilibrium, the parameters κ and κ^* are jointly chosen to maximize the equally weighted sum of Home and Foreign households lifetime utility, as to fully internalize any policy spillovers across countries. Conversely, we model noncooperative policies by assuming that each government maximizes the domestic agent lifetime utility while taking as given the rule followed by the other country. The equilibrium is thus the Nash outcome. In both cases we use a standard second-order approximation about the nonstochastic steady state to lifetime utility and the model equilibrium conditions to evaluate *ex-ante* global and national welfare for each value of κ and κ^*.

4.1.1 Cost of intervention and government budget constraint

In the benchmark case, the government finances its net asset purchases $\varphi_t Q_t S_t$ through government bonds held by households. It also finances its other expenditures through lump-sum taxes, implying the following flow budget constraint:

$$G + \Gamma_t + \varphi_t Q_t S_t = T_t + \left(R_{k,t} - R_{t-1}\right) \varphi_{t-1} Q_{t-1} K_{t-1}. \tag{17}$$

It is important to stress that the government policy we consider is such that the so-called Barro-Wallace irrelevance proposition does not apply (see Christiano and Ikeda (2011)). This is so because the government is assumed to be able to purchase private assets without being subject to the same incentive constraint as banks, while raising fund at the same risk-free rate. The government would make extra returns from this policy since the credit spread is positive.

We discussed earlier the possibility that this class of policies may not be optimal in this second best environment, despite the assumed asymmetry in favor of the government. Nevertheless, as a further counterweight we also introduce a cost Γ_t that, as in GKQ, is quadratic in the size of the purchases $\varphi_t Q_t S_t$:

$$\Gamma_t \equiv \tau_1 \varphi_t Q_t S_t + \tau_2 \left(\varphi_t Q_t S_t\right)^2 . \tag{18}$$

This is parameterized assuming $\tau_1 = 0.0001$, and $\tau_2 = 0.001$, The formulation of these costs as (wasteful) government expenditures which absorb output implies they cannot be readily interpreted as reflecting an increase in sovereign borrowing costs due to a rise in government debt – the latter would show as a transfer directly to households. Rather, the interpretation is in terms of resource costs stemming from the public activism in private financial markets.

Alternatively, as suggested by Gertler and Kiyotaki (2011), we may model these costs as implying the need to raise part of the funds through distortionary taxes to keep government debt from increasing too much according to some (exogenous) rule. For instance, if we assumed a balanced budget each period we would have the following formulation:

$$G + \varphi_t Q_t S_t = R_{k,t} \varphi_{t-1} Q_{t-1} K_{t-1} + \tau_t \left(1-\alpha\right) Y_t + T_t, \tag{19}$$

where again $\tau_t \lesseqgtr 0$, depending on whether it is a labor tax or a subsidy.

4.2 Liquidity facilities

The above policy of private asset purchases could be thought of as a good first order approximation of measures taken by the Federal Reserve System. As an alternative policy more in line with what central banks like the ECB have done, we could think of the government providing loans $\mathcal{D}_t$ directly to banks at a rate R_t^g, leading to the following modification of the intermediary flow of funds constraint:

$$\mathcal{W}_t = Q_t s_t^h + Q_t^* s_t^f = N_t + D_t + \mathcal{D}_t .$$

Assuming that only the fraction $\left(1-\lambda^g\right)\lambda_t$ of assets purchased with government loans $\mathcal{D}_t$ to banks can be diverted:

$$V_t \geq \lambda_t \left(\mathcal{W}_t - \lambda^g \mathcal{D}_t\right), \tag{20}$$

where $0 < \lambda^g \leq 1$ and $\lambda_t \left(1-\lambda^g\right) < \lambda_t$, Gertler and Kiyotaki (2011) show that the rate R_t^g should be set according to the following equation:

$$E_t \left\{\Omega_{t+1} \left(R_{k,t+1} - R_t^g\right)\right\} = \left(1-\lambda^g\right) v_t, \tag{21}$$

The assumption $\lambda_t (1 - \lambda^g) < \lambda_t$ can be rationalized with a superior power by the government to recover the funds in case of bank default. Intuitively, because borrowing public funds allows a bank to expand assets by a greater amount than private deposits, it is willing to pay a premium over the latter.

