Macroprudential Policies in a Global Perspective*

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Abstract

This paper analyzes the case for international coordination of domestic macroprudential policies and macroprudential capital controls in the context of a simple theoretical framework. I argue that domestic macroprudential policies are generally the first-best instrument to deal with excessive growth in domestic credit and capital inflows but that, given the narrow focus of domestic macroprudential policies on the banking sector, capital controls may have a useful role to play. Both domestic macroprudential policies and prudential capital controls generate international spillovers, and their uncoordinated use may lead to a "capital war" that depresses global interest rates. International coordination of macroprudential policies is not warranted in general but it may be if global demand is depressed. Similarly, there is scope for international policy coordination when one part of the world implememts a monetary stimulus while the rest of the world accumulates reserves for prudential reasons.

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1 Introduction

The notion that international capital flows should be "managed" in order to mitigate their volatility has received renewed interest in recent policy debates. The global financial crisis has revived the use of controls as a crisis-prevention tool, when (in late 2009) controls on inflows were introduced to deal with a new tide of capital flows from advanced to emerging market economies. Historically, emerging market economies have resorted to such capital controls before, for example Chile, Brazil and Colombia in the 1990s, but controls on inflows had largely fallen out of fashion. They are now making a comeback. The new measures have often been justified as a form of macroprudential regulation. As shown by figure 1, the macroprudential and capital control measures toward the financial sector have become more and more restrictive worldwide since 2009.[1] For example, Brazil introduced a tax on all capital inflows except direct investment in October 2009—Brazil's IOF (Imposto sobre Operações Financeiras) tax on bond and equity inflows. In August 2011 the Korean authorities introduced a macro-prudential stability levy on banks' non-deposit foreign-exchange in order to curb the excessive dependence of banks on non-core foreign-exchange funding. Prudential capital controls have also 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 G20 summit in Seoul), the G20 endorsed the use of "carefully designed macro-prudential measures" to deal with excessive volatility in capital flows to emerging market economies.

The increasing use of capital controls as a macro-prudential tool raises many questions. What are the desirable features of such controls and how do these features depend on specific country circumstances? Why and when resort to capital controls rather than domestic macro-prudential policies that do not differentiate between transactions between residents or nonresidents? Should capital controls be used as a policy tool on a routine basis or only in exceptional circumstances? Given the international spillovers induced by prudential capital controls, should there be international coordination or rules for the use of capital controls?

This paper will touch on all these questions but it is mostly about the last one. It may seem surprising that unlike for international trade in goods, where the World Trade Organization offers a strong set of rules, there are no international rules for capital account policies.[2] The rationale for government management of capital flows, and whether there is a need for international "rules of the game" for those policies, have been identified as important questions for the G20 discussions after the crisis, and the staff of the IMF has produced several analytical papers on those issues (IMF, 2011; Ostry et al., 2011).

The case for international rules for capital account policies has been made based on different grounds (Jeanne, Subramanian and Williamson, 2012; Ostry, Ghosh and Korinek, 2012; Korinek, 2012). There is a theoretical presumption that international cooperation is desirable for capital account policies for the same reason as it is desirable in the area of

[1] In its Annual Report on Exchange Arrangements and Exchange Restrictions, the IMF reports provisions specific to commercial banks and institutional investors with a focus on prudential measures that are akin to capital controls. A measure is formally classified as a capital control if its discriminates between residents and nonresidents. Figure 1 reports the number of provisions whose direction was toward easing versus the number of provisions whose direction was toward tightening.

[2] With some exceptions, such as the pre-requisite of capital mobility for European Union membership.

international trade. At an abstract level, capital controls are taxes on intertemporal trade between countries, and there is no reason to believe that they should be less of a collective concern than taxes on intratemporal trade, i.e., tariffs. One country's capital account policies have spillovers on the rest of the world that may need to be taken into account. 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.

Unlike for trade policies, where the welfare benefits of international cooperation have been studied in a large literature, there has been relatively little research on the international coordination of capital account policies. Recent exceptions are Costinot, Lorenzoni and Werning (2011) and Korinek (2012), who reach different conclusions. Both papers point out that international cooperation is warranted if countries are large enough to influence their intertemporal terms of trade (the world real interest rate). But Korinek (2012) shows that international cooperation is less justified if countries are small and use capital account restrictions to redress domestic externalities. The Nash equilibrium in this case may look like a capital war and lead to a decrease in the world real interest rate but it is Pareto efficient. There is no true international externality as the spillovers that countries impose to each other are mediated through a price (the real interest rate) in a perfectly competitive market.[3]

Several questions are left unaddressed by the recent theoretical literature. In particular, the literature does not provide a comparison between domestic prudential regulation and capital controls. It is generally assumed that all the lending comes from foreigners so that by assumption, prudential regulation can take the form of a capital control. I try to start filling this gap in this paper.

This paper relies on a simple reduced-form theoretical framework that draws on Jeanne (2013*b*). In its most general form the model simply assumes that certain expenditures generate negative externalities because they are financed by debt. Being small relative to the economy, the agents who finance their expenditures with debt do not internalize the impact of their debts on the risk and severity of a systemic debt crisis. The first-best instrument in such a setting is a Pigouvian tax on the externality-creating expenditures (or on debt itself). The optimal Pigouvian tax should be interpreted as domestic macropudential regulation rather than capital controls since it does not differentiate by the residency of the lender or the debt-holder. Given the real-world limitations in the use of macroprudential policy, however, there is scope for using prudential capital controls as a second-best instrument. Macroprudential policy is often understood to be the macroprudential regulation of *banks*. Narrowing the definition of domestic macroprudential regulation in this way puts important externality-creating expenditures out of reach. Capital controls can fill the gap to some extent even though they are a blunt instrument that affect all expenditures, not only those that generate negative externalities.

I then proceed to look at the case for the international coordination of macroprudential policies. A macroprudential restriction in one country lowers the global real interest rate,

[3]Bengui (2012) presents a multi-country version of the model of public liquidity provision of Holmström and Tirole (1998). He finds that the Nash equilibrium between national regulators leads to an inefficiently low level of liquidity regulation as national regulators do not internalize the benefits of their country's provision of liquidity to the rest of the world.

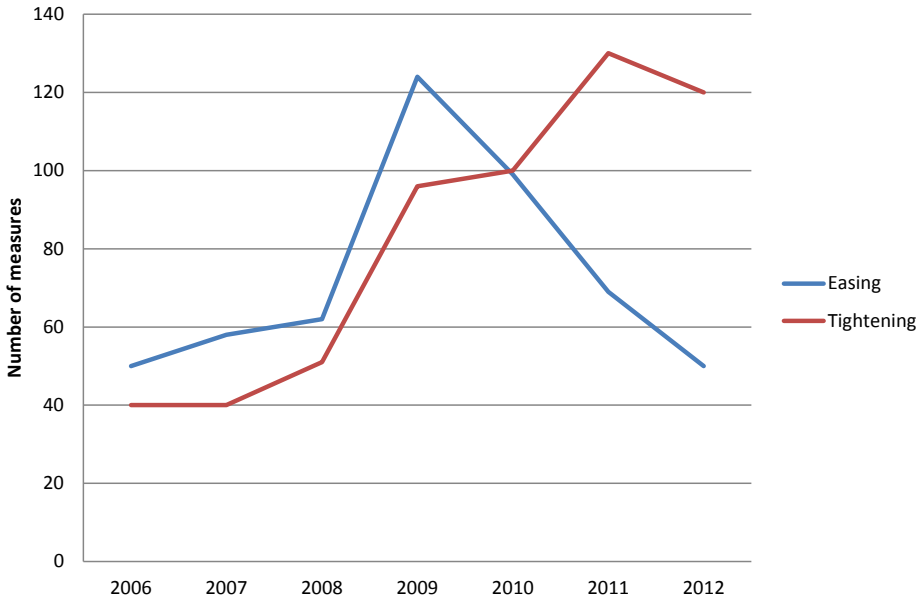

Figure 1: Measures specific to the financial sector (World. 2006-12. Source: IMF Annual Report on Exchange Arrangements and Exchange Restrictions)

leading other countries to raise their macroprudential taxes. In spite of these spillovers there is little scope for international coordination of macroprudential policies to improve global welfare for the same reason as in Korinek (2012). The results are different however if the downward pressure in the real interest rate leads to a global liquidity trap. I present a Keynesian extension of the model and show that in a global liquidity trap the countries with unemployment benefit from a coordinated relaxation of their macroprudential policies.

