Macroprudential Policies in a Global Perspective

Olivier Jeanne

This paper analyzes the case for the international coordination of macroprudential policies in the context of a simple theoretical framework. Both domestic macroprudential policies and prudential capital controls have international spillovers through their impact on capital flows. The uncoordinated use of macroprudential policies may lead to a "capital war" that depresses global interest rates. International coordination of macroprudential policies is not warranted, however, unless there is unemployment in some countries. There is scope for Pareto-improving international policy coordination when one part of the world is in a liquidity trap while the rest of the world accumulates reserves for prudential reasons.

1. Introduction

One legacy of the global financial crisis is the emergence of macroprudential policy as a new policy tool towards financial stability. The policymakers in charge of financial stability missed the mark before the crisis because they failed to perceive and contain the financial vulnerabilities that were building up during the boom. Macroprudential policy fills this gap—retrospectively and hopefully looking forward—by restraining the factors of systemic risk in the balance sheets of the banking and real sectors before the crisis. To the extent that it succeeds, macroprudential policy will allow monetary policy to continue to focus on its traditional objectives.

This paper is about the nexus between macroprudential policies and international capital flows. This nexus is important because international capital flows play a key role in generating the financial vulnerabilities that macroprudential policy tries to remedy. There is evidence that inflows of private capital to emerging market economies help generate domestic credit booms that often lead to financial crashes (Obstfeld 2012). Emerging market economies

Author's note: *A preliminary version of this paper was presented at the BOJ-IMES Conference, "Financial Crises and the Global Financial System" at the Bank of Japan, May 29–30, 2013. I thank the participants at these conferences for their comments, especially my discussants Guillermo Calvo, Jonathan Ostry, and Eric Santor. I also thank Anton Korinek for his comments on a previous draft.*

have responded to surges in capital inflows by accumulating large stocks of foreign reserves and with prudential capital controls.[1] International capital flows pose macroprudential challenges for advanced economies too. For example, it has been argued that the rest of the world's appetite for U.S. "safe assets" was an important factor behind the U.S. credit and asset price boom and the subsequent crisis (Bernanke et al. 2011).

The relationship between macroprudential policies and international capital flows goes both ways. Not only do macroprudential policies respond to capital flows, they also affect capital flows, and they do so in a way that may generate undesirable international spillovers. For example, the accumulation of large stocks of reserves may have prudential motives from the perspective of emerging market economies, but it may have had a destabilizing effect on the U.S. economy. At a conceptual level the existence of such spillovers is not surprising. In a globally integrated financial market, a macroprudential restriction in one part of the world deflects financial flows toward the rest of the world, which must then deal with the consequences for its own financial stability.[2]

While there is a long line of literature on the international spillovers generated by monetary policy (and to a lesser extent fiscal policy), we would like to know more about how macroprudential policies interact in the global economy and whether there is a case for international rules or mechanisms of coordination in this area. This issue is discussed in Jeanne, Subramanian, and Williamson (2012), Ostry, Ghosh, and Korinek (2012), and Korinek (2012), but there remains scope for more theory to inform the policy discussions. This paper contributes to fill this gap.

For this purpose, I present a simple framework to analyze the international consequences of macroprudential policies. The model is in line with the recent theoretical literature that motivates the role of macroprudential policies by the need to address certain financial externalities, as reviewed in Section 2. The model assumes that certain financial contracts generate negative externalities because they increase the risk of a systemic debt crisis. The role of macroprudential policy is to correct the distortions induced by these externalities. I adopt here a broad view of macroprudential policy, that includes but is not limited to banking regulation and also covers measures such as prudential capital controls on inflows or the accumulation of international reserves.

I then look at the international spillovers generated by macroprudential policies. The key result is that macroprudential policies are *strategic complements*, to use game theory terminology. A macroprudential restriction in one country deflects capital flows toward the other countries, leading them to restrict their own macroprudential policies. In the uncooperative equilibrium,

all countries implement macroprudential policies that are more intense because of these spillovers, a situation that might be reminiscent of an inefficient arms race.

In spite of these spillovers I find that there is little scope for international coordination of macroprudential policies to improve global welfare. The reason is the same as in Korinek (2012), who derived this result earlier. The spillovers induced by macroprudential policies are not true externalities because they are mediated through a competitive price, the global interest rate. There is no more reason to coordinate macroprudential policies than, say, to coordinate competitive producers and consumers in a general equilibrium model because their supply and demand affect the prices of goods.

The fact that macroprudential policies tend to lower the global interest rate can become problematic when there are nominal frictions, however. Macroprudential policies tend to depress demand, an effect that monetary policy may be unable to offset because of the zero-bound constraint on the nominal interest rate. I present a Keynesian extension of the model in which the uncoordinated use of macroprudential policies can push some or all countries into a liquidity trap with a positive level of unemployment. In such a situation, there is scope for Pareto-improving coordination of macroprudential policies. The countries with unemployment benefit from a coordinated relaxation of their macroprudential policies that raises global demand.

Finally, I study the scope for the international coordination of monetary policy and macroprudential policy. I present a specification of the model in which one country (the United States) is in a liquidity trap with unemployment while the rest of the world (China) attempts to mitigate the effects of the U.S. monetary stimulus by a prudential accumulation of reserves. I find that there is again a case for international coordination, leading both countries to be less aggressive in the pursuit of their objectives.

The paper is structured as follows. Section 2 presents a selective review of the literature. Section 3 presents the model and compares domestic macroprudential policies and prudential capital controls. Sections 4 and 5 look at the case for the international coordination of prudential capital account policies, respectively assuming full employment and less than full employment. Section 6 concludes with a brief discussion of the policy implication of my analysis for the international community.

2. Literature

This paper belongs to a rapidly growing literature on financial externalities and regulation. One important part of this literature focuses on the banking

sector, where there was a shift in emphasis from the microprudential regulation to the macroprudential regulation of banks (see Hanson, Kashyap, and Stein 2011 and Galati and Moessner 2013).[3] In a nutshell, macroprudential regulation focuses on how the collective behavior of banks makes the financial system riskier, whereas microprudential regulation focuses on individual banks' risk of insolvency, taking their financial environment as given.[4]

From a theoretical perspective, the shift toward macroprudential regulation has been justified by the need to address certain *externalities* that lead to financial amplification in a crisis. Two externalities have received most of the attention in the literature.[5] The first one is related to the interconnectedness between financial institutions that stems from the network of claims and liabilities across institutions. A shock to a given institution may propagate itself to a large number of other institutions through a domino effect, including those that are not directly linked to the bank at the origin of the shock. Banks do not internalize their contribution to the propagation of systemic risk when they contract with other banks, which leads to a network that may be excessively fragile.

The second externality is related to the fire sales that occur when all banks try to deleverage by selling the same assets at the same time. Ex post (in the crisis), banks do not internalize that selling an asset drives other banks into insolvency by depressing the asset's price. Ex ante, they do not take into account the contribution of their own leverage to systemic risk induced by fire sales.

In theory, the most direct and natural policy instrument to address an externality is a Pigouvian tax. Some analyses of macroprudential banking regulation indeed take Pigouvian taxation as a theoretical benchmark, and some measures that were recently implemented or proposed take the form of taxes on certain banking activities. For example, Shin (2010) and Perotti and Suarez (2011) proposed using a tax on banks' noncore liabilities as a tool for prudential regulation, and such a tax was introduced in Korea in August 2011. But overall, the macroprudential regulation of banks relies on the traditional quantity-based instruments of banking regulation.[6]

Macroprudential policy is often taken to mean the macroprudential regulation of *banks*, especially in central banking circles, but it is important to realize that the externalities that justify the use of macroprudential policies work not only in the banking sector but also are relevant in the real sector. For example, the evidence in Mian and Sufi (2009) suggests that one important reason behind the large and persistent fall in U.S. demand after the banking crisis was excessive leverage in the *household* sector.

The recent theoretical literature on Fisherian "debt deflation" has studied how the type of externalities that have been invoked to justify macroprudential

regulation of banks can also lead to excessive leverage in the real sector. For example, in a residential real estate bust the fact that households are credit-constrained puts further pressure on house prices. The feedback loop that this generates is very similar to the fire sale mechanism in the banking literature. This mechanism is analyzed in the three-period model of Lorenzoni (2008) and more dynamic quantitative contributions can be found in Jeanne and Korinek (2010b) and Bianchi and Mendoza (2010).

Another transmission mechanism involves aggregate demand. For example, the model in Jeanne (2013a) features an economy in which firms produce inputs that are complementary in the production of the consumption good. As a result default may be contagious. Sectoral shocks that make the producers of certain inputs insolvent lower the price of complementary inputs and may draw the producers of those other inputs into default. There is excessive borrowing under laissez-faire because each firm does not internalize the impact of its debt on the default risk of other firms.

Similar arguments can be developed in the open economy. A boom in capital inflows is associated with a real appreciation of the domestic currency, which increases the internationally acceptable collateral on the basis of which domestic agents can borrow abroad. The problem is that booms in capital inflows are often followed by "sudden stops" à la Calvo (1998), in which exactly the same amplification mechanisms work in reverse. The sudden capital outflow is associated with a depreciation of the currency and a decline in the foreign-currency price of domestic assets.

One strand of recent theoretical literature examines whether prudential capital controls are desirable from the perspective of improving the overall domestic welfare of an emerging market economy when there are booms and busts in capital flows (Korinek 2010, 2011, Jeanne and Korinek 2010a, and Bianchi 2011). The optimal policy is a Pigouvian tax on capital inflows that makes private market participants internalize their contributions to systemic risk in order to restore the efficiency of the decentralized market equilibrium.[7]

Consistent with the recent theoretical literature, I adopt in this paper a broad view of macroprudential policy which is not limited to banking regulation. I define macroprudential policy as a system of Pigouvian taxes (or equivalent quantity-based measures) that aim at reducing excessive leverage in a boom, whether it takes place in the banking sector or the real sector. In the open economy, macroprudential policy can be implemented through the management of international reserves.

Unlike for trade or monetary policies, where the welfare benefits of international cooperation have been studied extensively, there has been relatively

little research on the international coordination of macroprudential policies. In a recent contribution, Korinek (2012) shows in a model similar to the one presented here that international cooperation is not justified if small countries use prudential capital controls to redress domestic externalities. In another, Bengui (2012) studies the scope for international coordination in an open-economy version of the Hölmstrom and Tirole (1998) model of public liquidity provision. He finds that the uncooperative equilibrium between national regulators is inefficient as national regulators do not internalize the benefits of their country's provision of liquidity to the rest of the world.[8]

Let me conclude the discussion of the literature by emphasizing two things that this paper is *not* about.