Assuming the incentive constraint binds, bank assets will be now proportional to net worth and government deposits according to

$$\mathcal{W}_t = \phi_t N_t + \lambda^g \mathcal{D}_t, \tag{22}$$

while the evolution of bank's net worth is given by:

$$\begin{aligned} N_t &= Q_{t-1} s_{t-1}^h R_{k,t} + Q_{t-1}^* s_{t-1}^f R_{k,t}^* - R_{t-1} D_{t-1} - R_{t-1}^g \mathcal{D}_{t-1} \qquad (23) \\ &= \left[(R_{k,t} - R_{t-1}) - \frac{Q_{t-1}^* s_{t-1}^f}{\mathcal{W}_{t-1}} \left(R_{k,t} - R_{k,t}^* \right) \right] \mathcal{W}_{t-1} - \left(R_{t-1}^g - R_{t-1} \right) \mathcal{D}_{t-1} + R_{t-1} N_{t-1}, \end{aligned}$$

where recall that the term $\left(R_{t-1}^g - R_{t-1} \right)$ is positive. In turn, the amount of government funds can be determined according to a feedback rule similar to the one for asset purchases:

$$\begin{aligned} \mathcal{D}_t &= \delta_t Q_t S_t \\ \delta_t &= \kappa_\delta \left[E_t \left(R_{k,t+1} - R_t \right) - \left(R_k - R \right) \right], \end{aligned} \tag{24}$$

resulting in the following obvious modification of the government budget constraint:

$$G + \Gamma_t + \delta_t Q_t S_t = T_t + (R_{k,t} - R_{t-1}) \delta_t Q_{t-1} K_{t-1}. \tag{25}$$

There is an interesting relation between the policy of asset purchases described above and the liquidity provisions. The former can be thought of as a policy of direct lending to banks at a (state-contingent) rate $R_{k,t+1}$, under the assumption that assets bought with public funds cannot be diverted by intermediaries ($\lambda^g = 1$). In future versions of the paper we will analyze these alternative funding and intervention policies for values of $0 < \lambda^g < 1$.

4.3 Results for unconventional policies: Asset purchases

4.3.1 Capital quality shocks

Here we report (preliminary) results for both capital quality and financial shocks. Starting first with the quality shock, we find that asset purchases lead to a *fall* in unconditional welfare unless they are not only implausibly large but also inconsistent with the model. This result is the same whether we look at cooperative or unilateral policies, and emerges even in the case of a closed economy setting.

To focus ideas, Table 2 shows how the unconditional expectations of Home welfare and of selected Home variables change with $\kappa = \kappa^*$ for a case in which there is no cost of purchases ($\Gamma_t = 0$, as shown in the second column before the last).[5] Unconditional expectations are reported in deviations from their steady state counterparts. For instance, for $\kappa = 0$, the case of no intervention, the average capital stock (E(K)) in the third column is lower than in the nonstochastic steady state. Two results stand out. First, unconditional welfare (in the second column) is higher in the stochastic economy than in the nonstochastic economy. The average level of consumption is higher, that of hours lower, despite the fact that the average spread (premium) is also higher, and obviously its volatility is positive. Therefore, in this economy volatility of the spread per se is not welfare decreasing, pointing to the fact that the unconventional policies geared towards its reduction will not necessarily be welfare improving. The second result in the table support this observation: unconditional welfare decreases and stays below the case $\kappa = 0$ reflecting decreasing values of consumption and of the capital stock. This is so even though both the average spread and its volatility fall when κ rises.[6]

These results are derived assuming away the costs of intervention. Introducing the latter can only reinforce them, given that the costs are increasing in κ. Therefore, we conclude that under both cooperation and Nash is ex-ante optimal not to implement asset purchases in response to capital quality shocks.

These findings are different from those in GK. Preliminary analysis shows that what seems to matter are the different assumptions on nominal prices, as GK consider sticky prices under a conventional Taylor rule. Conversely, the case of flexible prices studied in this paper would correspond in their model to a policy of price stability.[7] On the other hand, it is also important to stress that our results are silent on the question of whether asset purchases would be optimal if deployed against negative shocks that increase the credit spread. The local methods we adopt are not immediately suited to analyze this case. It will be interesting to look at these issues in future versions of the paper.

4.3.2 Financial shocks

Turning to financial shocks, the main finding is that moderate asset purchases can be welfare improving. Therefore, unless associated costs are large, under cooperation global welfare is in general maximized by positive values of the rule coefficients κ and κ^*. Conversely, under Nash the degree of intervention is generally lower and could happen that in equilibrium $\kappa = \kappa^* = 0$, resulting in lower welfare than in the cooperative solution. However, welfare differences will be generally small.