Finally, I present a specification of the Keynesian version of the model in which one country (the US) attempts to reduce its unemployment through a monetary stimulus while the rest of the world (China) attempts to mitigate the effects of the US monetary stimulus by a prudential accumulation of reserve. I find that there is again a case for international coordination leading both countries to be less aggressive in the pursuit of their objectives (both countries benefit if the US mitigates its monetary stimulus while China accumulates less reserves).

The paper is structured as follows. Section 2 reviews some conceptual issues related to macroprudential policies. 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.

2 Conceptual issues

The word "prudential" is being used with different meanings in different contexts. The most general definition of a prudential policy would be that it is a policy that proceeds from prudence, i.e., which reduces the probability or severity of a future bad event (a crisis). A

prudential policy is implemented ex ante (before the crisis) rather than ex post (in the crisis). It is preventative rather than curative, and about risks that may or not materialize.

Many would find such a definition too general and there are different ways of narrowing it down. First, one may restrict the attention to financial risk, i.e., the risk of a financial crisis. Second, one may restrict the attention to the risk of a banking crisis (a type of financial crisis). Conditional on these two restrictions, one can identify prudential policies with the prudential regulation of banks. This is most central bankers' definition of macroprudential policies and this is the one we will start with.

However the focus on banking may excessively narrow the analysis. In principle, the reach of macroprudential policies might have to extend beyond the banking sector. I review in the second and third parts parts of this section the case for broader definitions of macroprudential policy.

2.1 Macroprudential regulation of banks

There is a large and rapidly expanding literature on how the 2008-09 global banking crisis led to a shift in emphasis from microprudential regulation to macroprudential regulation (Hanson, Kashyap and Stein, 2011; Galati and Moessner, 2013). In a nutshell, microprudential regulation focuses on individual banks' risk of insolvency taking the financial environment as given whereas macroprudential regulation focuses on how the behavior of banks taken collectively makes the environment riskier.[4] An area that illustrates this difference very starkly is the use of Value-at-Risk (VaR) models by banks. The microprudential approach would hold that risk is appropriately contained if all banks limit their exposure to market risk using VaR models. By contrast, the macroprudential approach recognizes that collectively, VaR models may generate systemic risk if they compel all banks to sell the same assets in a crisis, leading to an asset-price crash (Shin, 2010*b*). Similarly, constant capital adequacy ratios could be procyclical and exaggerate systemic risk even though they may seem appropriate from a microprudential perspective. A macroprudential approach, thus, would gear these instruments (VaR or capital adequacy ratios) to the stability of the system as a whole rather than individual institutions.

From a theoretical perspective, the shift toward macroprudential regulation can be justified by the need to address *externalities*. De Nicolo, Favara and Ratnovski (2012) point to three main externalities that may require a response in the form of macroprudential banking regulation, respectively related to strategic complementarities, fire sales, and interconnectedness.[5] By strategic complementarities these authors mean the fact that banks tend to overexpose themselves to correlated risk during booms, for example because each individual bank is more likely to benefit from a government bailout if it fails together with many other

[4] Hanson, Kashyap and Stein (2011) 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.*" (p.3)

[5] Another externality involves market spirits. For example, Aizenman (2011) presents a model in which the amplification comes from contagious runs in the banking system. The assumption is that the probability of a self-fulfilling bank run on a given individual bank is increasing with the number of self-fulfilling bank runs.

banks than if it fails alone (Farhi and Tirole, 2012). Fire sale externalities arise ex post (in a crisis) because banks do not internalize the impact of their asset sale on the solvency of other banks, and may lead ex ante (in the boom) to excessive leverage as individual banks do not internalize the impact of their own leverage on the risk of a systemic crisis (Stein, 2012). Finally, the interconnectedness externality comes from the fact that the distress or failure of a bank can directly affect other institutions through exposures in the interbank market or the derivative markets because of a "domino effect". The literature on financial networks suggests that high interconnectedness mitigates the impact of small shocks but amplifies large shocks (Acemoglu, Malekian and Ozdaglar, 2013).

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 taken or proposed take the form of Pigouvian taxes on certain banking activities. For example, Shin (2010*a*) and Perotti and Suarez (2011) proposed to use a tax on banks' non-core liabilities as a tool for prudential regulation and such a tax was introduced in Korea in August 2010. But overall, quantity-based regulation still dominates by a wide margin. Of the ten macroprudential instruments reviewed by Lim et al. (2011), none takes the form of a tax.[6]

To a large extent the macroprudential approach to banking regulation is an inflexion in traditional policies rather than a radical change. The notion that banking regulation had to mitigate systemic externalities was understood and accepted before the crisis, although it was overlooked by some regulators, as was the extent of the systemic vulnerabilities that had developed in the global banking system.[7] Most of the policy instruments used for macroprudential regulation are the traditional instruments of banking regulation. Some of these instruments target certain characteristics of bank loans, such as restrictions on debt-to-income or loan-to-value ratios. Other instruments, still aimed at banks' assets, attempt to limit the growth in banks' total loans, the loans to particular sectors, or the loans denominated in foreign currency. On the bank liability side, capital adequacy regulation is also being used for macroprudential purposes. These tools are not new but they are used with an eye to limiting the contribution of banks to systemic risk rather than simply limiting the risk of individual banks. For example, time-varying capital requirements, in the form of a capital surcharge linked to aggregate credit growth, are part of the new Basel III accord. In the future, these regulatory developments could rely more on new measures of systemic risk contributions, such as CoVaR (Adrian and Brunnermeier, 2011) and systemic measures of equity shortfall (Acharya et al., 2010).

The macroprudential regulation of banks has an open economy dimension. Non-US banks finance themselves in the global wholesale funding market, a large part of which is denominated in US dollars. This means that the liquidity mismatch that is intrinsic to banking was supplemented in some cases by a currency mismatch. The US Federal Reserve Bank and the European Central Bank provided the required international liquidity to other

[6]The ten instruments reviewed in Lim et al. (2011) are: Caps on the loan-to-value (LTV) ratio; Limits on maturity mismatch; Caps on the debt-to-income (DTI) ratio; Reserve requirements; Caps on foreign currency lending; Countercyclical capital requirements; Ceilings on credit or credit growth; Time-varying/dynamic provisioning; Limits on net open currency positions/currency mismatch; and Restrictions on profit distribution.

[7]See Borio (2003) for a pre-crisis presentation of the case for macroprudential regulation.

central banks and large global banks in the crisis but there is no institutional global safety net in place to guarantee that such liquidity provision will be forthcoming in future global banking crises. See Shin (2012).

Existing empirical research finds that the macroprudential regulation of banks has been effective in some ways. Based on aggregate data, Lim et al. (2011) and Dell'Ariccia et al. (2012) find evidence of some macro-prudential policies being effective in reducing the pro-cyclicality of credit and leverage. Claessens, Ghosh and Mihet (2013) look at the experience of 48 emerging market and advanced economies, of which 35 used macroprudential measures over the period 2000-2010 based on disaggregated data on more than 2,000 banks. They look at the impact of 9 different macroprudential instruments and find that they generally reduce the growth in leverage, total assets and noncore liabilities of banks. There is evidence that measures contingent on the characteristics of the borrowers, such as caps on the loan-to-value ratios or the debt-to-income ratios, are more effective than capital adequacy ratios or rules about provision.