First, this paper does not address the effectiveness of macroprudential policies when the private sector attempts to circumvent them. There is evidence that the private sector makes such efforts, but the empirical literature suggests that they are not entirely successful—although they may constrain the set of effective policies. Existing empirical research finds that the macroprudential regulation of banks has been effective at least in some ways. Based on aggregate data, Lim et al. (2011) and Dell'Ariccia et al. (2012) find evidence of some macroprudential policies being effective in reducing the procyclicality of credit and leverage.[9] Similar results have been obtained in the empirical literature on capital controls.[10] I ignore problems related to the avoidance of macroprudential measures.

Second, this paper does not discuss the international coordination required to close the gaps that come from international arbitrage between regulators. Traditional arguments for international coordination of banking regulation are the need to maintain a level playing field for banking competition and to avoid regulatory races to the bottom. These arguments also apply to the macroprudential part of banking regulation. But the fact that booms and busts are often country-specific generates a new tension because macroprudential regulation may have to be restricted in some countries and not others. A problem arises when the macroprudential regulation of banks is used to contain excessive leverage in the real sector. In a financially integrated world, borrowers who see the cost of borrowing from the domestic banking sector increase because of a macroprudential restriction can borrow from foreign banks, either directly (for the largest corporate borrowers) or through their domestic branches (if they are not subject to domestic macroprudential regulation).[11] This problem is especially salient in the euro area, where country-specific macroprudential regulation is more important than elsewhere to fulfill the stabilizing role that monetary policy can no longer play at the national level, and at the same time

banking integration is an explicit objective. However, in this paper I will consider this problem solved by assuming that the domestic policymaker can tax borrowing by domestic agents irrespective of the residency of the lender.[12]

3. Macroprudential Policies in a Small Open Economy: A Simple Model

The key concept in the literature reviewed in the previous section is that of externality. There is excessive borrowing in a boom because debt has social costs that are not internalized by the borrowers. The uninternalized social costs of borrowing can be modeled in several ways, but they all boil down, in reduced form, to the existence of a wedge between the private return and the social return on borrowing. I present in this section a model, based on Jeanne (2013b), that captures this idea in a simple reduced-form way. Note that the model is not specifically about banking, although one could view it as a model of banking by interpreting the borrowers as bankers who make loans to the real sector. Thus the macroprudential policies discussed in this section are not limited to the macroprudential regulation of banks.

3.1. Assumptions

The model has two periods. Lending and investment take place in the first period and repayment takes place (or not) in the second period. The model is completely real (there is no money) and it features one single good which is used for both investment and consumption.

The assumptions about the lenders are simple and standard. The country has a mass of identical lenders who are endowed with the country's GDP, denoted by Y, in the first period. The lenders maximize their utility, U, which is the sum of a concave function of their first-period consumption, C, plus the expected value of their second-period consumption, C'

$$U_l = u(C) + E(C').$$

The lenders lend their saving, $S = Y - C$, at the riskless interest rate, r. If capital is perfectly mobile this interest rate is equal to the world riskless interest rate, r^* (taken as exogenous for now). In general, r could be higher or lower than r^* because of restrictions to international capital mobility.

The lenders save until the marginal benefit of saving is equal to the marginal cost, $u'(Y - S) = 1 + r$, which implies that saving is an increasing function of the real interest rate,

$$S = S(r), \quad S'(\cdot) > 0.$$

The mass of lenders is normalized to 1, so that S represents both the saving of an individual lender and the country's aggregate saving.

The borrowers are identical atomistic entrepreneurs (or firms) who need funds to finance investment projects. A given entrepreneur invests a quantity I of good in the first period in the hope of receiving a quantity $f(I)$ of good in the second period. There are decreasing marginal returns to investment, i.e., function $f(\cdot)$ is concave. The investment is risky because the payoff $f(I)$ is obtained with a probability p that is in general lower than one. With probability $1-p$ the investment yields nothing. Although this is not crucial for the results, I will assume that this risk is perfectly correlated across firms, i.e., there is a "good" aggregate state in which all firms have a high payoff and a "bad" aggregate state in which they all have a zero payoff. The bad state will lead to a systemic debt crisis.

The borrowers have no funds in the first period, implying that the investment is entirely financed with debt, $D = I$. If the borrowers are unable to repay their debts in the second period because of a zero payoff, they default and the lenders receive nothing. Because of this risk the borrowers must pay a default risk premium: They promise a repayment of $(1+r)D/p$ to the lenders.

The borrowers consume in the second period only (for example because the agency cost of debt deters them from borrowing to finance first-period consumption). The borrowers, thus, simply maximize the expected level of their second-period consumption,

$$U_b = E(C').$$

Similar to lenders, the mass of borrowers is normalized to 1. Domestic welfare is the sum of the welfare of lenders and borrowers, $U = U_l + U_b$.

The following assumption is key in generating systemic risk. I assume that the expected payoff of an investment is a decreasing function of the aggregate level of debt,

$$p = p(D), \quad p'(\cdot) < 0. \tag{1}$$

Note that in this expression D is the *aggregate* level of debt rather than the debt of an individual entrepreneur. This assumption generates the externality leading to systemic risk: Individual borrowers do not take into account the impact of their borrowing on the risk of default for the other borrowers. It can be viewed as a reduced form for the microfounded model of contagion in systemic debt crises presented in Jeanne (2013b). In that model, as mentioned in the previous section, entrepreneurs produce inputs that are complementary in the production of the consumption good. As a result default may be contagious because of a

demand externality. Sectoral shocks that make the producers of certain inputs insolvent lower the price of complementary inputs and may draw the producers of those other inputs into default. Assuming that the probability of default of a given entrepreneur is a function of the aggregate level of debt, as we do in equation (1), is a simple reduced form for this mechanism.[13]

Essentially, the model captures the idea that some expenditures generate negative externalities because they are financed by debt. There is nothing essential to the assumption that productive investment is debt-creating whereas consumption is not. In the following one can think of I and C as notations for expenditures that are financed relatively more by debt and by cash, respectively.

3.2. Domestic Macroprudential Regulation

It is easy to see how laissez-faire may lead to overborrowing. Since the representative borrower repays $(1+r)I/p$ with probability p, his expected repayment is $(1+r)I$ and his ex ante utility is given by,

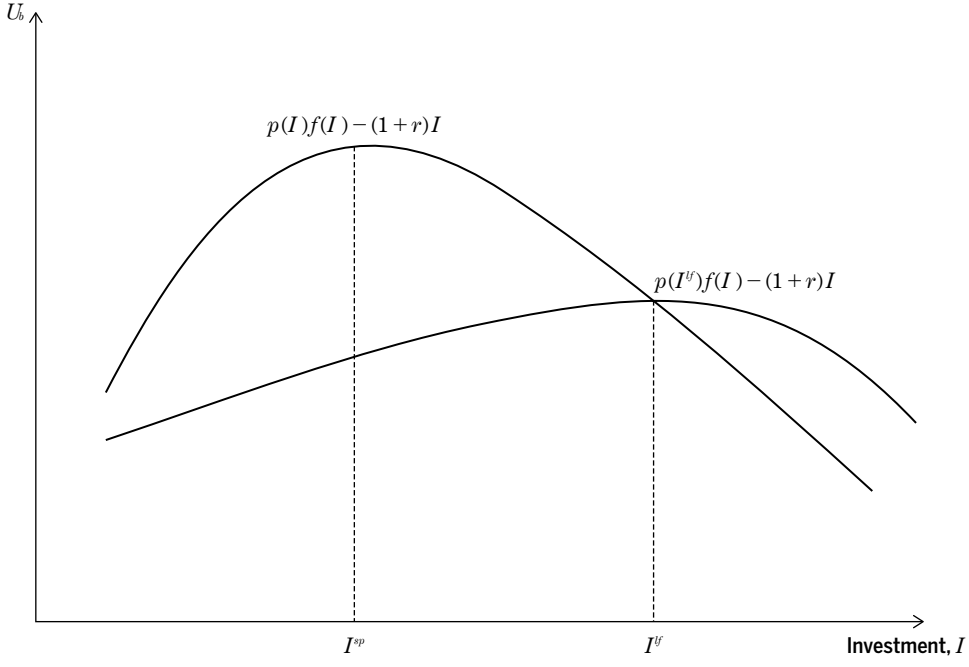
$$U_b = pf(I) - (1+r)I.$$

The entrepreneur borrows until the marginal benefit is equal to the marginal cost of borrowing, $pf'(I) = 1+r$, which implicitly defines the demand for loans as a decreasing function of the real interest rate. The equilibrium level of debt under laissez-faire satisfies $p(I^{lf})f'(I^{lf}) = 1+r$.

The level of borrowing is excessive under laissez-faire because individual borrowers do not internalize that the probability of a systemic debt crisis depends on the aggregate level of debt. A benevolent social planner, by contrast, would take this effect into account and maximize $p(I)f(I) - (1+r)I$. The difference between laissez-faire and the social planner solution is shown in Figure 1. At the laissez-faire equilibrium level of debt and investment, $I = I^{lf}$, the ex ante welfare of borrowers is increased by marginally reducing the investment level in order to reduce the probability of the state in which all the borrowers default (a systemic debt crisis). The social planner, thus, would pick a level of investment, I^{sp}, that is lower than under laissez-faire. This is also the level of investment that maximizes ex ante domestic welfare, $U = U_l + U_b$, since in this simple model the welfare of lenders is not affected (ex ante) by the risk of a systemic debt crisis.[14]

Figure 2 shows the Metzler diagram for this simple economy. The figure shows, on the horizontal axis, the level of investment and saving, and on the vertical axis, the gross marginal gain from investing and the gross marginal cost of saving. Under perfect capital mobility and laissez-faire both the marginal

FIGURE 1
Borrowers' Welfare under Laissez-Faire and a Social Planner

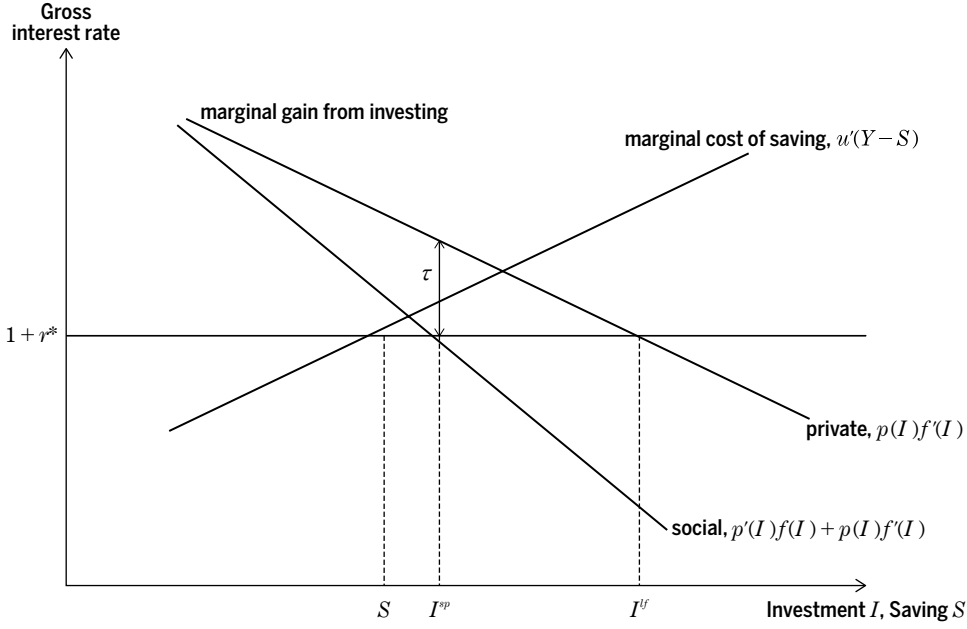


gain from investing and the marginal cost of saving must be equal to the gross cost of external borrowing, $1+r^*$. The difference between domestic saving and domestic investment, $S-I$, is the country's current account balance.