Table 3 and Figure 3 illustrate these results for the benchmark cost parameterization. In this case, we find that under Nash $\kappa = \kappa^* = 0$, while under cooperation $\kappa = \kappa^* = 360$. Consider first Table 3. Similarly to Table 2, it shows

[5] Because $\kappa = \kappa^*$, the two economies are symmetric, so we do not need to report Foreign variables.

[6] We consider values of κ that implies a government intermediation share below 100%.

[7] Our results are also different from those in GKQ with flexible prices, but there are several differences in the respective environments, as for instance they assume a different form of investment adjustment costs. Moreover, as discussed above they also use a different approach to compute the second order approximation to their model.

unconditional averages as a function of $\kappa = \kappa^*$. In contrast to Table 2, when $\kappa = \kappa^* = 0$ welfare is lower than in the nonstochastic economy: consumption is lower, the spread is higher and obviously its volatility is nonzero. While welfare is initially decreasing in κ as before, it start increasing again for relatively small values as the spread volatility falls quickly, along with its average. Because of the associated increasing costs, welfare start decreasing again when the intermediation fraction becomes larger. As a result, there is a well defined maximum for under cooperation. Both the capital stock and consumption are larger under the cooperative rule parameters than under Nash, more than compensating for the higher labor effort. The spread is close to nonstochastic steady state level and its volatility is basically zero. However, welfare gains are relatively small.

The difference between the Nash and the cooperation outcome is the result of a classic free-riding problem: because asset purchases in the other country entail positive spillovers, they reduce the incentive to undertake costly asset purchases domestically. The result is underprovision of financial stabilization at the global level, for the assumed cost parameterization. The severity of the free-riding problem, and the resulting degree of relative policy inaction, depends on the interplay between the costs of public intermediation and the non-monotonic shape of welfare. In the limit with zero costs the Nash and cooperative policy rule will coincide with the maximum amount of intermediation allowed. Increasing the intermediation costs will decrease the rule coefficients in both cases, but proportionally more for the Nash equilibrium. At some point the Nash rule coefficients will show a discrete change and jump to zero, while they will be still positive under cooperation. Further costs increases will not affect the Nash rule anymore but will reduce the cooperative coefficients, up to the point where they will also jump to the corner at zero. Therefore, differences between the two cases will be maximized, other things equal, for costs parameterization for which Nash coefficients are zero but close to their point of discrete change.

It is also useful to examine the impulse responses to the shock λ_t under the cooperative policy — obviously those under Nash are the same as in Figure 2. By aggressively curbing fluctuations in spreads about their averages, coordinated credit policies lead to a great deal of macroeconomic stabilization relative to the economy with no intervention. The spread barely increases to around (annualized) 2 basis points, while fluctuations in consumption and hours an order of magnitude smaller than in Figure 2. This is so with a relative small size of purchases, which amounts to around 2.5 percent of the steady state capital stock on impact.

5 Concluding remarks

There is a presumption that the increasing degree of financial integration spurred on by globalization has resulted in a strengthening of financial channels of international transmission. These channels arguably have featured prominently in precipitating the recent global financial crisis. However, their role is seldom discussed in the analysis of the unprecedented and unconventional policy measures adopted by major central banks and governments in response to the crisis. This paper has argued that a simple model in which financial integration results into more powerful international transmission of idiosyncratic shocks has some interesting implications for these unconventional policies. In particular, the very same factors that strengthen the international transmission also imply that the international coordination of unconventional policies may be especially important under some circumstances. National policies that ignore these transmission channels and do not internalize their international effects may result in an insufficient degree of stabilization in the face of adverse financial shocks. These findings seem consistent with the observation that central bank cooperation in the recent crisis has appeared particularly close, including for instance a significant liquidity management dimension. However, in general gains from cooperation should not be expected to be much larger for unconventional policies than for more standard policies.

A second finding that requires further discussion concerns the suboptimality of asset purchases in response to capital quality shocks, as it stands in contrast with influential earlier literature, such as GK. As argued above, we suspect that a key source of this discrepancy revolves around the presence of other distortions in addition to financial frictions, such as nominal rigidities. To the extent that unconventional policies may be considered as an alternative to standard monetary policy, rather than as complementary, it is important to consider how their desirability may depend on the specific objectives of monetary policy and on their feasibility. We plan to look at this issue in future versions of the paper.