However the empirical literature has also pointed to evidence of leakage. There are two conceptually distinct channels of leakage. First, the agents that generate negative financial externalities are not necessarily in the banking sector and as such fall outside the scope of banking regulation. We will discuss this channel in more detail in the following section. Second, even if one restricts the attention to financial externalities that take place inside the banking sector, some leakage occurs through the branches of foreign banks which, unlike the subsidiaries of foreign banks, are typically not subject to domestic regulation.[8] For example, in the UK Aiyar, Calomiris and Wieladek (2012) find that UK-owned banks and resident foreign subsidiaries reduce lending in response to tighter capital requirements but that this effect is partially offset by an increase in lending from resident foreign branches. This "leakage" is substantial, amounting to about one-third of the initial impulse from the regulatory change.

The new literature on the macroprudential regulation of banks says relatively little that is new on the need for international coordination of macroprudential policies. 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 sometimes asymmetric (country-specific) generates new tensions because this implies that macroprudential regulation may have to be restricted in some countries and not others. Banking integration generates leakage: the borrowers that see the cost of borrowing from the domestic banking sector increase because of a macroprudential restriction can borrow from the domestic branches of foreign banks (which are not subject to domestic macroprudential regulation) or directly from foreign banks (for the largest corporate borrowers). This problem is especially salient in the euro area where banking integration is an explicit objective while country-specific macroprudential regulation may be more important than elsewhere to fulfill the stabilizing role that monetary policy can no longer play at the national level.

[8]Basel III allows domestic regulators to require foreign regulators to impose higher capital standards on domestic lending by foreign banks, which may reduce leakage through this channel in the future.

2.2 Financial externalities in the real sector

The externalities identified in the literature on banking are also relevant in the nonfinancial corporate and household sector. This is especially true for the demand externalities and financial frictions related to collateral prices in the real estate sector.[9] This is perhaps less true for the strategic complementarities resulting from the expectation of bailouts as borrowers in the real sector do not benefit from the same financial safety nets as banks.

The recent theoretical literature on debt deflation has studied these mechanisms. This literature often relies on the fact that the debt contracted to purchase an asset is collateralized by the same asset. During the boom, increases in the price of the asset relax the credit constraint on borrowers, which tends to further raise their demand for the asset. The same feedback mechanism works in reverse during the bust. For example, in a residential real estate bust the fact that households are credit-constrained puts further pressure on house prices. This feedback loop is very similar to the "fire sale" mechanism in the banking literature. An early contribution is the three-period model of Lorenzoni (2008). More dynamic quantitative contributions can be found in Jeanne and Korinek (2010*b*) and Mendoza and Bianchi (2010).

Similar arguments can be developed in an open economy.[10] We observe that domestic credit booms and busts are correlated with capital flows. A boom in capital inflows is associated with a buildup in external debt, a real appreciation of the domestic currency, and a general rise in the price of domestic assets. Those developments mutually reinforce each other, as the rise in the dollar value of domestic assets 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" a 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), Korinek (2011), Jeanne and Korinek (2010*a*)). The optimal policy is a Pigouvian tax on capital inflows that make private market participants internalize their contributions to systemic risk in order to restore the efficiency of the decentralized market equilibrium.

Calibrated versions of various models tell us something about the size of the optimal Pigouvian tax. For example, Korinek (2010) calibrates a stylized model by looking at the experience of Indonesia before and during the Asian crisis and determines the optimal rate of taxation on various types of debt flows. He finds that the tax rate should be higher on systemically more dangerous forms of debt, e.g., it should be higher on dollar-denominated debt than on domestic currency debt. Similarly, it should be higher on short-term debt than

[9] As shown by Mian and Sufi (2009), household leverage is an important predictor of the fall in demand in the US.

[10] In fact some of the models discussed above consider an open economy (although they do not always advertise this property) simply for the reason that it is analytically and computationally convenient to take the real interest rate as exogenous. In a truly closed economy the equilibrium interest rate tends to rise during a credit boom, which endogenously moderates the excess in credit. The models that we discuss now are different because they have an exchange rate.

on long-term debt. Bianchi (2011) quantifies the optimal tax in a dynamic model of a small open economy calibrated to Argentina. He finds that the relationship between the capital flow cycle and the optimal tax is highly nonlinear. The optimal tax rate varies between 0 and 22 percent and the average tax rate, taken over a large number capital flow booms and busts, is close to 4.5 percent.

[Review recent empirical literature on capital controls: Ostry et al. (2012), Klein (2012), Klein and Shambaugh (2013).]

Another transmission mechanism is demand. The model in Jeanne (2013*b*) features a small open economy with two types of agents, investors and entrepreneurs (or firms). The entrepreneurs have no funds and must borrow to finance their investment. Entrepreneurs produce inputs that are complementary in the production of the consumption good. The microeconomic financial friction takes the form of a deadweight reduction in the output of defaulting entrepreneurs due to a costly-state-verification debt contract. As a result default may be contagious because of a demand externality. Sectoral shocks that make the producers of certain production 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 entrepreneur does not internalize the impact of his individual debt on aggregate demand.

Even in an open economy it is not clear that the optimal macroprudential policy should take the form of a capital control. In fact, in some of the papers reviewed so far there is no reason to differentiate the Pigouvian tax depending on the residency of the lender. To the extent that the externality is on the borrower's side, the tax should be differentiated by the type of debt rather than that of the lender. In models with foreign currency debt and a pecuniary externality that involves the exchange rate, however, it matters for systemic risk whether the debt is held by residents or nonresidents since repaying the debt induces a real depreciation only there is an international transfer. In this case, the optimal macroprudential policy takes the form of capital control.

Another question is whether the systemic externalities in the real sector can be addressed by the macroprudential regulation of *banks*. In a closed economy in which all credit is bank-intermediated the answer would be yes. But in general the answer is no. There are multiple avenues for leakage and circumvention if macroprudential policy is limited to banks. Limiting macroprudential regulation to banks tends to move lending out of the banking sector. In an environment with international banking integration, domestic macroprudential regulation can be circumvented by relying on foreign banks.

Thus there is a case for using taxes outside of the banking regulatory toolbox. However, following this route leads into the politics of Pigouvian taxation. The experience with Pigouvian taxes is not encouraging. One area in which the Pigouvian inspiration is perhaps the clearest is environmental taxation. Since the 1980s the US federal government has increasingly used the tax code to deliver Pigouvian subsidies or impose Pigouvian taxes on polluters. But as argued by Barthold (1994), who illustrates his point with the case of the excise tax on ozone-depleting chemicals introduced by the US congress in 1989, the implementation has generally failed to follow the underlying principles implied by Pigouvian economic theory. The tax rate seems to have been determined by the objectives of raising certain amounts of revenue rather than Pigouvian calculus about the size of the externality. The tax policy was muddled by the multiplicity of goals of politicians—the tax rate was influenced by ancillary

goals such as export promotion.

As imperfect as the experience with environmental taxation has been, there are reasons to believe that Pigouvian taxation of financial systemic risk broadly defined would be even more difficult. For example, the taxation of the real estate sector and of mortgage loans is a politically charged area in the US. It is difficult to believe that the tax rate would be changed in the optimal countercyclical way if it were under the control of US Congress.

2.3 Non-financial macroeconomic risk

A very common theme in discussions of the exchange rate policies of emerging market economies is that it is prudent to resist the appreciation of the currency during a boom in capital inflows to preserve the country's exporting capacity—which comes in handy when there is a reversal of the capital inflows and the country must repay the external liabilities accumulated during the boom (Williamson, 2005). This motive could be called "prudential" in the sense that the resistance to appreciation is meant to mitigate the consequences of a reversal, if it occurs. From this perspective, resisting a secular trend of appreciation (Chinese style) would not be prudential if this is not done in the expectation of a reversal—although the intent or expectations of the policymakers may be difficult to assess, as noted by Blanchard and Milesi-Ferretti (2012).

This argument is often used in policy discussions, it seems intuitive and compelling but it is surprisingly difficult to back up with rigorous theory. The problem is that the "Dutch disease" case for resisting appreciation is structural rather than cyclical: it applies equally strongly whether or not there is an expectation of a reversal.