The main difference with the textbook Metzler diagram is that in the presence of systemic debt externalities, the social marginal gain from borrowing is lower than the private marginal gain. The difference, $p'(I)f(I)$, reflects the impact of aggregate debt on systemic risk. As a result the social planner would like to reduce domestic investment below the laissez-faire level, which means—domestic saving being unchanged—that the country's current account balance must increase. The figure illustrates the case where the social planner reduces a current account deficit that remains positive. But in general, the intervention of the social planner could also reverse the sign of the current account balance and transform a capital-importing country into a capital exporter.

What policy instrument can the social planner use to achieve the optimal level of borrowing and investment? The most direct policy instrument is a Pigouvian tax on domestic borrowing equal to the wedge between the private return and the social return (labeled τ in Figure 2).[15] The proceed of the tax can

FIGURE 2
Metzler Diagram with Systemic Debt Externalities



be rebated in such a way that both the borrowers and the lenders benefit. To the extent that the tax is imposed on domestic borrowing irrespective of the residency of the lender, this policy should be interpreted as domestic macroprudential policy rather than a capital control.

More formally, let us assume that the tax increases the riskless cost of borrowing from r^* to $r^*+\tau$.[16] The level of debt and investment in the decentralized equilibrium is now given by

$$p(I)f'(I) = 1 + r^* + \tau.$$

This coincides with the level of debt and investment chosen by the social planner,[17] which satisfies $p'(I^{sp})f(I^{sp}) + p(I^{sp})f'(I^{sp}) = 1 + r^*$, if the tax is set at

$$\tau = -p'(I^{sp})f(I^{sp}).$$

That is, the optimal Pigouvian tax on domestic borrowing is equal to the marginal loss in expected output from the systemic risk caused by a marginal increase in aggregate debt.

How does the optimal domestic macroprudential tax vary in the cycle? For simplicity I will consider the case where the cycle is induced by variations in

the cost of foreign borrowing, r^*.[18] As can be seen from Figure 2, a lower cost of external borrowing is associated with more investment both under laissez-faire and under the social planner. It also leads to an increase in the optimal Pigouvian tax on domestic borrowing if the difference between the private marginal gain and the social marginal gain from investing increases with the level of investment, that is, if $-p'(I)f(I)$ is increasing with I. In this case the domestic macroprudential policy is countercyclical, in the sense that it is used to smooth investment, domestic borrowing, and capital inflows against variations in the cost of foreign borrowing.

Domestic macroprudential regulation leans against the ebbs and flows of international capital movements, whether they are caused by variations in global interest rates or in risk premia. Hereafter we will assume that this is true by making the following assumption:

Assumption 1. *The marginal cost of the systemic risk increases with the level of debt, i.e., $-p'(D)f(D)$ is increasing with D.*

3.3. Prudential Capital Account Policies

If the economy is receiving capital inflows, another way that the social planner can reduce lending to the socially optimal level is by imposing a tax on *external* borrowing, i.e., on lending from nonresidents to residents. Because the tax is differentiated by the residency of the lender, it is a capital control of the type, for example, that Brazil has been using since 2009. The tax on external borrowing raises the (riskless) interest rate at which domestic borrowers can borrow from r^* to $r^*+\tau$ and so has exactly the same impact on domestic borrowing and investment as the domestic macroprudential tax considered in the previous section. However, the capital control tax also increases the interest rate for domestic savers. At the margin, domestic borrowers can borrow from domestic lenders, and they will do so until the same interest rate is paid to domestic and foreign lenders.

More formally, let us consider a capital-importing country, i.e., a country for which the autarkic interest rate r^a (defined as the level of interest rate that equalizes domestic saving and domestic investment) is higher than the external cost of borrowing r^*. As long as the tax on capital inflows τ is lower than the difference between the autarkic interest rate and the external cost of borrowing, the country imports capital and increasing the tax on capital inflows raises the domestic interest rate one-for-one. When the tax rate reaches $r^a - r^*$, however, the country is in financial autarky and raising the tax further has no impact on the domestic interest rate, which remains equal to the autarkic level r^a. If the

social planner wants to increase the domestic cost of borrowing to a level r that is above r^a, he must *subsidize* capital outflows at rate $\tau = r - r^*$. In the following, τ is a wedge that will be interpreted either as a tax on capital inflows or a subsidy on capital outflows depending on the sign of the current account balance.

The use of subsidies on capital outflows does not seem to be widespread in the real world, but the capital account policies of countries such as China illustrate how the same outcome can be achieved with policies that affect quantities rather than prices (see Jeanne 2013a).[19] To simplify, China's capital account is closed to most capital inflows except foreign direct investment (FDI) whereas most of the accumulation of foreign assets takes the form of foreign exchange reserves at the central bank. As a counterpart to the purchase of foreign reserves the domestic banking sector, which is largely controlled by the government, produces domestic assets that must be purchased by residents since nonresident investors do not have access to these assets. The domestic interest rate, thus, must adjust to the level that makes resident investors willing to hold the domestic assets backing up the reserves. Essentially, the Chinese authorities divert a fraction of domestic saving—which would otherwise be lent domestically through the banking system—into the accumulation of foreign exchange reserves (Jeanne 2013a).

In the context of my simple model, the impact of Chinese-style reserve accumulation can be captured in a simple way by assuming that the capital account is closed, so that the current account balance $B = S - I$ is equal to the accumulation of reserves by the authorities. Then in equilibrium the domestic interest rate r has to adjust to a level such that the domestic lenders are willing to save B in excess of the domestic demand for loans,

$$B = S(r) - I(r).$$

If the level of reserve accumulation B is higher than the level of net foreign assets that would be observed in the absence of capital account restrictions, this policy raises the domestic interest rate above the world level, $r > r^*$. The equilibrium is effectively the same as if the authorities had imposed a subsidy $r - r^*$ on capital outflows.

How do prudential capital account policies compare with domestic macroprudential regulation in terms of welfare? Since the underlying externality affects domestic investment, not domestic consumption, it is inefficient to change the levels of both consumption and investment. Capital account policies affect all expenditures alike, including those that do not generate externalities. The impact of a tax on external borrowing has a welfare-enhancing

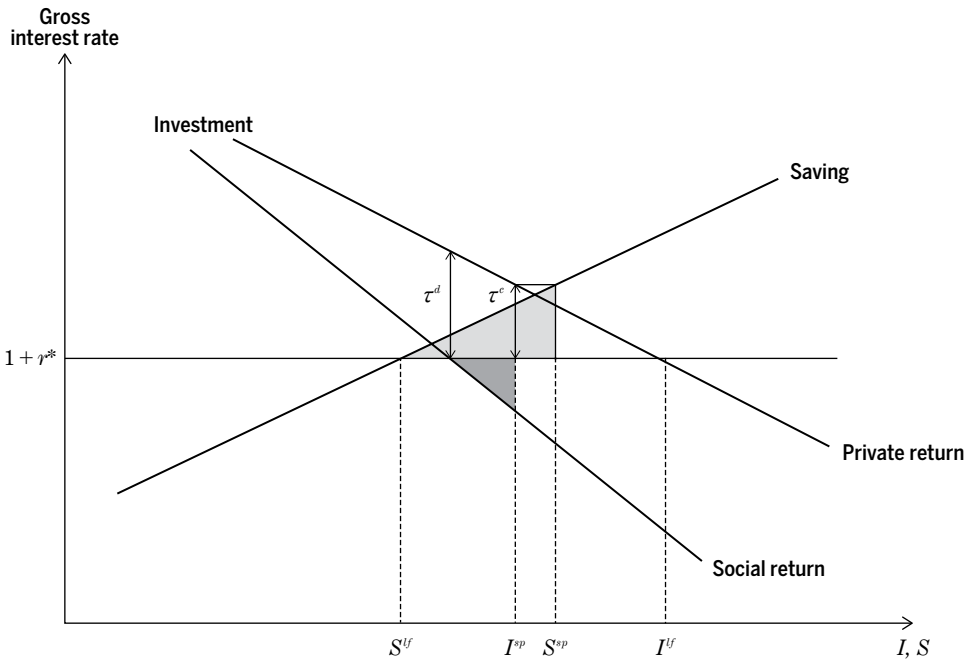
effect on domestic borrowing, but its impact on domestic saving is distortive. In this model, thus, prudential capital controls are a second-best instrument—the first-best instrument is domestic macroprudential regulation.

As a result, the optimal tax on capital inflows is lower than the optimal domestic macroprudential tax. To distinguish between the two types of taxes, let us denote by τ^c the tax on capital inflow, as opposed to τ^d the domestic macroprudential regulation tax. Figure 3 shows the impact of the capital control tax on the equilibrium. Unlike the domestic macroprudential tax, the capital control tax raises the level of saving. This implies that a given level of tax has a larger impact on the current account balance if it applies to external borrowing rather than domestic borrowing. Figure 3 illustrates a case where the optimal capital flow tax transforms a capital-importing country into a capital-exporting country, whereas the optimal tax on domestic borrowing would not.