Of course the paper, in addition to the interaction between unconventional policies and more conventional fiscal and monetary policy has not touched upon many other important issues. These would include among others, a thorough analysis of the many different policy measures adopted in reality by governments and central banks, such as direct bank liquidity provisions; the potential moral hazard problem raised by the kind of financial market interventions we studied. These are all important topics for future research.

References

[1] Bernanke, Ben S., Mark Gertler, and Simon Gilchrist (1999). The Financial Accelerator in a Quantitative Business Cycle Framework. In *Handbook of Macroeconomics*, eds. John B. Taylor and Michael Woodford. Elsevier.

[2] Carlstrom, C. T. and Fuerst, T. S. (1997). Agency Costs, Net Worth, and Business Fluctuations: A Computable General Equilibrium Analysis. *American Economic Review*, 87(5):893-910.

[3] Christiano, L.J., Motto, R., and Rostagno, M. (2008). Financial factors in economic fluctuations. Northwestern University manuscript.

[4] Christiano, L.J. and D. Ikeda (2011). Government policy, credit markets and economic activity. Northwestern University manuscript.

[5] Coeurdacier, N., Kollmann, R., and Martin, P. (2010). International Portfolios, Capital Accumulation and Foreign Asset Dynamics. *Journal of International Economics.*

[6] Cúrdia, V. and Woodford, M. (2009). Credit Spreads and Monetary Policy. Discussion Papers 0910-01, Columbia University, Department of Economics.

[7] Dedola, Luca and Giovanni Lombardo (2012). Financial Integration, Financial Frictions, and the International Propagation of Shocks. *Economic Policy.*

[8] Del Negro, M., Eggertsson, G., Ferrero, A., and Kiyotaki, N. (2010). The great escape? A quantitative evaluation of the Fedfs non-standard policies. Unpublished, Federal Reserve Bank of New York.

[9] Devereux, M. B. and Sutherland, A. J. (2008). Country portfolios in open economy macro models. *Journal of the European Economic Association.*

[10] Devereux, M. B. and Yetman, J. (2010). Financial Deleveraging and the International Transmission of Shocks. *Journal of Money, Credit and Banking.*

[11] Faia, E. (2007a). Finance and international business cycles. *Journal of Monetary Economics*, 54(4):1018-1034.

[12] Gertler, M., Gilchrist, S., and Natalucci, F. M. (2007). External Constraints on Monetary Policy and the Financial Accelerator. *Journal of Money, Credit and Banking*, 39(2-3):295-330.

[13] Gertler, M. and P. Karadi (2011). A model of unconventional monetary policy. *Journal of Monetary Economics*, 58:17-34.

[14] Gertler, M., and N. Kiyotaki (2011). Financial intermediation and credit policy in business cycle analysis. *Handbook of Monetary Economics,* Volume 3A.

[15] Gertler, M., N. Kiyotaki, and A. Queralto (2011). Financial Crises, Bank Risk Exposure and Government Financial Policy. , *Journal of Monetary Economics*, forthcoming.

[16] Gilchrist, S., Ortiz, A., and Zakrajek, E. (2009). Credit Risk and the Macroeconomy: Evidence from an Estimated DSGE Model. Boston University.

[17] Imbs, J. (2010). The First Global Recession in Decades. *IMF Economic Review* 58:327-354.

[18] Kollmann, R, Enders, Z. and Müller G.J (2011). Global banking and international business cycles. *European Economic Review*, 55: 407-426.

[19] Kosicki, S., E. Santor and L. Suchanek (2011). Unconventional monetary policy: The international experience with central bank asset purchases. *Bank of Canada Review*, Spring.

[20] Kiyotaki, Nobuhiro and John Moore, 1997. Credit Cycles. *Journal of Political Economy* 105(2):211–248.

[21] Krugman, Paul, 2008. The International Financial Multiplier. Unpublished manuscript.

[22] Mendoza, E. G., Quadrini, V (2010). Financial globalization, financial crises and contagion. *Journal of Monetary Economics*, 57:24-39.

[23] Milesi-Ferretti, Gian-Maria and Cedric Tille, 2011. The great retrenchment: international capital flows during the global financial crisis. *Economic Policy* 26(66):285–342.