Caballero and Lorenzoni (2007) present an attempt to model the idea that it is optimal to resist the appreciation of the domestic currency in a capital inflow boom to preserve the domestic export sector. Their model features a small open economy with irreversibilities in the creation and destruction of firms in the export sector. As a result the firms destroyed during an episode of currency appreciation are costly to reconstitute when the episode is over. This by itself is not sufficient, however, to make a case for public intervention. The irreversibility per se does not create a wedge between private and social optimality, and the exporting firms close down during a boom only when it is socially optimal to do so. In order to have a case for public intervention Caballero and Lorenzoni (2007) need to add a financial friction. They assume that the exporting firms are subject to a credit constraint which leads to a socially excessively large number of closures during the boom and an inefficiently slow pace of recovery in the tradable sector in the bust. It is then optimal for a social planner to smooth the variations in the real exchange rate, but the fundamental reason is a financial friction like in the models discussed in the previous section.

Schmitt-Grohé and Uribe (2012) make a different case for prudential capital controls to deal with macroeconomic risk. These authors consider a small open economy with downward nominal rigidity that pegs its nominal exchange rate (they have euro area members in mind). The nominal wage (and so the real wage, given the fixed nominal exchange rate) increases during a boom in capital inflows. But the nominal wage does not fall when there is a reversal, leading to unemployment. The externality, in this case, is that agents do not take into account the impact of increasing their nominal wages on future unemployment. A tax on capital inflows help to contain the increase in nominal wage during the boom and raises

average employment. The magnitude of these effects is potentially large. Under plausible calibrations, the optimal capital controls are shown to lower the average unemployment rate by 10 percentage points, to reduce average external debt by 10 to 50 percent, and to increase welfare by 2 to 5 percent of consumption per period. The capital controls in Schmitt-Grohé and Uribe (2012)'s model are prudential in the sense that they try to reduce the probability and cost of a crisis before it occurs.

3 Macroprudential policies in a small open economy: A simple model

The key concept in the strands of 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 recent literature provides several models with uninternalized social costs of borrowing, 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 am presenting in this section a model that captures this idea in a simple reduced-form way. The model is based on the analysis in Jeanne (2013*b*). 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 rather than entrepreneurs investing in real projects. Thus the macroprudential policies discussed in this section are not limited to the macroprudential regulation of banks in a narrow sense.[11]

3.1 Assumptions

There are 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 has one single good, which is used both for investment and for consumption. Extensions of the model with two goods and an exchange rate will be discussed in section 6.

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, Y, in the first period. The lenders maximize their utility, which is the sum of a concave function of their first-period consumption plus the expected value of their second-period consumption,

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

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), but r could be higher or lower than r^* because of restrictions to international capital mobility. Note that since they are risk-neutral in the second period, the lenders do not require a pure risk premium to hold risky debt.[12] The lenders are indifferent between safe and risky debt as long as the two types of debt yield the same expected return.

[11] However, the model assumes a financial friction related to debt, and so is not a priori applicable to the analysis of non-financial macroeconomic risk discussed in section 2.3.

[12] Of course the lenders require a premium for the risk of default.

The lenders save until the marginal cost of saving is equal to the marginal benefit of saving, $u'(Y-S)=1+r$, which implies that saving can be written as 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 assumptions about the borrowers are simple too. The borrowers are identical atomistic entrepreneurs (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 because their investment projects have a zero payoff, they default and the lenders receive nothing. Because of this default risk the borrowers must 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 discourages borrowing to finance first-period consumption). The borrowers, thus, simply maximize the expected level of their second-period consumption,

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

Like for 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 last assumption is key in generating systemic risk. I assume that the expected payoff of an investment is a decreasing function of the level of aggregate 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 micro-founded model of contagion in systemic debt crises presented in Jeanne (2013*b*). 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 production 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 related to the risk of a systemic debt crisis because they are financed by debt. There is nothing essential to the assumption that productive investment is debt-creating whereas consumption is not. Residential investment and consumption can be financed by debt too. 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 over-borrowing. 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,

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

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 social planner, by contrast, would take this effect into account and maximize $p(I)f(I) - (1+r)I$ over I. The difference between laissez-faire and the social planner solution is shown in figure 2. 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 aggregate debt 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 3 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 gain from investing and the marginal cost of saving must be equal to the gross cost of external borrowing, $1+r^*$.[15] The difference between domestic saving and domestic investment, $S - I$, is the country's current account balance.

[13] In models with collateral constraints the externality involves aggregate debt too. In these models, the severity of the collateral constraint for each individual borrower depends on the price of collateral, which itself is determined by the level of aggregate debt.

[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 the risk of debt crisis ex ante through several channels, for example is if they receive a wage income from the productive sector in the second period. 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] The cost of external borrowing r^* could be influenced by variations in the country-specific risk premium required by foreign investors or by changes in the world monetary conditions.

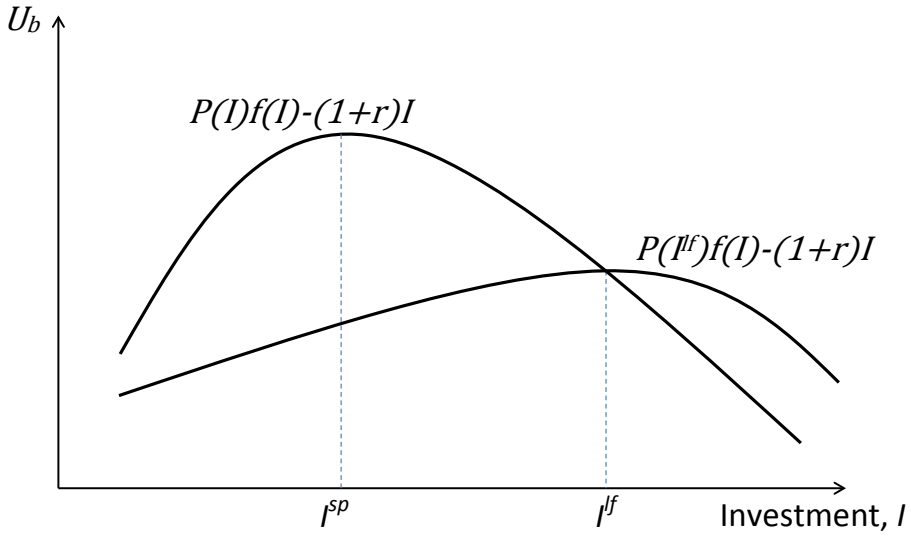

Figure 2: Borrowers' welfare under laissez-faire and a social planner

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-exporting country.

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 3). The proceed of the tax can be rebated in such a way that both the borrowers and the lenders are better off. 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 $r^* + \tau$. The level of debt that maximizes domestic welfare satisfies the first-order condition,[16]

$$p'(I^{sp})f(I^{sp}) + p(I^{sp})f'(I^{sp}) = 1 + r^*.$$

Comparing this equation with the first-order condition for the individual borrower's problem, $p(I^{sp})f'(I^{sp}) = 1 + r^*$, one can see that borrowing is at the socially optimal level 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

[16]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.