In addition, the figure shows the welfare loss from excessive borrowing (the lower triangle) as well as the welfare loss due to the distortion of saving (the upper triangle). The tax on external borrowing τ^c is at the optimal level when it minimizes the total welfare loss (the sum of the areas of the two triangles).

FIGURE 3

Lending and Saving in the Open Economy: The Case of Capital Controls



It is easy to see that the optimal tax on external borrowing is lower than the optimal tax on domestic borrowing. If τ^e were set at the same level as τ^d, the lower triangle would disappear but the upper triangle would be much larger. Then there would be a first-order gain (in terms of higher consumption) but a second-order cost (in terms of higher crisis risk) from marginally reducing τ^e below τ^d. Intuitively, capital controls should be used less aggressively than domestic macroprudential regulation because they come with a collateral cost: They distort non-debt-creating expenditures at the same time as they correct debt-creating expenditures.

The cyclical properties of the optimal tax on external borrowing are not necessarily the same as for the tax on domestic borrowing, but one can ensure that the optimal capital controls are countercyclical at the cost of an additional assumption. To understand this, it is useful to introduce the country's total expenditures,

$$E = C + I. \tag{2}$$

Using a tax on foreign borrowing implies that the marginal utility of consumption must be equal to the gross private marginal return on investment,

$$u'(C) = p(I)f'(I). \tag{3}$$

This constraint implies that investment and consumption are positively related in equilibrium: With capital controls it is impossible to reduce investment without also repressing consumption. Together equations (2) and (3) make it possible to write consumption and investment as a function of total expenditure, *C(E)* and *I(E)*. Then it is possible to show that the optimal tax on external borrowing is countercyclical (i.e., smooths the domestic cost of borrowing against variations in the cost of external borrowing) if and only if the following assumption is satisfied.

Assumption 2. *The marginal cost of systemic risk increases with the level of domestic expenditures, i.e.,* $-p'(I(E))f(I(E))I'(E)$ *is increasing with E.*

This assumption is the analog of Assumption 1 for the case of capital controls. The social planner targets the *total* level of expenditures because he can no longer target the level of debt-creating expenditures (investment) separately. Assumption 2 ensures that the optimal tax on external borrowing varies inversely with the external cost of borrowing. Assumptions 1 and 2 are independent (neither one implies the other), but it is not difficult to find specifications of the model in which they are both satisfied. Appendix B presents a quadratic specification of the model in which both assumptions are satisfied and closed-form expressions for the main variables can be derived.

Our main results are summarized below.

Result 1. *Consider a small open economy in which domestic borrowing may be excessive because of a systemic risk externality. The first-best policy instrument is a macroprudential tax on domestic borrowing. A second-best instrument is a macroprudential tax on external borrowing. Under Assumptions 1 and 2, both taxes should be used in a countercyclical way to smooth the domestic cost of borrowing against variations in the external cost of borrowing.*

Proof. See Appendix A.

This analysis raises the question of why governments should ever use prudential capital controls since the first-best instrument is domestic prudential regulation. There are several possible answers to this question.[20]

First, discriminating between the transactions involving residents and nonresidents may be justified if nonresident investors contribute more to systemic risk than resident investors in a crisis. For example, short-term debt could be systemically more dangerous in the hands of nonresident investors if they have a stronger tendency to rush out of a crisis than resident investors. There is evidence that this was the case in the 2008 crisis, when investors tended to retrench on their own countries' assets (Forbes and Warnock 2012). These factors are not explicitly captured by my simple model but they may be important in the real world. In the model, systemic risk is determined by the level of D irrespective of the residency of the debt holders. But one could decompose total debt into the component held by residents (D^h) and the component held by foreigners (D^f) and assume that p is more sensitive to D^f than to D^h.[21]

Second, the appropriate domestic macroprudential taxes may not be available as policy instruments. As discussed in the introduction, the externalities leading to systemic risk do not necessarily all take place inside the banking sector. Thus the scope of macroprudential regulation may be too narrow if it is limited to banks. Although broader macroprudential taxes can in principle be used, they are determined in the context of a political process that makes it unlikely that they will be used according to Pigouvian principles.[22] Capital controls may be the only broad tax-like instruments that are somewhat sheltered from the political process.

Finally, policymakers might have to rely on a wide range of instruments (including second-best ones) because exclusive reliance on a narrow set of instruments may encourage avoidance and circumvention efforts by the private sector. In this case, there could be a maximum level for τ^d, above which there will be excessive avoidance, and at the margin τ^c must be used.

For these reasons, there might be a case for using prudential capital controls as a second-best instrument. In the rest of the analysis, thus, I will assume that countries use capital controls and domestic macroprudential policies.

4. International Spillovers and "Capital Wars"

I now consider a world composed of a large number of small open economies like the one described in the previous section. The countries are indexed by $j \in J$. The global capital market finds its equilibrium for an interest rate r^* such that

$$\sum_{j \in J} S_j(r^* + \tau_j^c) = \sum_{i \in J} I_j(r^* + \tau_j^d + \tau_j^c),$$

where τ_j^d and τ_j^c are country j's taxes on domestic borrowing and external borrowing, respectively. This equation endogenizes the equilibrium global interest rate, r^*, as the level for which global investment is equal to global saving.

It is easy to see that prudential taxes on domestic or external borrowing have international spillovers. All else equal, raising the domestic macroprudential tax in country j lowers the global demand for investment and so the global interest rate. Raising the capital control tax by the same amount lowers the global interest rate even more since it raises the global supply of saving at the same time as it lowers the global demand for investment. In both cases, the other countries respond to the lower global interest rate by increasing their tax rates on domestic or external borrowing. Intuitively, raising the macroprudential taxes in a given country deflects capital flows to the other countries, inducing them to raise their own macroprudential taxes. Macroprudential policies are strategic complements.

This raises the question of the efficiency of the equilibrium that is reached when all countries set their prudential taxes in an uncoordinated way. To answer this question in the context of the model I assume that countries belong to two groups that use different policy instruments: the countries in the first group use the tax on domestic borrowing ($j \in J^d$) whereas the countries in the second group use the tax on external borrowing ($j \in J^c$). The equilibrium global interest rate, then, satisfies

$$(4) \qquad \sum_{j \in J^d} S_j(r^*) + \sum_{j \in J^c} S_j(r^* + \tau_j^c(r^*)) = \sum_{j \in J^d} I_j(r^* + \tau_j^d(r^*)) + \sum_{j \in J^c} I_j(r^* + \tau_j^c(r^*)),$$

where $\tau_j^d(r^*)$ and $\tau_j^c(r^*)$ are the optimal tax responses discussed in the previous section.

The equilibrium level of the global interest rate is lower, and could be much lower than in the absence of macroprudential policies.[23] The Nash equilibrium

in tax policies may thus give the impression of a "capital war," in which countries are engaged in a self-defeating effort to export capital to the rest of the world. As first shown by Korinek (2012) in a similar context, however, the impression that the uncoordinated equilibrium is inefficient is misleading. The Nash equilibrium in macroprudential policies is efficient, as stated in the following result.

Result 2. *Consider a world composed of many small open economies such as the one analyzed in the previous section. Countries mitigate their systemic debt externalities using a macroprudential tax on either domestic borrowing or external borrowing. Then the Nash equilibrium in which each country independently sets its macroprudential tax yields the same allocation as the equilibrium in which all the taxes are set by a global social planner who maximizes global welfare.*

Proof. See Appendix A.

There is no need for the international coordination of macroprudential policies (whether purely domestic or involving the capital account) since the Nash equilibrium between domestic policymakers is Pareto-optimal. The capital war, in other words, is efficient.[24]

The reason for this result is that the international spillovers associated with the use of capital controls (or domestic prudential policies) do not constitute a true international externality. The spillovers countries impose on each other are mediated through a price (the real interest rate) in a perfectly competitive market so that the first welfare theorem applies to the decentralized equilibrium between countries in the same way as it applies between consumers in a general equilibrium model. Each domestic social planner is like a small agent in a competitive market.

An important caveat to this result will be presented in the next section when we look at the case with Keynesian unemployment. But before we proceed with a Keynesian version of the model, other caveats are in order.

First, the results would be different in the presence of cross-country systemic debt externalities. Going back to the microfoundations of the model, one could assume that the consumption good is produced with production inputs from different countries, making default contagious across countries and not only across firms in a given country. This would make it optimal to coordinate national social planners to internalize the cross-country externalities. The point made by Result 2, from this perspective, is that it is not enough to point to cross-country spillovers to justify international policy coordination: One must show that the spillovers involve a true externality.

Second, the uncoordinated use of capital controls increases global welfare less than the uncoordinated use of domestic prudential policies. In fact, it is

easy to construct an example where the uncoordinated use of capital controls does not change global welfare at all. Assume that all countries set their taxes on external borrowing in the same way, i.e., they have the same tax response function $\tau^c(r^*)$. Then the global interest rate must satisfy,

$$\sum_j S_j(r^* + \tau^c(r^*)) = \sum_j I_j(r^* + \tau^c(r^*)).$$

It follows that the equilibrium cost of borrowing, $r^* + \tau^c(r^*)$, must be the same as the level of the interest rate that would be observed in the equilibrium without macroprudential taxes. The uncoordinated use of capital controls, thus, is self-defeating in the sense that it leads to exactly the same allocation (and the same level of welfare) as if no capital control were used. If the use of capital controls entailed some administrative cost on the side of governments, or costly circumvention effort on the side of the private sector, there would be a case for international coordination to reduce or save these costs, as noted by Ostry, Ghosh, and Korinek (2012).

Third, we have assumed so far a large number of countries. With strategic interactions between a small number of countries, the results are different. In the two-country model of Costinot, Lorenzoni, and Werning (2011), the borrowing country can raise its welfare relative to the laissez-faire level by restricting its borrowing and in this way lower the interest rate that it must pay to the lending country. Conversely, the lending country will want to restrict its lending to raise the world interest rate. The Nash equilibrium of this game leads to a Pareto inefficient "capital war" in which both countries see their welfare decreased. This is essentially the transposition to intertemporal trade of the classical optimal tariff argument for free trade.

5. Capital War in a Global Liquidity Trap

The previous section showed that a capital war was efficient even though it depressed the level of the global interest rate. The model, however, may have missed an important reason why depressing the real interest rate is problematic in the real world: the existence of a zero bound on the nominal interest rate that prevents the real interest rate from reaching the full-employment level. Could a capital war be costly and inefficient because it leads to unemployment in a global liquidity trap?