[24] Neely, Christopher J., 2010. The large scale asset purchases had large international effects. Federal Reserve Bank of St. Louis Working Paper No 2010-018C.

[25] Obstfeld, Maurice and Kenneth Rogoff, 2002. Global Implications of Self-Oriented National Monetary Policy Rules. *Quarterly Journal of Economics* 117:503–535.

[26] Perri, Fabrizio and Vincenzo Quadrini, 2011. International Recessions. NBER Working Papers 17201, National Bureau of Economic Research.

[27] Shin, H. S. (2011). Global banking glut and loan risk premium. 2011 Mundell Fleming Lecture.

[28] Ueda, Kozo (2010). Banking globalization and international busi- ness cycles. IMES Discussion Paper Series 10-E-16, Institute for Monetary and Economic Studies, Bank of Japan.

[29] Van Wincoop, E. and Tille, C. (2007). International Capital Flows. NBER Working Papers 12856, National Bureau of Economic Research, Inc.

Table 1: Calibration

discount factor	β	0.99
risk aversion	σ	1
habits	h	0.815
inverse Frish-elasticity of labor supply	φ	0.276
survival probability	θ	0.972
capital share	α	0.33
government share in GDP	$\frac{G}{Y}$	0.2
investment adjustment cost	η_i	1.728
(continues...)		

Table 1: Calibration

standard deviation financial shock	σ_{Ne}	0.05
standard deviation quality shock	σ_{Ne}	0.05
persistence financial shock	ρ_{Ne}	0.8
persistence quality shock	ρ_{ψ}	0.66
starting up transfer	ω	0.002
divertible fraction	λ	0.381
steady-state leverage	ϕ	4
steady-state premium	$(R_K - R)\,400$	0.99

Table 2: Moments under a capital quality shock

κ	E(Welfare)	E(K)	E(C)	E(L)	E(premium)	E(cost)	E(φ)	variance. prem.
0	0.074036	-0.026585	0.11276	-0.2013	0.0050611	0	0	0.00023592
20	0.071186	-0.046944	0.10683	-0.20282	0.0040418	0	0.081498	3.2389e-05
40	0.070963	-0.049461	0.10625	-0.20333	0.0038557	0	0.15589	1.9101e-05
60	0.070801	-0.051021	0.10593	-0.20372	0.0037657	0	0.22863	1.3925e-05
80	0.070674	-0.052126	0.10572	-0.20402	0.0037094	0	0.30044	1.1078e-05
100	0.070573	-0.052949	0.10557	-0.20426	0.0036693	0	0.37161	9.2466e-06
120	0.070492	-0.053579	0.10547	-0.20446	0.0036384	0	0.44226	7.9573e-06
140	0.070427	-0.054069	0.10539	-0.20463	0.0036133	0	0.51248	6.995e-06
160	0.070375	-0.054456	0.10534	-0.20478	0.0035922	0	0.58232	6.2465e-06
180	0.070332	-0.054762	0.10531	-0.2049	0.0035739	0	0.65181	5.6462e-06
200	0.070298	-0.055007	0.10528	-0.20501	0.0035578	0	0.721	5.153e-06
220	0.07027	-0.055201	0.10527	-0.2051	0.0035434	0	0.7899	4.7403e-06
240	0.070248	-0.055355	0.10526	-0.20519	0.0035303	0	0.85853	4.3893e-06
260	0.070231	-0.055475	0.10526	-0.20526	0.0035183	0	0.92692	4.0871e-06
280	0.070217	-0.055569	0.10527	-0.20533	0.0035072	0	0.99508	3.8239e-06