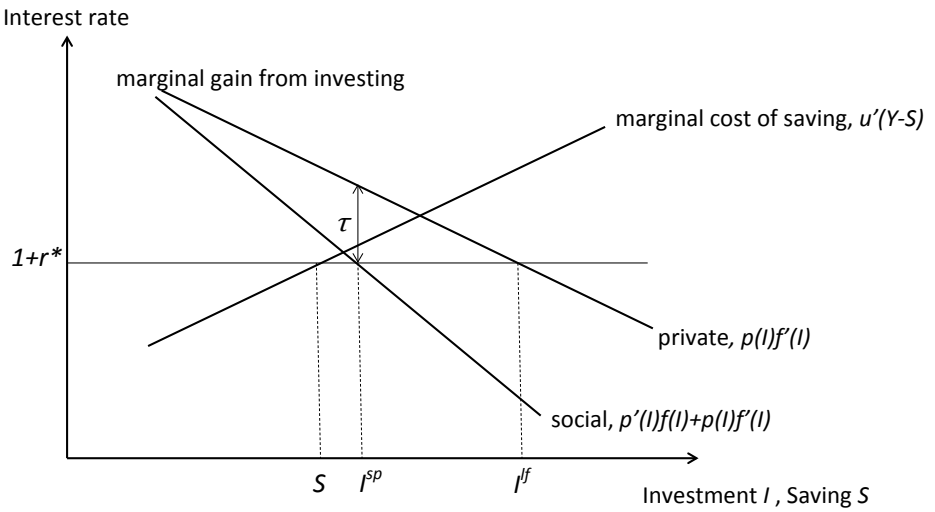

Figure 3: Metzler diagram with systemic debt externalities

increase in aggregate debt. Note that this level of taxation is computed assuming that the borrowers cannot default on the tax, i.e., they pay τD in the second period irrespective of the state. If the borrowers default on the tax when the return on investment is low, then the tax should be set at a higher level to account for the default risk: the borrowers must pay a gross interest rate of $(1 + r^* + \tau)/p$ for the aggregate level of debt to be at the optimum level.

Since the same Pigouvian tax is applied to domestic borrowing irrespective of the residency of the lenders, it falls under the purview of domestic macroprudential policy rather than capital account policies. How does the optimal domestic macroprudential tax change in the cycle? The cycle could be domestically induced by a change in domestic productivity or externally induced by variations in the foreign cost of borrowing r^*. As can be seen from figure 3, an increase in domestic productivity that raise the private and social marginal gain from investing in the same proportion leads to an increase in investment and capital inflows under both laissez-faire and 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. This is true if $-p'(I)f(I)$ is increasing with I, that is if the marginal cost of the systemic risk increases with the level of debt. In this case the domestic macroprudential tax is countercyclical, in the sense that it is used to smooth investment, domestic borrowing and capital inflows against variations in domestic productivity.

As can be seen from figure 3, similar results hold if the cycle is induced by variations in the external cost of borrowing r^*. A lower cost of external borrowing should be associated with more investment both under laissez-faire and under the social planner. If $-p'(I)f(I)$ is increasing with I, the optimal macroprudential tax varies inversely with the cost of external borrowing. That is, the net cost of borrowing for domestic entrepreneurs (taking the tax into account) varies in the same direction but less than one for one with the external cost of

borrowing,

$$0 < \frac{d(r^* + \tau)}{dr^*} < 1.$$

To put it differently, the optimal tax is countercyclical in the sense that it *smoothes* the domestic cost of borrowing, $r^* + \tau$, against variations in the external cost of borrowing r^*. Domestic macroprudential regulation leans against the ebbs and flows of international capital movements, whether they are caused by variations in domestic productivity, 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., $-p'(I)f(I)$ is increasing with I.*

3.3 Prudential capital account policies

If the economy is receiving capital inflows, another way that the social planner (government) 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 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. 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 interest rate is the same as on external borrowing.

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 for which domestic saving is equal to 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 still 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 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 (rather than tax capital inflows) at rate $\tau = r - r^*$. In the following, τ is a wedge that will be interpreted either as a tax or a subsidy.

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 illustrates how the same outcome can be achieved with policies that affect quantities rather than prices (see (Jeanne, 2013*a*)).[17] China's capital account is closed to most capital inflows except FDI—which is subject to administrative authorizations and in some cases actively encouraged through tax exemptions— whereas most of the accumulation of foreign assets takes the form of foreign

[17]This is not to say that the motive for reserve accumulation in China is primarily prudential. One popular interpretation of Chinese policies is that they resist a secular trend of appreciation of the renminbi so as to preserve the export sector as an engine of growth.

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, 2013*a*).

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 expenditures at the same time. Capital account policies affect all expenditures alike, including those that do not generate externalities. The impact of a tax on external borrowing on domestic borrowing is welfare-enhancing 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 tax, let us denote by τ^c the tax on *c*apital inflow, as opposed to τ^d the *d*omestic macroprudential regulation tax. Figure 4 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 4 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 lending (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 set at the optimal level when it minimizes the total welfare loss (the sum of the areas of the two triangles). It is easy to see that the optimal tax on external borrowing is lower than the optimal tax on domestic borrowing. If τ^c 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^c below τ^d. Intuitively, capital

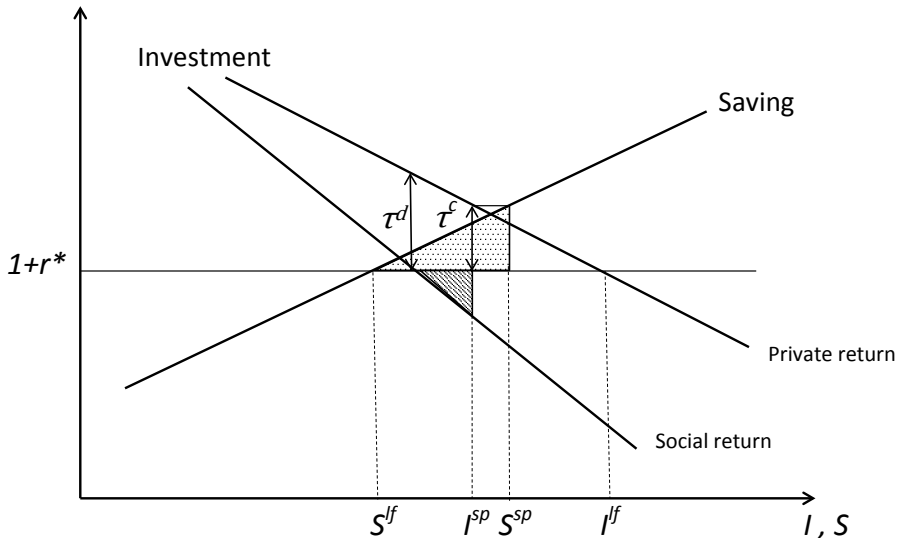

Figure 4: Lending and saving in the open economy: the case of capital controls

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 is is impossible to reduce investment without also repressing consumption. Together equations (2) and (3) make it possible to write consumption and investment in 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., smoothes 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 they are both satisfied. The appendix presents a quadratic specification of the model in which both assumptions are satisfied and closed-form expressions for all 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. 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 so as to smooth the domestic cost of borrowing against variations in the external cost of borrowing.*

Proof. See appendix.

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.[18]

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 more systemically more dangerous in the hands of nonresident investors than in those of residents if the former have a stronger tendency to rush of the exits in a crisis. 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 by residency of the the holder, $D = D^h + D^f$, and assume that p is more sensitive to D^f than to D^h.

Second, the appropriate domestic macroprudential taxes may not be available as policy instruments. As discussed in section 2.2, 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. Broader macroprudential taxes can in principle be used but they are under the control of political bodies that are unlikely to use them as optimal Pigouvian taxes. Capital controls may be the only broad tax-like instruments that are not too politically controlled. One could capture this idea, in the model, by assuming that only τ^c can be made contingent on r^* in the appropriate way.

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 is 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. Thus, I will look at equilibria in which countries use capital controls or domestic macroprudential policies in the rest of the analysis.

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

4 International spillovers and "capital wars"

I now consider a world composed of a large number of open economies indexed by $i \in I$ like the one described in the previous section. It is assumed from now on that countries do not pay a premium on their foreign borrowing, so that r^* is the global real rate of interest. The global capital market finds its equilibrium for an interest rate r^* such that

$$\sum_{i \in I} S_i(r^* + \tau_i^c) = \sum_{i \in I} I_i(r^* + \tau_i^d + \tau_i^c),$$

where τ_i^d and τ_i^c are country i'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. Other things equal, raising the domestic macroprudential tax in country i lowers the lowers the global demand for investment and so the equilibrium global interest rate. Raising country i's 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 country i deflects capital flows to the other countries $j \neq i$, which induces these other countries to raise their own macroprudential taxes.