One cannot study this question without making significant changes in the model. Instead of looking at a real endowment economy, I now introduce money and nominal rigidities and make output endogenous. With the new model in hand, I re-examine the case for international coordination of macroprudential policies. Finally, I look at the scope for international policy coordination in

an asymmetric world with one country (interpreted as the United States) that attempts to implement a monetary stimulus in a liquidity trap whereas countries in the rest of the world set their macroprudential policies to limit the spillovers from the monetary stimulus.

5.1. A Keynesian Model

The model is made Keynesian in the most simple way possible. In particular, I consider a world with only one currency to focus on the interactions between national macroprudential policies rather than between monetary policies. This could also be interpreted as a world with fixed exchange rates (not necessarily a bad approximation if one thinks of the policy interactions between, say, the United States and China.) The nominal price of the good in terms of the global currency is denominated by P.

One key difference with the model used so far is that first-period output is now endogenous and can be demand-determined. Each country produces output with labor according to the production function $Y_j = g_j(L_j)$ where $g_j(\cdot)$ is increasing and concave. The demand for labor from the first-order condition,

$$g_j'(L_j) = \frac{W_j}{P},$$

where W_j is the nominal wage in country j and P is the nominal price of the good (the same in all countries by the law of one price).

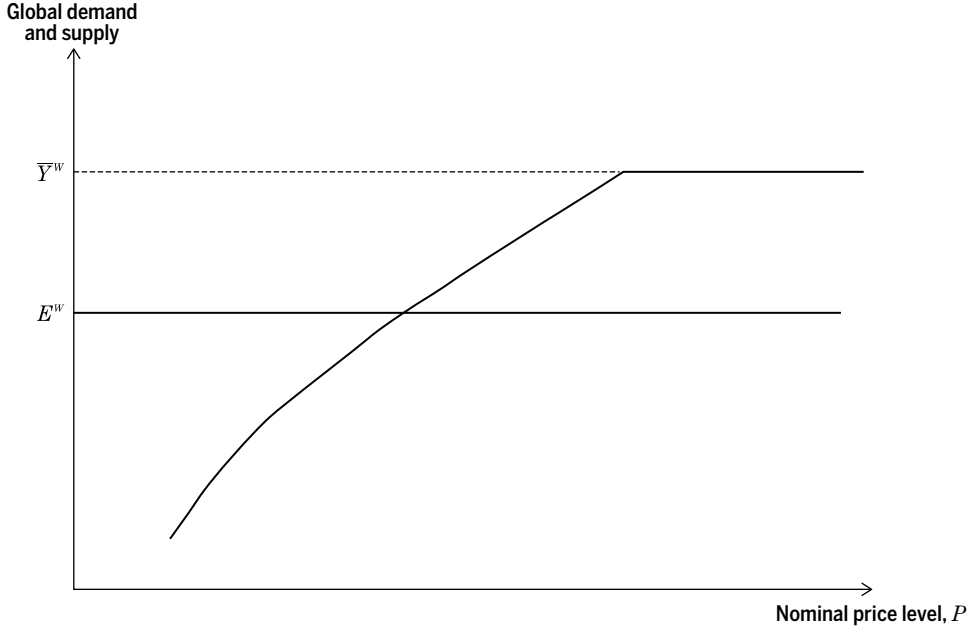
I assume that the nominal wage is rigid downward in the same way as in Schmitt-Grohé and Uribe (2012). The total quantity of labor used in the economy cannot increase above a level corresponding to full employment, whereas the nominal wage cannot fall below a level that is predetermined for each country,

$$L_j \leq \overline{L}_j, \quad W_j \geq \underline{W}_j.$$

A given economy can then be in two regimes. Either there is full employment and $W_j = g_j'(\overline{L}_j)P$, or there is less than full employment and $W_j = \underline{W}_j$. Which regime the economy lands in depends on how the global price of the good compares with the country's nominal wage. Country j has full employment if $P \geq \underline{W}_j / g_j'(\overline{L}_j)$. Once full employment is achieved, increases in the world price level are reflected one-for-one in domestic wages because wages are flexible upward.

Figure 4 shows how global supply $Y^W = \sum_j g_j(L_j)$ varies with the nominal price level. An increase in the nominal price level raises supply by lowering the real wage, like in the textbook model of aggregate supply and aggregate demand. When the nominal price level falls below a certain threshold, there is unemployment in some countries. In general, the unemployment could be

FIGURE 4
Global Supply and Global Demand



spread across all countries (this would be true in the symmetric case where all countries are identical) or it would be concentrated in a few countries that have high nominal wages relative to their productivity.

The figure also shows the level of aggregate demand,

$$E^W = \sum_{j \in J^d} [C_j(r^*) + I_j(r^* + \tau_j^d)] + \sum_{j \in J^c} [C_j(r^* + \tau_j^c) + I_j(r^* + \tau_j^c)],$$

where $C_j(\cdot)$ gives consumption in country j as a function of the interest rate. Global demand is represented by a horizontal line in Figure 4 because it does not depend on the nominal price level. It is determined instead by the real interest rate as well as the macroprudential taxes, and it is decreasing in these variables. Global demand is equal to the full-employment level of global supply when the real interest rate is at the Wicksellian level.[25] Importantly, the macroprudential taxes depress global demand and thus lower the Wicksellian interest rate.

Finally, we need to specify how the real interest rate is determined. I assume that a global monetary authority sets the nominal interest rate i^*. The expected rate of inflation, denoted by π^*, is taken as exogenous, for example because it results from a credible inflation targeting mandate. Variations in the

nominal interest rate, thus, are reflected one-for-one in the real interest rate, $r^* = i^* - \pi^*$. In addition monetary policy is constrained by the usual zero bound on the nominal interest rate. Thus, one can think of the monetary authority as setting the real interest rate subject to the constraint,

$$r^* \geq -\pi^*.$$

5.2. The Benefits from International Coordination

We now return to the Nash equilibrium between the domestic social planners in charge of macroprudential policy. Like before I assume that each domestic social planner uses one macroprudential tax, which is either on domestic borrowing or on foreign borrowing. There is now one more player in the game between policymakers: the global monetary authority. For simplicity I assume that the global monetary authority maximizes global employment conditional on the inflation target π^*. In the next section I will address a case where the monetary authority maximizes the welfare of a particular country.

An equilibrium, then, is characterized by a set of macroprudential taxes on domestic borrowing, τ_j^d ($j \in J^d$), and on foreign borrowing, τ_j^e ($j \in J^e$), as well as a real interest rate r^* such that:

(1) the domestic social planner of each country j sets his macroprudential tax (τ_j^d or τ_j^e) to maximize domestic welfare, taking the macroprudential taxes of the other countries and the global real interest rate as given;

(2) the global monetary authority sets the real interest rate r^* to maximize global employment subject to the constraint $r^* \geq -\pi^*$ taking the countries' macroprudential taxes as given.

It is easy to see that now, a capital war can decrease the welfare of all countries. This is clear in the special case where all countries are identical and use capital controls. Then as we saw in Section 4 in the case of an endowment economy without nominal stickiness, the capital war decreases the real interest rate without changing the allocation. If it decreases the real interest rate from a level that is above $-\pi^*$ to a level that is below $-\pi^*$, the capital war will lead, in the presence of nominal stickiness, to a global liquidity trap with unemployment in all countries. All the countries would then benefit from an international agreement not to use capital controls, which would restore full employment.

The case for the international coordination of macroprudential policies is more general than that. It arises as soon as there is unemployment in some countries, as stated in the following result.

Result 3. *Assume that there is unemployment in some countries in the Nash equilibrium between macroprudential policymakers. Then a coordinated*

reduction in the macroprudential taxes of the countries with unemployment raises the welfare of those countries without affecting the welfare of the countries with full employment.

Proof. See Appendix A.

There is scope for Pareto-improving international coordination of macroprudential taxes in a world with unemployment. The intuition is that the countries with unemployment do not internalize the impact of their macroprudential taxes on global demand. Global demand creates a true international externality because each country, by imposing taxes on domestic or external borrowing, reduces the demand for the output of other countries in a way that is not mediated by a competitive price. At the margin, countries with unemployment suffer a second-order loss from lowering their prudential taxes but a first-order gain from an increase in global demand that raises their employment level. As for the welfare of countries with full employment, it does not change since the global real interest rate stays at the same level (it is equal to minus the inflation target because the zero-bound constraint is binding).

Importantly, the scope for policy coordination does not include the countries with full employment. This is because (realistically) we have not allowed the countries that lose from a change in macroprudential policies to be compensated by international transfers. Otherwise the countries with unemployment would find it optimal to pay the countries with full employment to reduce their macroprudential taxes. The countries with full employment would suffer a second-order loss from slightly reducing their taxes, whereas the countries with unemployment would have a first-order gain from increasing their employment. But in the absence of transfer (or any other type of reward), there is no way that the countries with full employment can be induced to reduce their macroprudential taxes below the uncooperative level.

5.3. U.S. Monetary Stimulus vs. Chinese Reserve Accumulation

I now consider an application of the model to the equilibrium between monetary policy in one part of the world and prudential reserve accumulation in the rest of the world. In the wake of the Great Recession the monetary authorities in most advanced economies, after lowering their policy rates to levels close to zero, have resorted to unconventional forms of monetary stimulus such as quantitative easing or forward guidance. This induced global capital to move towards emerging market economies, which in response accumulated foreign exchange reserves and in some cases imposed restrictions on capital inflows. Does the model support the view that there is scope for efficient policy coordination in such a situation?[26]

The question can be addressed by specializing the model as follows. Two countries in the model are labeled "U.S." and "China." The global real interest rate is set by the U.S. to maximize its welfare. The capital account of China is closed except for the accumulation of foreign assets (reserves).[27] The accumulation of foreign reserves by China is denoted B_C. We consider a Nash equilibrium between the U.S. setting the interest rate r^* and China accumulating reserves B_C.