Table 3: Moments under a financial shock

κ	E(Welfare)	E(K)	E(C)	E(L)	E(premium)	E(cost)	E(φ)	variance. prem.
0	-0.00068026	-0.00164	-0.00051766	-8.2873e-05	0.00032201	0	0	0.00018648
20	-0.001053	-0.0036386	-0.001147	-9.1102e-05	9.8876e-05	0.00025665	0.0020464	4.8568e-06
40	-0.00082758	-0.00197	-0.00070775	9.42e-05	5.5163e-05	0.00032858	0.0022633	1.5555e-06
60	-0.00073258	-0.0012104	-0.00050996	0.00018187	3.6659e-05	0.00036544	0.0022492	7.694e-07
80	-0.0006816	-0.00077214	-0.00039703	0.00023436	2.6315e-05	0.00038917	0.0021496	4.611e-07
100	-0.00065056	-0.00048498	-0.00032379	0.00026997	1.9669e-05	0.00040631	0.0020068	3.083e-07
120	-0.00063015	-0.0002813	-0.00027236	0.00029608	1.5021e-05	0.00041959	0.0018385	2.212e-07
140	-0.00061605	-0.00012876	-0.00023423	0.00031627	1.1581e-05	0.00043037	0.0016534	1.668e-07
160	-0.00060599	-9.9192e-06	-0.00020483	0.0003325	8.9256e-06	0.00043942	0.0014567	1.305e-07
180	-0.00059864	8.5509e-05	-0.00018146	0.00034592	6.8121e-06	0.00044721	0.0012513	1.05e-07
200	-0.0005932	0.00016398	-0.00016245	0.00035729	5.088e-06	0.00045405	0.0010393	8.64e-08
220	-0.00058915	0.00022976	-0.00014668	0.0003671	3.6534e-06	0.00046015	0.00082212	7.24e-08
240	-0.00058614	0.00028578	-0.00013339	0.00037569	2.4402e-06	0.00046566	0.00060073	6.16e-08
260	-0.00058392	0.00033413	-0.00012205	0.00038331	1.4002e-06	0.00047069	0.00037588	5.31e-08
280	-0.00058232	0.00037634	-0.00011226	0.00039014	4.984e-07	0.00047532	0.00014812	4.62e-08
300	-0.0005812	0.00041355	-0.00010373	0.00039633	-2.915e-07	0.00047962	-8.2098e-05	4.07e-08
320	-0.00058047	0.00044664	-9.6227e-05	0.00040198	-9.893e-07	0.00048363	-0.00031444	3.61e-08
340	-0.00058005	0.00047628	-8.9589e-05	0.00040717	-1.6104e-06	0.0004874	-0.00054862	3.22e-08
360	-0.00057989	0.00050301	-8.3675e-05	0.00041197	-2.1671e-06	0.00049095	-0.00078442	2.89e-08
380	-0.00057995	0.00052726	-7.8376e-05	0.00041644	-2.6689e-06	0.00049432	-0.0010217	2.62e-08