This raises the question of the efficiency of the global equilibrium that is reached when all countries set their prudential taxes in an uncoordinated way. 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 ($i \in I^d$) and the countries in the second group use the tax on external borrowing ($i \in I^c$). I assume that each country is small enough to take the global interest rate as given, so that each country sets its tax rate to $\tau_i^d(r^*)$ or $\tau^c(r^*)$, like in the small-open economy model of the previous section. The equilibrium global interest rate, then, satisfies

$$\sum_{i \in I^d} S_i(r^*) + \sum_{i \in I^c} S_i(r^* + \tau_i^c) = \sum_{i \in I^d} I_i(r^* + \tau_i^d) + \sum_{i \in I^c} I_i(r^* + \tau_i^c), \tag{4}$$

Since the global demand for investment is lower and the global supply of saving is higher than under laissez-faire, the global interest rate is lower than in the absence of macroprudential taxes. Each country is induced to raise its macroprudential tax above the level that it would set if it were the only country to have such a tax, as a result of the cross-country spillovers in tax setting.[19] 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 so that the level of taxes will be inefficiently high in equilibrium. If this were true, the intervention of a global social planner would be called for to mitigate the inefficiency associated with the capital war. As first shown by Korinek (2012) in a similar

[19] It is not obvious that using taxes on external borrowing depresses the global interest rate more than using taxes on domestic borrowing, as the optimal tax rate is lower for the former than for the latter.

context, however, the impression that the uncoordinated equilibrium is inefficient is misleading. The efficiency of the Nash equilibrium in macroprudential policies is 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 i independently sets its macroprudential tax so as to maximize domestic welfare yields the same allocation as the equilibrium in which all the taxes are set by a global social planner who maximizes global welfare (the sum of all countries' domestic welfare).*

Proof. See appendix.

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.[20]

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 that countries impose to 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 the textbook general equilibrium model. Each domestic social planner is like a small agent in a competitive market.[21]

An important caveat to this result will be presented in the next section when we look at the case with less than full employment. But other caveats are in order.

First, there would be a case for international coordination 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, implying that when the firms producing these inputs default in one country, the price of complementary inputs is lowered in other countries, pulling more firms into default. Default would then be contagious across countries and not only across firms in a given country, which would make it optimal to coordinate national social planners to internalize the cross-country externalities. The point made by Result 2 is that it 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

[20] 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.

[21] In general equilibrium theory, the term "pecuniary externality" is sometimes used for the fact that a change in the demand for a good by some agents affect the price of this good and so the welfare of other agents. However, these pecuniary externalities are not true externalities that justify public intervention.

that all countries set the tax on external borrowing in the same way, i.e., they have the same tax response function $\tau^c(r^*)$.[22] Then the global interest rate must satisfy,

$$\sum_i S_i(r^* + \tau^c(r^*)) = \sum_i I_i(r^* + \tau^c(r^*)).$$

It appears that the equilibrium cost of borrowing, $r^* + \tau^c(r^*)$, is the same as the level of the interest rate, r^*, that would be observed in the equilibrium without macroprudential tax. 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 all countries try to reduce their investment and increase their saving in the same way, in equilibrium no one does. 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, results are different. In the two-country model of Costinot, Lorenzoni and Werning (2011), the country that borrows can raise its welfare relative to the laissez-faire level by imposing a tax on capital inflows, and lower in this way the interest rate that it must pay to the lending country. Conversely, the lending country will want to impose a tax on capital outflows in order 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 wars with global demand externalities

I have assumed so far that the global interest rate could adjust at whatever level was required to make global demand equal to global supply. In practice, this may be impossible because of the zero-bound constraint on the nominal interest rate. It has been argued that when the global economy is in a liquidity trap, the negative impact of certain policies such as reserve accumulation on global demand could indeed justify international coordination (Blanchard and Milesi-Ferretti (2012)). Is it the case in this model? I start by extending the model so as to include nominal stickiness, unemployment and the zero-bound constraint. I then 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 US or advanced economies) that attempts to implement a monetary stimulus in a liquidity trap whereas countries in the rest of the world sets their macroprudential policies so as to limit the spillovers from the monetary stimulus.

[22] This is the case if the countries have the same preferences and the same investment possibilities per capita. But the countries' populations and first-period GDP per capita could be different.

5.1 Assumptions

I consider a world with one currency to focus the attention on the interactions between macroprudential policies rather than between monetary policies.[23] The main 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 $Y_i = g_i(L_i)$ where $g_i(\cdot)$ is increasing and concave. The demand for labor is,

$$g_i'(L_i) = \frac{W_i}{P},$$

where W_i is the nominal wage in country i 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 cannot increase above a level corresponding to full employment whereas the nominal wage cannot fall below a level that is predetermined for each country,

$$L_i \leq \overline{L}_i,$$

$$W_i \geq \underline{W}_i.$$

A given economy can then be in two regimes. Either there is full employment and the nominal wage adjusts to the level where the demand for labor is equal to $\overline{L}_i$, or there is less than full employment and the nominal wage is equal to the lower bound $\underline{W}_i$. Which regime the economy lands in depends on the nominal price of the good. For each country there is a price level $\underline{P}_i$ such that the economy is in full employment when the nominal wage is at its lower bound, $\underline{P}_i = \underline{W}_i / g_i'(\overline{L}_i)$. Whether a given economy is at full employment depends on whether the world price level is higher or lower than this country-specific threshold. If $P < \underline{P}_i$, the real wage in country i is too high to achieve full employment and the nominal wage is at its lower bound. If $P > \underline{P}_i$, there is full employment and any increase in the nominal price of the good is reflected one-for-one in the domestic nominal wage.

The interest rate is determined by monetary policy. A global monetary authority sets the nominal interest rate i^*. The expected rate of inflation rate, 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,

$$r^* = i^* - \pi^*.$$

Global demand is determined by the real interest rate and by the macroprudential taxes on domestic and foreign borrowing,

$$\sum_{i \in I^d} \left[C_i(r^*) + I_i(r^* + \tau_i^d \right] + \sum_{i \in I^c} \left[C_i(r^* + \tau_i^c) + I_i(r^* + \tau_i^c) \right].$$

[23] The case with national monetary policies and exchange rates will be discussed in section [.]: it will appear there that the world with one currency is equivalent to a world in which national monetary policies are constrained by zero-bound constraints.

Global demand is decreasing with the real interest rate, and is equal to the full-employment level of global supply when the real interest rate is at the "Wicksellian" level.[24] Note that the macroprudential taxes depress global demand and thus lower the Wicksellian interest rate.

I will assume that the global monetary authority maximizes global employment conditional on the inflation target π^*. It may be impossible to achieve full employment at the global level with monetary policy because of the zero-bound constraint on the nominal interest rate, which implies that the real interest rate must be larger than minus the inflation target,

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

In this case the global economy is in a liquidity trap and some countries (those with the highest levels of unit labor cost) have some unemployment.

Before we come to the analysis of the international policy equilibrium, it is interesting to see that the closed-economy version of this simple model has something to say about the macroprudential role of monetary policy. There have been debates about whether monetary policy should be used for prudential purposes, e.g., whether the interest rate should be raised in a credit boom above and beyond the level implied by the macroeconomic objectives of monetary policy.[25] We can look at this question using a closed-economy version of the model with nominal stickiness. Then a social planner who can set the levels of consumption, investment and labor solves the following problem,

$$\begin{cases} \max_{C,I,L} p(I)f(I) + u(C) & \text{s.t.} \\ C + I = g(L), \\ L \leq \overline{L}. \end{cases}$$

It is easy to see from the first-order conditions of this problem that the optimum involves full employment. Furthermore, the optimum can be implemented by using monetary policy to set the real interest rate at the appropriate (Wicksellian) level and a macroprudential tax on borrowing to take care of the systemic externality. That is, the first best allocation can be achieved by granting the task of mitigating systemic risk to macroprudential policy, whereas monetary policy pursues full employment conditional on an inflation target. This does not mean that there is no interaction between macroprudential policy and monetary policy. As macroprudential policy reduces debt-creating expenditures, monetary policy must be relaxed to offset the fall in demand by raising non-debt-creating expenditures. But conditional on macroprudential policy doing its job, there is no need for monetary policy to pursue systemic objectives. This seems consistent with the view developed by many central bankers since the crisis (see e.g. Svensson).