For simplicity I focus on equilibria in which there is full employment in China but not in the United States. There is less than full employment in the U.S. because of the lower bound on the real interest rate,

$$r^* \geq -\pi^*.$$

China accumulates reserves to contain the growth in domestic credit caused by U.S. monetary stimulus. For simplicity I assume that there is no debt externality in the United States.[28]

Given that there is full employment in China, its output is equal to $Y_C = g_C(\overline{L}_C)$. Setting foreign reserves B_C is equivalent to setting the level of domestic expenditures $E_C = Y_C - B_C$. Increasing Chinese reserves by one dollar reduces Chinese domestic expenditures by the same amount. Thus Chinese consumption and investment can be written as functions of reserves in the same way as in section 3.3., $C_C(B_C)$ and $I_C(B_C)$. Both consumption and investment are decreasing with B_C since reserve accumulation reduces domestic expenditures. The problem of the Chinese social planner can be written,

$$U_C = \max_{B_C} u_C(C_C(B_C)) + p_C(I_C(B_C))I_C(B_C) + (1 + r^*)B_C.$$

It then follows from the envelope theorem that the partial derivative of Chinese welfare with respect to the real interest rate is equal to the level of Chinese reserves,

$$\frac{\partial U_C}{\partial r^*} = B_C.$$

An increase in the interest rate raises Chinese welfare by increasing the return that it receives on its reserves.

As for U.S. welfare, it is given by,

$$U_{US} = u_{US}(C_{US}) + p_{US}I_{US} - (1 + r^*)B_C, \tag{5}$$

where we have used the fact that Chinese foreign assets are U.S. foreign liabilities. The probability of a high payoff on the investment does not depend on the level of debt because we have assumed away the debt externality in the U.S.

The U.S. social planner's problem, thus, is rather simple. If China accumulates a positive level of reserves ($B_C > 0$), the right-hand side of equation (5) is maximized when the real interest rate is minimized. It is thus optimal for the U.S. social planner to set the real interest rate at the lowest possible level subject to the zero-bound constraint, $r^* = -\pi^*$. At the margin, any increase in U.S. consumption or investment is "free" since it is produced by unemployed U.S. labor.

Given that the first two terms on the right-hand side of equation (5) do not depend on B_C, U.S. welfare is decreasing with Chinese reserves,

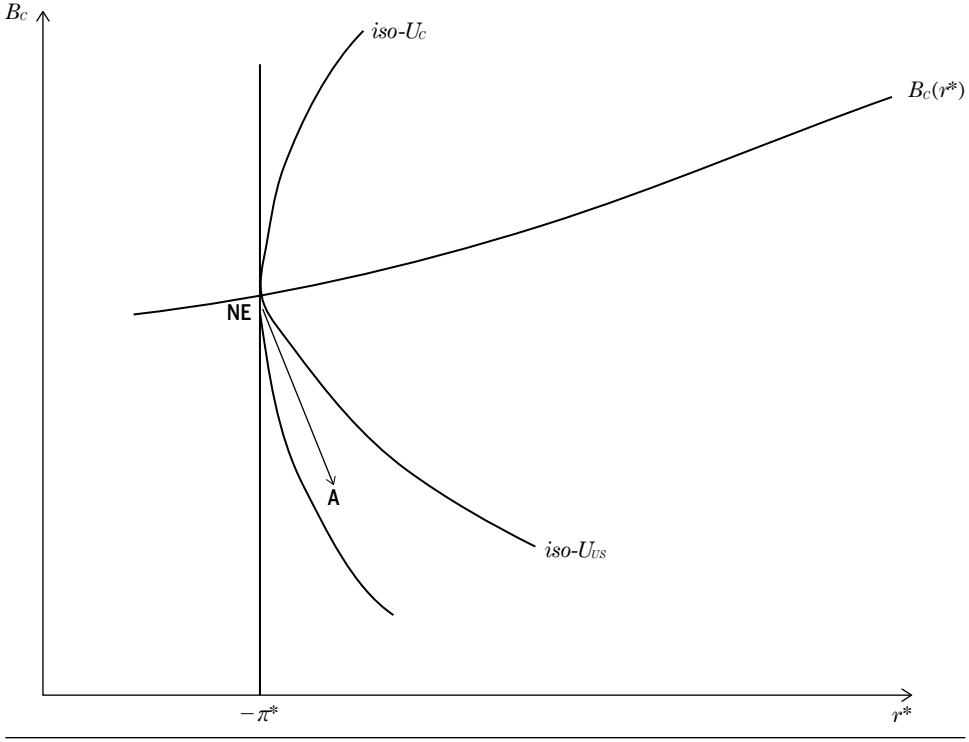
$$\frac{\partial U_{US}}{\partial B_C} = -(1 + r^*).$$

An increase in Chinese reserves lowers global demand and U.S. production by the same amount (since Chinese production does not increase at the margin). The gross interest rate appears on the right-hand side of the expression above because the U.S. borrows from China to cover the fall in its first-period income.

We are now ready to look at the case for international coordination. Figure 5 shows the policy instruments of the U.S. on the horizontal axis and China on the vertical axis. The curve labeled $B_C(r^*)$ shows how China's optimal level of reserves increases with the real interest rate. The vertical line corresponds to the optimal U.S. policy, which sets the real interest rate at the minimum level irrespective of what China does. The Nash equilibrium is at the intersection of the two countries' best response curves (the point labeled NE in the figure). As a condition for optimality the iso-welfare curve of China must be tangent to the vertical line. Finally, the figure shows the U.S. iso-welfare curve that passes through the Nash equilibrium. This curve is downward-sloping since an increase in the real interest rate that reduces U.S. welfare must be offset by a decrease in Chinese reserves that raises the demand for U.S. output.

The figure shows that the Nash equilibrium is not Pareto-optimal. Welfare for both the U.S. and China are increased by moving from the Nash equilibrium to a point such as A, where the U.S. sets a higher interest rate and China accumulates less reserves than in the uncooperative equilibrium. Then China benefits from receiving a higher return on its reserves, whereas the U.S. benefits from a higher level of Chinese demand. The U.S. suffers from raising its own interest rate, but it is always possible to make this cost smaller than the benefit that it receives from larger Chinese demand. This is because the cost incurred by China for raising its own demand is second-order since Chinese welfare was at its maximum in the Nash equilibrium. Thus China can be compensated for

FIGURE 5
Monetary Stimulus and Reserve Accumulation



increasing global demand by a very small (second-order) increase in the U.S. interest rate.

Result 4. *Assume that the model has two countries. One country (the U.S.) sets the global interest rate and has some unemployment because of the zero-bound constraint. The other country (China) has full employment and accumulates foreign reserves for prudential reasons. Then in the Nash equilibrium there is scope for Pareto-improving policy coordination in which the U.S. raises its interest rate and China lowers its reserve accumulation at the margin.*

Proof. See discussion above.

6. Conclusion

I have presented a simple framework that allows us to compare the welfare effects of domestic prudential policies and prudential capital account policies in a small open economy; analyze the general equilibrium effects of the

uncoordinated use of these policies; and explore the case for the coordination of macroprudential and monetary policies at the global level. The main conclusions are as follows: (1) Domestic prudential policies are generally preferable to capital controls, but realistic constraints on the use of the former may justify using the latter. (2) The fact that these policies have international spillovers does not per se imply that they should be subject to international rules or coordination. However, (3) International coordination may be justified if there is a global demand shortage.

The bottom line, thus, is that a case for the international coordination of macroprudential policies can be made, but it is not as robust or generic as one might expect. The case for coordination cannot be based merely on the existence of international spillovers and depends on the circumstances of global demand.[29] The case for coordination is stronger in a bust—when global resources are underutilized—than in a boom. This suggests that coordination should be run on an ad hoc basis and, when circumstances require, perhaps under the auspices of the Group of Twenty. Furthermore it will be difficult to involve the countries that have full employment in the coordination effort. Basic theory does not suggest that the international oversight of prudential capital control policies should be supported by the kind of permanent institutions that exist for international trade, such as the World Trade Organization.

APPENDIX A

Proofs

Proof of Result 1. The claims in Result 1 have been proven in the text except for the statement that the optimal tax on external borrowing is countercyclical under Assumption 2. Domestic welfare is equal to the utility that lenders derive from their first-period consumption, $u(C)$, plus the expected second-period income of lenders and borrowers, which is equal to the payoffs from the domestic investment and from the foreign assets,

$$U = u(C) + p(I)f(I) + (1 + r^*)(Y - C - I).$$

If the domestic social planner uses capital controls, consumption and investment can be written as functions of the level of domestic expenditure, E, with $C(E) + I(E) = E$. Differentiating domestic welfare with respect to the level of expenditure gives,

$$\frac{dU}{dE} = p(I(E))f'(I(E)) + p'(I(E))f(I(E))I'(E) - (1 + r^*).$$

To derive this expression we have used the first-order condition $u'(C) = p(I)f'(I)$ as well as $C'(E) + I'(E) = 1$. The first term on the right-hand side is the private marginal utility gain from increasing total expenditure, which by the envelope theorem is the same as if the marginal expenditure were spent on investment. The second term on the right-hand side is the social cost from increasing total expenditure, equal to the marginal increase in the probability of a systemic crisis due to higher debt.

Figure A1 is similar to Figure 2 but with total expenditures instead of investment on the horizontal axis. The marginal gain from increasing total expenditures is lower from a social perspective than from a private perspective. A social planner would choose a level of expenditures E^{sp} such that the social marginal gain is equal to the gross external cost $1 + r^*$. This can be achieved by a Pigouvian tax on external borrowing equal to

$$\tau^c = -p'(I(E^{sp}))f(I(E^{sp}))I'(E^{sp}).$$

As shown by Figure A1, a lower cost of external borrowing r^* increases total expenditures and, if Assumption 2 is true, also increases the optimal tax on external borrowing.

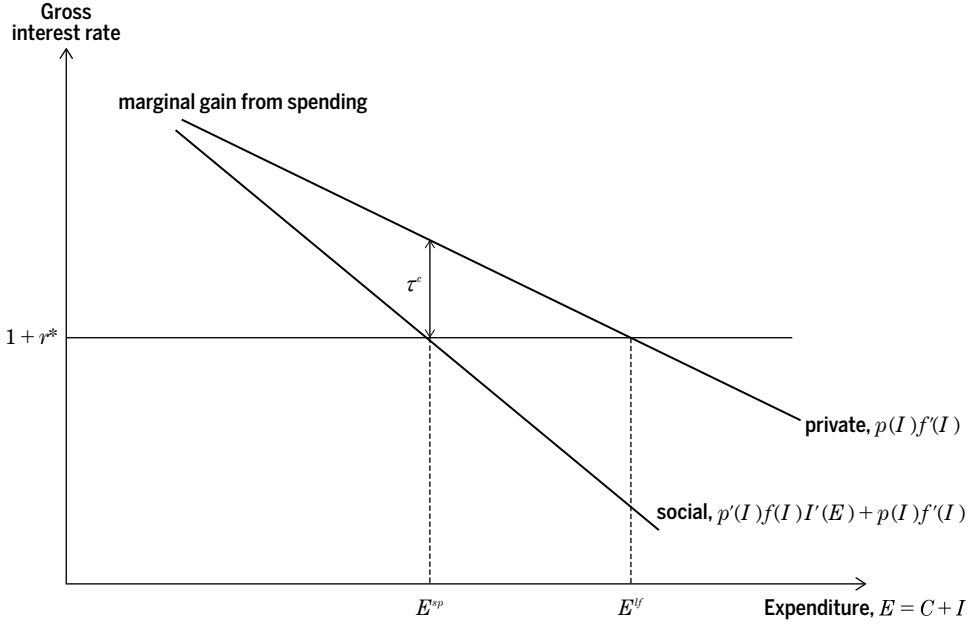
Proof of Result 2. The global social planner's problem is

$$\begin{cases} \max \sum_j [u_j(C_j) + p_j(I_j)f_j(I_j)] \text{ s.t.} \\ \sum_j (C_j + I_j) \leq \sum_j Y_j, \\ u_j'(C_j) \geq p_j(I_j)f_j'(I_j) \text{ for } j \in J^c. \end{cases}$$

The global social planner maximizes global welfare, which is equal to the sum of the utilities that lenders derive from first-period consumption plus the expected levels of second-period output. The first constraint is the global resource constraint. The second constraint is that the marginal utility of consumption cannot be smaller than the private marginal return on investment for the countries that use capital controls.