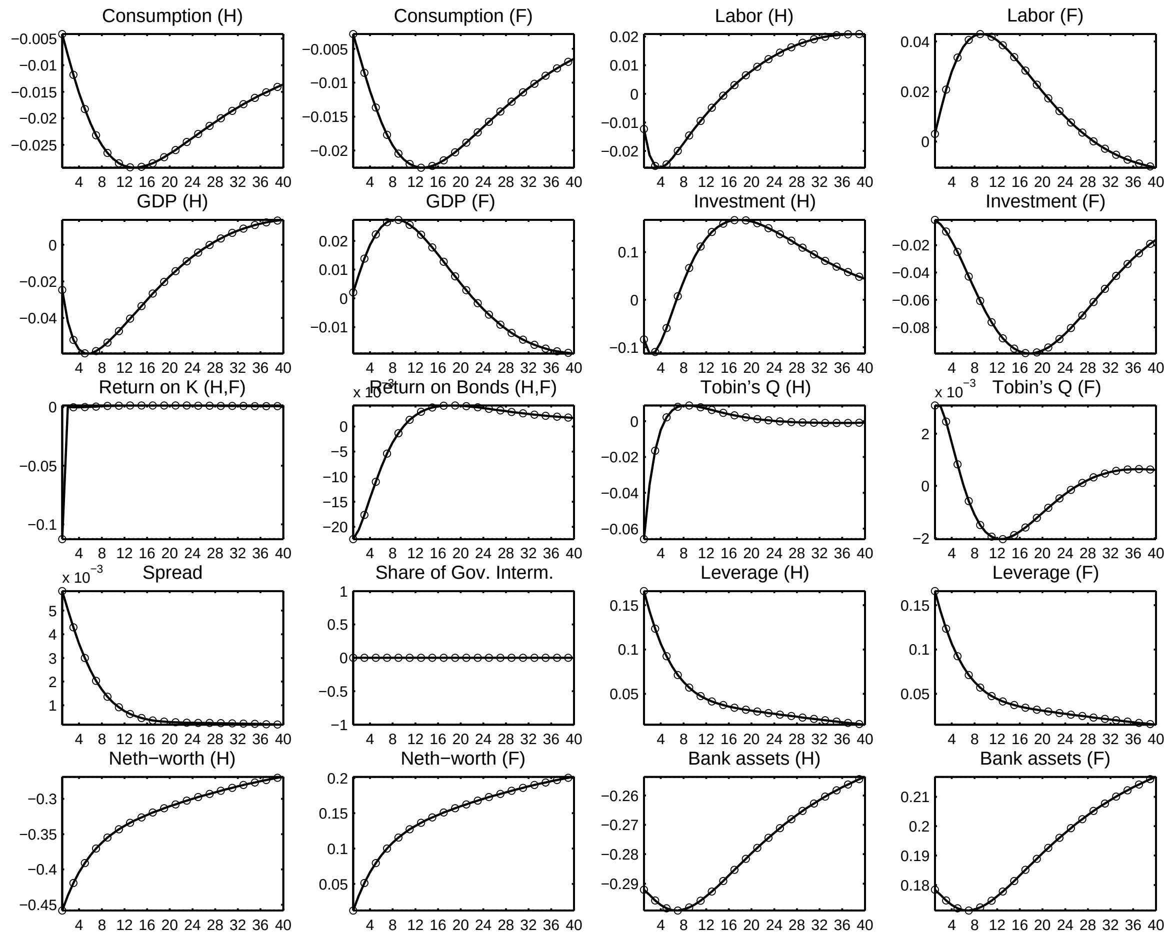

Figure 1: Home capital quality shock under full integration

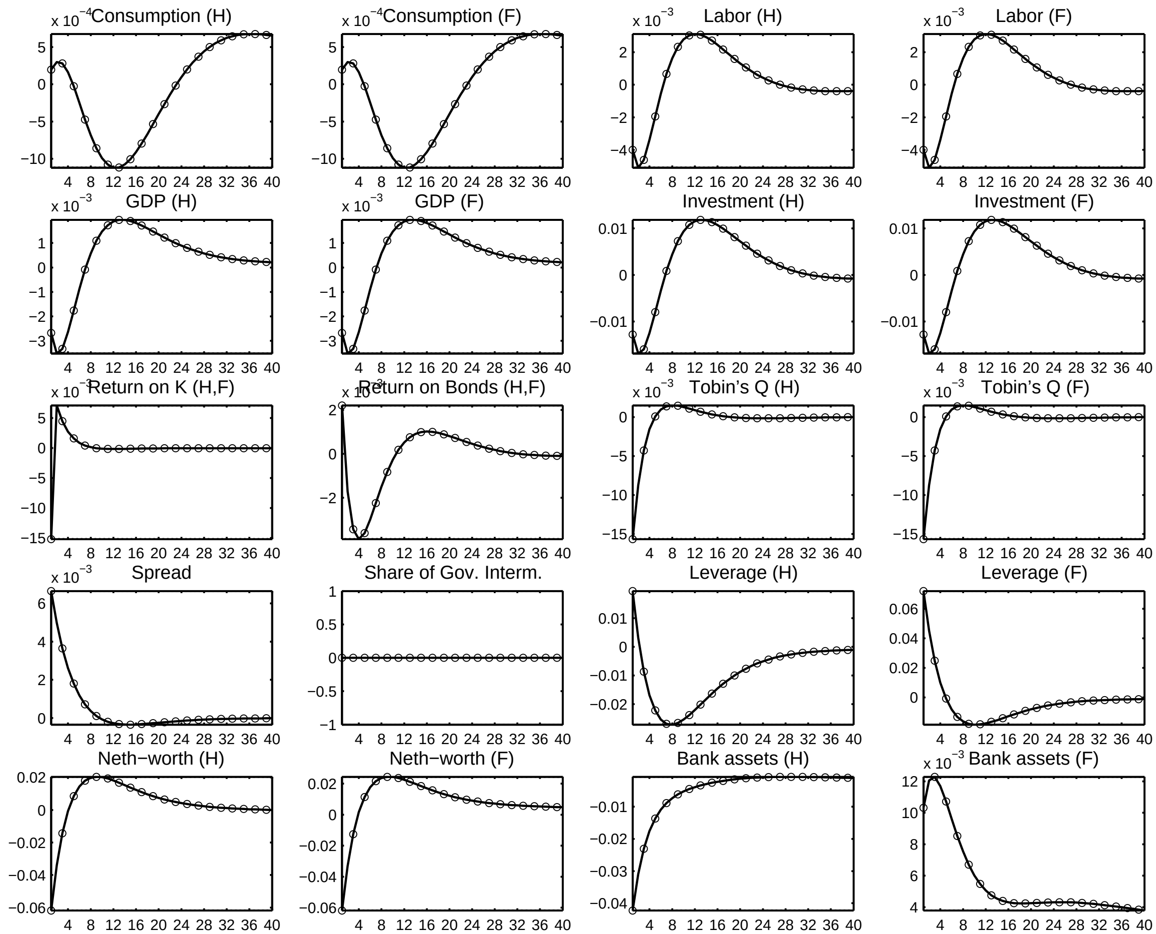