However, it is interesting to see how the problem changes if the appropriate macroprudential instruments are not available, for example because systemic risk builds up outside of the banking sector. In this case, the social planner has only one instrument, the interest

[24] 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 will result in an unbounded increase in the first-period nominal price level.

[25] Debate pre-crisis: see e.g. Bordo and Jeanne ().

rate. The lack of instrument is reflected in my simple model as an additional constraint on the social planner's problem, which is that the marginal utility of consumption must be equal to the private gross marginal return on investment, $u'(C) = p(I)f'(I)$. This is the same constraint as when the social planner has to use capital controls rather than domestic macroprudential policies in the open economy (see section). As a result consumption and investment can be written as the same functions of total expenditures as before and the social planner's problem becomes,

$$\begin{cases} \max_{E} p(I(E))f(I(E)) + u(C(E)) & \text{s.t.} \\ E \leq g(\overline{L}). \end{cases}$$

Because of the systemic risk it is not obvious in general that the constraint is binding at the optimum. If it is, domestic welfare is maximized when there is full employment: the social planner determines monetary policy so as to achieve full employment without regard to systemic risk. If the constraint is not binding, the social planner trades off employment against systemic risk. It is is optimal to raise the interest rate above the Wicksellian level so as to mitigate the risk of a systemic debt crisis.

5.2 The benefits from international coordination

A Nash equilibrium between the domestic social planners in charge of macroprudential policy and the global monetary authority is characterized by a set of taxes on domestic borrowing, τ_i^d $(i \in I^d)$, and on foreign borrowing, τ_i^c $(i \in I^c)$, as well a nominal interest rate i^* such that:

(1) the domestic social planner of each country i sets his macroprudential tax (τ_i^d or τ_i^c) at the level that maximizes domestic welfare, taking the global real interest rate $r^* = i^* - \pi^*$ as given;

(2) the global monetary authority sets the nominal interest rate i^* so as to bring global employment as close as possible to the full-employment level, taking the countries' macroprudential taxes as given.

Then it is possible to show the following result.

Result 3 *Assume that the Nash equilibrium leads to a global liquidity trap with unemployment in some countries. 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.

There is scope for Pareto-improving coordination of macroprudential taxes. The intuition is that the countries with unemployment do not internalize the benefit from reducing their macroprudential taxes in terms of higher 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 the increase in global demand that raises their unemployment 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 (minus the inflation target).

Importantly, the scope for policy coordination does not include the countries with full employment. This is the case because (realistically) we have not allowed the countries that lose from a change in domestic and foreign macroprudential policies to be compensated by international transfers. If the countries with unemployment could pay the countries with full employment to reduce their macroprudential taxes, they would find it optimal to do so as 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 Quantitative easing and reserve accumulation

I now consider an application of the model to the equilibrium between unconventional monetary stimulus in one part of the world and 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 (QE), forward guidance on future policy rates or raising the inflation target. 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. The resulting equilibrium has sometimes been characterized as a "currency war" or a "capital war". Does the model support the view that there is scope for efficient policy coordination in such a situation?

The question can be addressed by specializing the model as follows. There are two countries that will be labeled "the US" and "China". The global real interest rate is set by the US so as to maximize US welfare. The capital account of China is closed except for the accumulation of foreign assets (reserves). This assumption may seem stark but it could be replaced (without changing anything to the results) by the assumption that China applies a subsidy on capital outflows. The accumulation of foreign reserves by China is denoted by B_C. We will thus consider a Nash equilibrium between the two policy instruments r^* and B_C.

I will focus on equilibria in which there is full employment in China but not in the US. There is less than full employment in the US because of the lower bound on the real interest rate,

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

China accumulates reserves so as to contain the growth in domestic credit caused by US monetary stimulus. For simplicity I assume that there is no debt externality in the US.[26]

[26]This assumption is not restrictive as it is in general optimal for the US to set the domestic macroprudential

Given that there is full employment in China, output is equal to $Y_C = g_C(\overline{L}_C)$ and 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. It will be convenient in analyzing the equilibrium to assume that the Chinese social planner sets the level of domestic expenditures, E_C. The Chinese social planner sets the level of domestic expenditures so as to maximize Chinese welfare taking the real interest rate set by the US as given. Chinese consumption and investment can be written as functions of total expenditures in the same way as in section . The problem of the Chinese social planner then can be written,

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

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,

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

We consider an equilibrium in which the Chinese level of reserves is positive. This implies that China gains from an increase in the global real interest rate because of the higher return on its reserves.

US welfare is given by,

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

where we have used the fact that the change in US foreign liabilities is equal to the accumulation of Chinese reserves. The US social planner's problem, thus, is rather simple. Then if China accumulates a positive level of net foreign assets ($Y_c > E_C$), the three terms on the right-hand side of this expression are maximized when the real interest rate is set at its lowest possible level, $r^* = -\pi^*$. It is thus optimal for the US social planner to set the real interest rate at the lowest possible level subject to the zero-bound constraint. At the margin, any increase in US consumption or investment is "free" since it is produced by unemployed US labor.

Given that the first two terms on the right-hand side of (5) do not depend on E_C, US welfare is increasing with Chinese expenditures,

$$\frac{\partial U_{US}}{\partial E_C} = 1 + r^*.$$

An increase in Chinese expenditures raises US production by the same amount (since Chinese production does not increase at the margin). The additional US income is saved for consumption in the second period as first-period US consumption remains unchanged. This is why the gross interest rate appears on the right-hand side of the expression above.

We are now ready to look at the case for international coordination. Figure 5 shows the policy instruments of the US and China on the horizontal and vertical axis respectively.

tax to zero if there is unemployment.

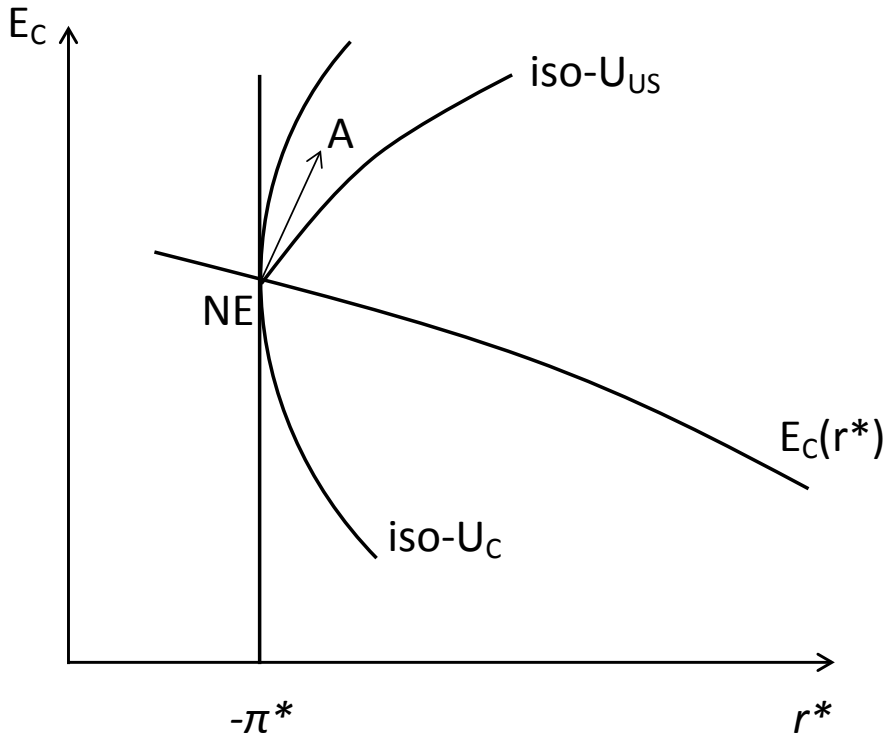

Figure 5: Monetary stimulus and reserve accumulation

The curve labeled $E_C(r^*)$ shows how China's level of expenditures is decreasing with the global real interest rate. The vertical line corresponds to the US optimal policy, which is to set 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 on the figure). The figure shows that as a condition for optimality the iso-welfare curve of China must be tangent to the vertical line. Finally, the figure shows the US iso-welfare curve that passes through the Nash equilibrium. This curve is upward-sloping since an increase in the real interest rate that reduces US welfare must be offset by an increase in Chinese expenditures.