For the countries that use domestic macroprudential policies ($j \in J^d$), the first-order conditions are

FIGURE A1
The Optimal Level of Tax on Capital Inflows



$$u_j'(C_j) = \lambda,$$
$$p_j'(I_j)f_j(I_j) + p_j(I_j)f_j'(I_j) = \lambda,$$

where λ is the shadow cost of the global resource constraint.

For the countries that use prudential capital controls ($j \in J^c$), the first-order conditions are:

$$u_j'(C_j) = \lambda - \mu_j u_j''(C_j),$$
$$p_j'(I_j)f_j(I_j) + p_j(I_j)f_j'(I_j) = \lambda + \mu_j[p_j'(I_j)f_j'(I_j) + p_j(I_j)f_j''(I_j)],$$

where μ_j is the shadow cost of the constraint on the marginal utility of consumption.

The first-order conditions and the constraints are the same as in the Nash equilibrium with independent national planners, with $\lambda = 1 + r^*$. Hence a global social planner who maximizes global welfare chooses the same allocation as the one obtained in the Nash equilibrium between national social planners.

Proof of Result 3. We consider a Nash equilibrium with unemployment in some countries. In such an equilibrium the zero-bound constraint is binding, $r^* = -\pi^*$.

Let us assume that all the countries with unemployment ($j \in U$) reduce their macroprudential tax by a small (first-order) amount $d\tau$. This increases global demand by,

$$-\sum_{j \ni U \cap J^d} I'(r^* + \tau_j^d(r^*))d\tau - \sum_{j \ni U \cap J^c} [C'(r^* + \tau_j^c(r^*)) + I'(r^* + \tau_j^c(r^*))]d\tau = dE^W > 0.$$

The increase in global demand is matched by an increase in supply from the countries with unemployment. In equilibrium, there is a small increase in the nominal price of the good ($dP > 0$), which raises supply in all the countries with unemployment by $dY_j > 0$ in such a way that $\sum_{j \in U} dY_j = dE^W$. Since there is still some unemployment left after this first-order change, the global monetary authority keeps the nominal interest rate at the zero bound and there is no change in the real interest rate r^*.

The welfare of a country that uses domestic macroprudential regulation is given by,

$$U_j = \max_{C_j, I_j} u_j(C_j) + p_j(I_j) f_j(I_j) + (1 + r^*)(Y_j - C_j - I_j).$$

The welfare of a country that uses prudential capital controls can be written in the same way, with the additional constraint $p_j(I_j) f_j'(I_j) = u_j'(C_j)$. By the envelope theorem, the change in country j's welfare is,

$$dU_j = (1 + r^*) dY_j > 0.$$

Thus all the countries with unemployment have a positive welfare gain, whereas the countries at full employment see their welfare unchanged.

APPENDIX B

Linear-Quadratic Specification of the Model

Let us assume that output and systemic risk vary linearly with investment and debt respectively,

$$f(I) = (1+\rho)I, \quad p(D) = 1 - D/\overline{D},$$

where ρ and $\overline{D}$ are exogenous parameters. We assume $\rho > r^*$ to ensure that investment is profitable when there is no systemic risk. Under these assumptions the laissez-faire level of debt and investment satisfies $p(I^{lf})(1+\rho) = 1 + r^*$, implying

$$I^{lf} = \frac{\rho - r^*}{1+\rho}\overline{D}.$$

The first-best level of investment maximizes $(1 - I/\overline{D})(1+\rho)I - (1+r^*)I$. It is equal to one-half of the laissez-faire level of investment,

$$I^{fb} = \frac{\rho - r^*}{1+\rho}\frac{\overline{D}}{2}.$$

This level of investment can be achieved using a macroprudential tax on domestic borrowing $\tau^d = -p'(I^{fb})f(I^{fb}) = (1+\rho)I^{fb}/\overline{D}$ or

$$\tau^d = \frac{\rho - r^*}{2}.$$

As a result the net domestic cost of borrowing is $(r^* + \rho)/2$. The optimal tax smooths out one-half of the variations in the external cost of borrowing.

The utility for consumption is quadratic,

$$u(C) = \alpha C(\overline{C} - C/2),$$

where $\overline{C}$ is the satiation level in consumption. It follows that saving is a linear function of the real interest rate,

$$S(r) = Y - \overline{C} + \frac{1+r}{\alpha}.$$

When the social planner uses a tax on external borrowing, he optimizes under the constraint $u'(C) = p(I)f'(I)$, or

$$\alpha(C - \overline{C}) = (1+\rho)(1 - I/\overline{D}).$$

This constraint, together with the definition of total expenditures, $E = I + C$, can be used to derive how consumption and investment increase with total expenditures,

$$C = \frac{\overline{C} - \beta\overline{D} + \beta E}{1+\beta},$$

$$I = \frac{\beta\overline{D} - \overline{C} + E}{1+\beta},$$

where $\beta \equiv (1+\rho)/(\alpha\overline{D})$. The optimal tax on external borrowing is

$$\tau^e = \frac{\rho - r^*}{2+\beta}.$$

It is smaller than τ^d, the optimal tax on domestic borrowing. One can show, finally, that the current account balance is larger with the optimal tax on external borrowing than with the optimal tax on domestic borrowing.

REFERENCES

Acemoglu, Daron, Azarakhsh Malekian, and Asuman Ozdaglar. 2013. "Network Security and Contagion." National Bureau of Economic Research Working Paper 19174.

Aiyar, Shekhar, Charles W. Calomiris, and Tomasz Wieladek. 2012. "Does Macropru Leak? Evidence from a UK Policy Experiment." National Bureau of Economic Research Working Paper 17822.

Aizenman, Joshua, and Jaewoo Lee. 2010. "The Real Exchange Rate, Mercantilism, and the Learning By Doing Externality." *Pacific Economic Review* 15(3), pp. 324–335.

Barthold, Thomas A. 1994. "Issues in the Design of Environmental Excise Taxes." *Journal of Economic Perspectives* 8(1), pp. 133–151.

Bengui, Julien. 2012. "Macroprudential Policy Coordination and Global Regulatory Spillovers." Unpublished manuscript, University of Montreal.

Benigno, Gianluca, Huigang Chen, Christopher Otrok, Alessandro Rebucci, and Eric Young. 2013. "Financial Crises and Macro-prudential Policies." *Journal of International Economics* 89(2), pp. 453–470.

Bernanke, Ben S., Carol Bertaut, Laurie Pounder DeMarco, and Steven Kamin. 2011. "International Capital Flows and the Returns to Safe Assets in the United States, 2003–2007." International Finance Discussion Paper 1014, Board of Governors of the Federal Reserve System.

Bianchi, Javier, and Enrique Mendoza. 2010. "Overborrowing, Financial Crises, and Macroprudential Policy?" National Bureau of Economic Research Working Paper 16091.

Bianchi, Javier. 2011. "Overborrowing and Systemic Externalities in the Business Cycle." *American Economic Review* 101(7), pp. 3400–3426.

Blanchard, Olivier, and Gian Maria Milesi-Ferretti. 2012. "(Why) Should Current Account Balances Be Reduced?" *IMF Economic Review* 60(1), pp. 139–150.

Borio, Claudio. 2003. "Towards a Macroprudential Framework for Financial Supervision and Regulation?" Bank for International Settlements Working Paper 128.

Calvo, Guillermo A. 1988. "Servicing the Public Debt: The Role of Expectations." *American Economic Review* 78(4), pp. 647–661.

Calvo, Guillermo A. 1998. "Capital Flows and Capital-Market Crises: The Simple Economics of Sudden Stops." *Journal of Applied Economics* 1(1), pp. 35–54.

Claessens, Stijn, Swati R. Ghosh, and Roxana Mihet. 2013. "Macro-Prudential Policies to Mitigate Financial System Vulnerabilities." Manuscript, International Monetary Fund.

Costinot, Arnaud, Guido Lorenzoni, and Ivan Werning. 2011. "A Theory of Optimal Capital Controls." Manuscript, MIT.

Dell'Ariccia, Giovanni, Luc Laeven, Deniz Igan, and Hui Tong. 2012. "Policies for Macrofinancial Stability: How to Deal with Credit Booms." IMF Staff Discussion Note 12/06, International Monetary Fund.

De Nicolo, Gianni, Giovanni Favara, and Lev Ratnovski. 2012. "Externalities and Macro-Prudential Policy." IMF Staff Discussion Note 12/05, International Monetary Fund.

Farhi, Emmanuel, and Ivan Werning. 2012. "Dealing with the Trilemma: Optimal Capital Controls with Fixed Exchange Rates." National Bureau of Economic Research Working Paper 18199.

Forbes, Kristin, Marcel Fratzscher, Thomas Kostka, and Roland Straub. 2011. "Bubble Thy Neighbor: Direct and Spillover Effects of Capital Controls." MIT Working Paper.

Forbes, Kristin, and Francis Warnock. 2012. "Capital Flow Waves: Surges, Stops, Flight, and Retrenchment." *Journal of International Economics* 88(2), pp. 235–251.

Galati, Gabriele, and Richild Moessner. 2013. "Macroprudential Policy—A Literature Review." *Journal of Economic Surveys* 27(5), pp. 846–878.