Figure 2: Home financial shock under full integration

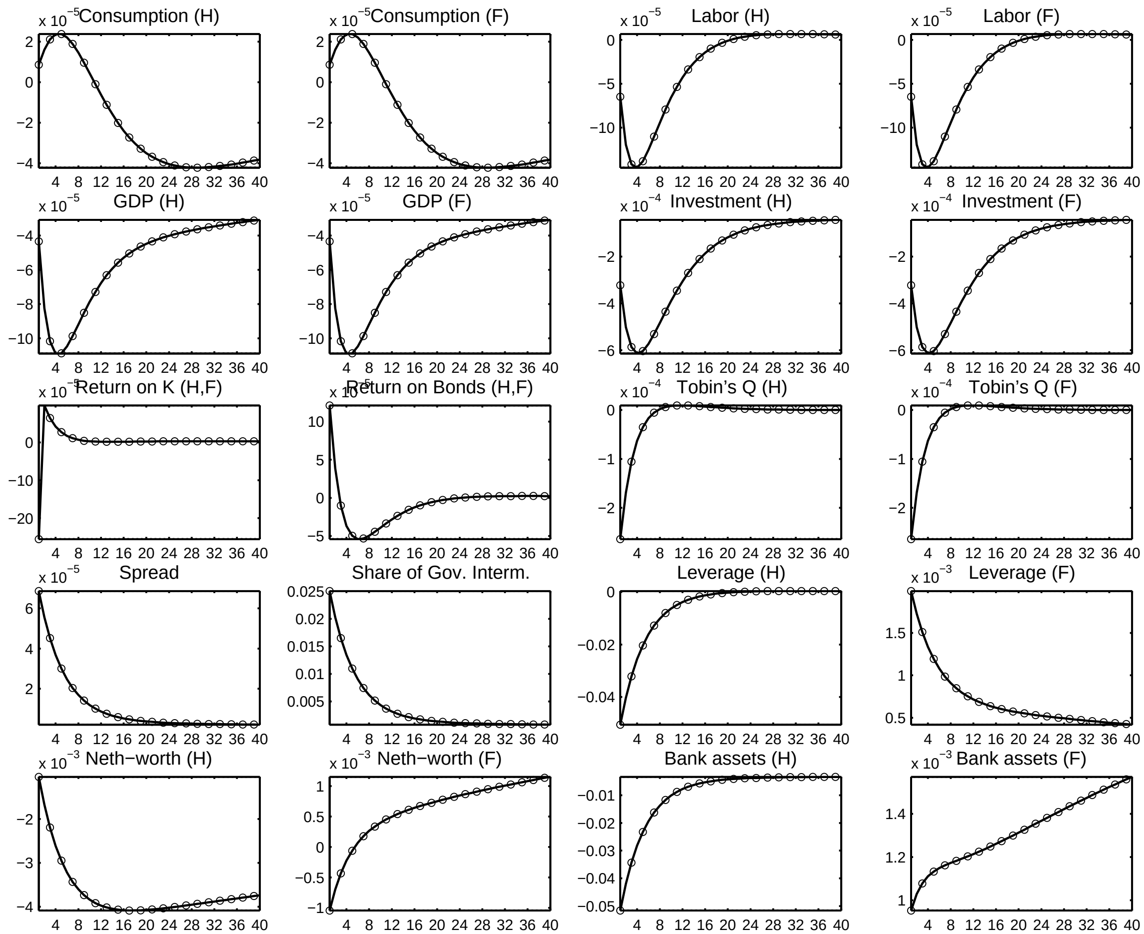

Figure 3: Home capital quality shock under cooperative policy and full integration