The figure shows that the Nash equilibrium is not Pareto-optimal. The welfare of both the US and China is increased by moving from the Nash equilibrium to a point such as point A, that is by increasing both the US interest rate and Chinese expenditures at the margin. Then China benefits from receiving a higher return on its reserves whereas the US benefits from higher Chinese demand. What makes the result nontrivial is that the US also suffers from raising its own interest rate: why is it the case that it is always possible to make the US gain from the increase in Chinese demand exceed the cost from its own monetary restriction? The answer involves the fact that 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 increasing global demand by a very small (second-order) increase in the US interest rate (provided that the Chinese reserves are not too small).

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

Proof. See discussion above.

Another form of international coordination would for the US to refrain from unconventional monetary stimulus. Because of its simplified time structure the model does not lend itself to the analysis of forward guidance or quantitative easing, but it shows how raising the inflation target π^* relaxes the constraint on monetary policy. Both the US and China could benefit from an agreement by which the US does not raise its inflation target whereas China increases its demand.

6 Exchange rates

[TO BE COMPLETED]

7 Conclusion

I have presented a simple framework that (i) allows us to compare the welfare effects of domestic prudential policies and prudential capital account policies in a small open economy; (ii) analyze the general equilibrium effects of the uncoordinated use of these policies, and (iii) explore the case for the coordination of macroprudential and monetary policies and monetary at the global level. The main conclusions are that (i) domestic prudential policies are generally preferable to capital controls but that realistic constraints on the use of the former may justify using the latter; (ii) the fact that these policies have international spillovers does not per se imply that they should be subject to international rules or coordination; but (iii) international coordination may be justified if there is a global demand shortage.

The bottomline, thus, is that a case for the international coordination of macroprudential policies can be made, but that it is not as robust or generic as one might expect as it cannot be based merely on the existence of international spillovers and depends on the circumstances of global demand.[27] 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 the circumstances require, perhaps under the auspices of the G20, and not necessarily supported by the kind of permanent institutions that exist for international trade (such as the WTO).

[27]There may be other reasons for having international rules of good conduct for capital account policies, e.g., reducing stigma for appropriate policies—see **?**. I have focused here on the rationale in terms of international spillovers and externalities.

The model was very stylized and omitted several issues that are important in the real world. Perhaps the most egregious omission is that of exchanges rates. Capital controls on inflows can be used, and often are, to mitigate the appreciation of a currency. In this case, the international spillovers generated by the capital controls involve expenditure-switching effects. However, this does not necessarily affect the essence of the results presented here. The analysis of Korinek (2012), which incorporates exchange rates, reaches many of the same conclusions as I do here. [Analysis of exchange rates to be added in forthcoming section 6.]

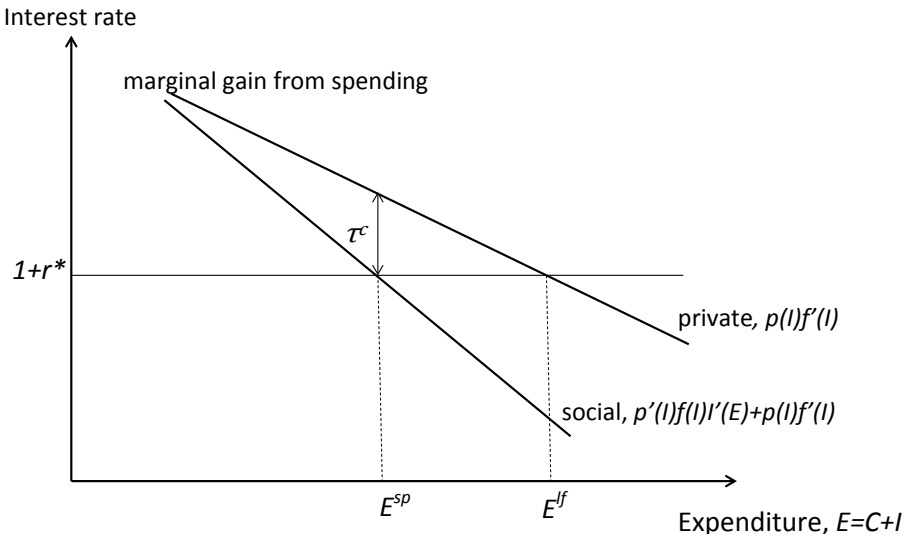

Figure 6: The optimal level of tax on capital inflows

APPENDIX

Appendix A. Proofs.

Proof of Result 1. The statements in the Result have been proven in the text except that the optimal tax on external borrowing is countercyclical under Assumption 2. Differentiating total welfare with respect to the level of expenditure gives,

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

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 second 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 first 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 6 is similar to figure 3 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 6, 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. As is standard in the taxation literature let us assume that the global social planner determines the optimal allocation under the constraints. The global social planner problem is

$$\begin{cases} \max \sum_i \left[u(C_i) + p(I_i)f(I_i)\right] \text{ s.t.} \\ \sum_i (C_i + I_i) \leq \sum_i Y_i, \\ u'(C_i) \geq p(I_i)f'(I_i) \text{ for } i \in I^c. \end{cases}$$

The global social planner maximizes global welfare, which is equal to the sums of lenders' utility from first-period consumption plus the second-period output, subject to two constraints. The first constraint is the resource constraint: the sum of global consumption and global investment cannot be larger than global output in the first period. 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.

The first-order conditions are:

$$\begin{aligned} u'(C_i) &= \lambda, \\ p'(I_i)f(I_i) + p(I_i)f'(I_i) &= \lambda, \end{aligned}$$

for the countries that use the domestic macroprudential tax ($i \in I^d$), where λ is the shadow cost of the resource constraint.

The first-order conditions are:

$$\begin{aligned} u'(C_i) &= \lambda - \mu_i u"(C_i), \\ p'(I_i)f(I_i) + p(I_i)f'(I_i) &= \lambda + \mu_i \left[p'(I_i)f'(I_i) + p(I_i)f"(I_i)\right], \end{aligned}$$

for the countries that use the macroprudential tax on external borrowing ($i \in I^c$), where μ_i is the shadow cost of the constraint on the marginal utility of consumption.

The first-order conditions and constraints are exactly the same as in the Nash equilibrium with independent domestic planners, with $\lambda = 1 + r^*$.

Proof of Result 3. Let us assume that all the countries with unemployment ($i \in U$) reduce their macroprudential tax by a small (first-order) amount $d\tau_i$. This increases global demand by,

$$-\sum_{i \in U \cap I^d} I'(r^* + \tau_i^d(r^*))d\tau - \sum_{i \in U \cap I^c} \left[C'(r^* + \tau_i^c(r^*)) + I'(r^* + \tau_i^c(r^*))\right] d\tau = dY > 0.$$

The increase in global demand is matched by an increase in global supply that comes 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 $dY_i > 0$ in such a way that $\sum_{i \in U} dY_i = dY$. The global real interest rate r^* does not change since the nominal interest rate remains at the zero lower bound.

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

$$U_i = \max_{C_i, I_i} u_i(C_i) + p_i(I_i)f_i(I_i) + \lambda_i \left[Y_i - C_i - I_i\right].$$

The welfare of a country that uses prudential capital controls can be written in the same way, with the additional constraint $p_i(I_i)f_i'(I_i) = u_i'(C_i)$. By the envelop theorem the change in country i's welfare is,

$$dU_i = \lambda_i dY_i > 0.$$

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,

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

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,

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

It 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 $r^* + \tau^d$ is $(r^* + \rho)/2$. The optimal tax smoothes 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

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

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,

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

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

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

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.

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