Hanson, Samuel, Anil Kashyap, and Jeremy Stein. 2011. "A Macroprudential Approach to Financial Regulation." *Journal of Economic Perspectives* 25(1), pp. 3–28.

Holmström, Bengt, and Jean Tirole. 1998. "Private and Public Supply of Liquidity." *Journal of Political Economy* 106(1), pp. 1–40.

International Monetary Fund (IMF). 2011. "Recent Experiences in Managing Capital Inflows: Cross-Cutting Themes and Possible Policy Framework." http://www.imf.org/external/np/pp/eng/2011/021411a.pdf

Jeanne, Olivier. 2013a. "Capital Account Policies and the Real Exchange Rate." Conference proceedings, NBER International Seminar on Macroeconomics 2012 (ISOM), ed. Francesco Giavazzi and Kenneth D. West, 7–42. Chicago: University of Chicago Press.

Jeanne, Olivier. 2013b. "Overborrowing and Demand Externalities." Manuscript in progress, Johns Hopkins University.

Jeanne, Olivier, and Anton Korinek. 2010a. "Excessive Volatility in Capital Flows: A Pigouvian Taxation Approach." *American Economic Review Papers and Proceedings* 100(2), pp. 403–407.

Jeanne, Olivier, and Anton Korinek. 2010b. "Managing Credit Booms and Busts: A Pigouvian Taxation Approach." National Bureau of Economic Research Working Paper 16899.

Jeanne, Olivier, Arvind Subramanian, and John Williamson. 2012. *Who Needs to Open the Capital Account?* Washington, DC: Peterson Institute for International Economics.

Klein, Michael, and Jay Shambaugh. 2013. "Rounding the Corners of the Policy Trilemma: Sources of Monetary Policy Autonomy." National Bureau of Economic Research Working Paper 19461.

Korinek, Anton. 2010. "Regulating Capital Flows to Emerging Markets: An Externality View." Unpublished manuscript, University of Maryland.

Korinek, Anton. 2011. "The New Economics of Prudential Capital Controls: A Research Agenda." *IMF Economic Review* 59, pp. 523–561.

Korinek, Anton. 2012. "Capital Controls and Currency Wars." Unpublished manuscript, University of Maryland.

Lim, C., F. Columba, A. Costa, P. Kongsamut, A. Otani, M. Saiyid, T. Wezel, and X. Wu. 2011. "Macroprudential Policy: What Instruments and How to Use Them? Lessons from Country Experiences." International Monetary Fund Working Paper 11/238.

Lorenzoni, Guido. 2008. "Inefficient Credit Booms." *Review of Economic Studies* 75(3), pp. 809–833.

Mian, Atif, and Amir Sufi. 2009. "House Prices, Home Equity-Based Borrowing, and the U.S. Household Leverage Crisis." National Bureau of Economic Research Working Paper 13936.

Obstfeld, Maurice. 2012. "Does the Current Account Still Matter?" *American Economic Review* 102(3), pp. 1–23.

Ostry, Jonathan D., Atish Ghosh, Karl Habermeier, Luc Laeven, Marcos Chamon, Mahvash Qureshi, and Annamaria Kokenyne. 2011. "Managing Capital Inflows: What Tools to Use?" IMF Staff Discussion Note, 11/06, International Monetary Fund.

Ostry, Jonathan D., Atish Ghosh, Marcos Chamon, and Mahvash Qureshi. 2012. "Managing Capital Inflows: The Role of Capital Controls and Prudential Policies." *Journal of International Economics* 88, pp. 407–421.

Ostry, Jonathan D., Atish Ghosh, and Anton Korinek. 2012. "Multilateral Aspects of Managing the Capital Account." IMF Staff Discussion Note 12/10, International Monetary Fund.

Perotti, Enrico, and Javier Suarez. 2011. "A Pigovian Approach to Liquidity Regulation." *International Journal of Central Banking* 7(4), pp. 3–41.

Schmitt-Grohe, Stephanie, and Martin Uribe. 2012. "Prudential Policy for Peggers." National Bureau of Economic Research Working Paper 18031.

Shin, Hyun Song. 2010. "Non-core Liabilities Tax as a Tool for Prudential Regulation." Policy memo, Princeton University.

Stein, Jeremy C. 2012. "Monetary Policy as Financial Stability Regulation." *Quarterly Journal of Economics* 127(1), pp. 57–95.

Williamson, John. 2005. *Curbing the Boom-Bust Cycle: Stabilizing Capital Flows to Emerging Markets.* Washington, DC: Institute for International Economics.

NOTES

1 For example, Brazil introduced a tax on all capital inflows except direct investment in October 2009. Prudential capital controls have been viewed with more sympathy than in the past by the official sector (IMF 2011, Ostry et al. 2011). In its Seoul Action Plan (following the 2010 Group of 20 summit in Seoul), the G-20 endorsed the use of "carefully designed macro-prudential measures" to deal with excessive volatility in capital flows to emerging market economies. See Williamson (2005) for a pre-crisis exposition of the merits of prudential capital flow management for emerging market economies.

2 There is evidence that capital controls deflect capital flows between emerging market economies. For example, Forbes et al. (2011) find that capital controls in Brazil caused investors to increase the share of their portfolios allocated to other Latin American countries, possibly shifting vulnerabilities from one country to another.

3 See Borio (2003) for a pre-crisis discussion of macroprudential policy.

4 Hanson, Kashyap, and Stein (2011, p. 3) differentiate microprudential and macroprudential regulation as follows: "A microprudential approach is one in which regulation is partial-equilibrium in its conception and is aimed at preventing the costly failure of individual financial institutions. By contrast, a macroprudential approach recognizes the importance of general-equilibrium effects, and seeks to safeguard the financial system as a whole."

5 See De Nicolo, Favara, and Ratnovski (2012) for a discussion of the externalities that underpin the macroprudential regulation of banks. See Stein (2012) and Acemoglu, Malekian, and Ozdaglar (2013) for models of systemic risk in the banking sector based on these externalities.

6 Of the 10 macroprudential instruments reviewed by Lim et al. (2011), none takes the form of a tax.

7 Benigno et al. (2013) compare the use of ex ante prudential capital controls and ex post interventions in a small open economy with collateral frictions.

8 The international coordination of capital control policies has also been studied in models where these controls are not implemented for prudential reasons. Farhi and Werning (2012) look at the macrostabilization benefits of capital controls for economies with a fixed exchange rate or a common currency in the context of a New Keynesian framework with nominal stickiness, and find a very limited need for coordination. Costinot, Lorenzoni, and Werning (2011) find that international cooperation may be warranted if countries are large enough to influence their intertemporal terms of trade (the world real interest rate).

9 Claessens, Ghosh, and Mihet (2013) find similar results based on disaggregated data on more than 2,000 banks in 48 emerging market and advanced economies.

10 See IMF (2011) for a review of this literature, and Ostry et al. (2012) for a recent study. Klein and Shambaugh (2013) find that capital controls must be broad-based in order to be effective.

11 For example, Aiyar, Calomiris, and Wieladek (2012) find that U.K.-owned banks and resident foreign subsidiaries reduce lending in response to tighter capital requirements, but this effect is partially offset by an increase in lending from resident foreign branches.

12 Basel III allows domestic regulators to require foreign regulators to impose higher capital standards on domestic lending by foreign banks, which may reduce future leakage.

13 In the microfounded model the probability of a systemic debt crisis depends on the level of debt repayment in period 2, $(1+r)D/p$, rather than on the level of debt issued in period 1, D. This complicates the model in ways that are interesting in some respects (for example by generating multiple equilibria à la Calvo 1988) but that are not essential for the analysis in this paper.

14 This is because the lenders are risk-neutral and appropriately compensated for the risk of default in equilibrium. This ignores the fact that the lenders could suffer from a debt crisis through other channels, for example if they receive a wage income from the productive sector. In this case the social planner has to take into account the impact of prudential policies on agents other than the borrowers, but the essence of our results carries through.

15 A tax on domestic borrowing is a tax paid by all domestic borrowers irrespective of the residency of the lenders or the jurisdiction of issuance.

16 The promised debt repayment must be $(1+r^*+\tau)/p$ if the tax is not paid when the borrower defaults. Like the interest rate, the ex ante tax rate is increased by a default premium.

17 For simplicity I assume that $p(I)f(I)$ is a concave function of I so that the first-order condition is sufficient for optimality.

18 Similar results hold if the cycle is induced by a change in domestic productivity that changes the private and social marginal gains from investing by the same factor.

19 This is not to suggest that the motive for reserve accumulation in China is primarily prudential—as opposed to, say, maintaining a competitive exchange rate.

20 See Ostry, Ghosh, and Korinek (2012) for a related discussion of this issue.

21 Another consideration is that in models where the pecuniary externality involves the real exchange rate, such as Korinek (2010), the repayment of foreign currency debt has a larger systemic impact on the domestic economy if it involves a transfer to foreign creditors.

22 The evidence suggests that even taxes that are explicitly designed to address externalities are heavily influenced by other considerations—see for example Barthold (1994) for the case of environmental taxation in the United States.

23 The strategic complementarity between macroprudential policies does not lead to equilibrium multiplicity. As $r^*+\tau^c(r^*)$ and $r^*+\tau^d(r^*)$ are both increasing in r^*, global saving and global investment are respectively increasing and decreasing with the interest rate so that the global loanable funds market has one unique equilibrium.

24 The fact that the uncoordinated use of macroprudential policies raises global welfare does not mean that it raises the welfare of all countries. The welfare of capital-exporting countries may be reduced by the lower return on their foreign assets.

25 It is impossible, in this simple model, to lower the real interest rate below the Wicksellian level because labor cannot be increased above the full employment level. Any attempt to do so would result in an unbounded increase in P.

26 Blanchard and Milesi-Ferretti (2012) argue that when the global economy is in a liquidity trap, the negative impact of certain policies such as reserve accumulation on global demand could justify international coordination.

27 This does not suggest that the Chinese accumulation of reserves is made primarily for prudential reasons as opposed to resisting the appreciation of the currency. The results in this section would remain valid, however, if China accumulated reserves because of a positive externality related to currency undervaluation, as in Aizenman and Lee (2010). The analysis in Korinek (2012) also encompasses this case.

28 This assumption is not restrictive as it is in general optimal for the U.S. to set the domestic macroprudential tax to zero if there is unemployment in the U.S.

29 There may be other reasons for having international rules of good conduct for capital account policies, e.g., reducing stigma for appropriate policies—see Jeanne, Subramanian, and Williamson (2012). I have focused here on the rationale for coordination based on international spillovers and externalities.