Balance sheet effects, foreign reserves and public policies

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European Stability Mechanism

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Abstract

This paper shows that countries can use foreign reserves to enhance their domestic economies' resilience to potential risks from balance sheet effects. Based on a theoretical model, this paper demonstrates that the government can either deploy its foreign reserves to lend in foreign currency to the private sector or increase fiscal spending on domestic goods. Both these policy tools can remedy the bad equilibrium characterized by large-scale domestic currency depreciation and very low aggregate investment, but they diverge in how they stabilize the domestic economy and require different minimum amounts of foreign reserves. Targeted lending works by altering investors' expectations of the domestic exchange rate and of firms' net worth. As long as foreign reserves are sufficient to cover the private sector's external debt, this approach eliminates the bad equilibrium without an actual depletion of reserves. In contrast, fiscal spending increases the demand for domestic goods and affects the relative price, leading to domestic exchange rate appreciation that subsequently increases firms' net worth and facilitates investment.

Key words:
Foreign reserves, Currency mismatch, Balance sheet effects

JEL codes
F31, F32, F41, G01

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1 Introduction

Global economic turmoil, which started with a local crisis in 2007 in the United States, quickly became a widespread global financial crisis (GFC) of a magnitude never seen since the Great Depression. One impressive phenomenon in this crisis is that emerging market economies (EMEs), which had seemed most vulnerable during the last waves of financial crises in the 1990s, fared much better than advanced economies.

First, EMEs on average performed better during the crisis in terms of output growth. Moreover, as Figure 1 illustrates, some EMEs, such as Argentina, Indonesia and Thailand,[1] which had experienced large currency depreciation in previous crisis periods, demonstrated remarkable exchange rate stability during the GFC. The recent literature on the GFC and its impact on EMEs[2] has largely documented these features. Against this background, one can observe that EMEs accumulated massive foreign reserve assets between the early 2000s and the onset of the GFC. Moreover, they seem to have slowly '[graduated] from fiscal procyclicality' (Frankel et al. 2013) and adopted bold fiscal policy measures during the crisis period. According to Obstfeld (2014), it seems that these fast-growing economies used the tranquil time after the emerging market crises of the 1990s to reform their policy framework, making them more resilient to external shocks of the 21st century.

Based on these observations, my work provides a stylized theoretical framework to understand the channels through which EMEs better protected themselves against the GFC. The mechanism of the model is based on the third-generation crisis model à la Krugman (1999). Namely, due to financial imperfections and currency mismatches in the private sector, an (expected) local currency depreciation would exacerbate debt service difficulties, wreck the balance sheets of domestic banks and firms, and magnify economic downturns.

There is in fact an extensive literature on third-generation crisis models and the policy solutions needed. In the aftermath of the Asian financial crisis, Krugman (1999) was among the pioneers to identify the feedback loop from financial imperfections to debt service difficulties and exchange rate problems. He extends the framework of Bernanke and Gertler (1989)[3] to an open economy setting, combining domestic credit constraints with exposure to foreign-currency liabilities. Although very simple, the model generates multiple equilibria and provides sufficient insight into how exchange rate depreciation would trigger balance sheet effects. Aghion et al. (2000), Aghion et al. (2004) and Céspedes (2004) extend Krugman's framework

[1] As for Korea, although still very volatile, the exchange rate depreciated less during the GFC than during the Asian financial crisis.

[2] For a detailed review, please refer to Crowe et al. (2009), Eichengreen (2010), Llaudes et al. (2010), Didier et al. (2012), Gourinchas and Obstfeld (2012), Ceballos et al. (2013), Catao and Milesi-Ferretti (2014), Obstfeld (2014) and Bussière et al. (2015).

[3] It is worth noting that there are also recent papers that look at feedback loops involving asset prices and borrowing capacity of financially constrained agents in a closed economy, e.g. Philippon and Schnabl (2013).

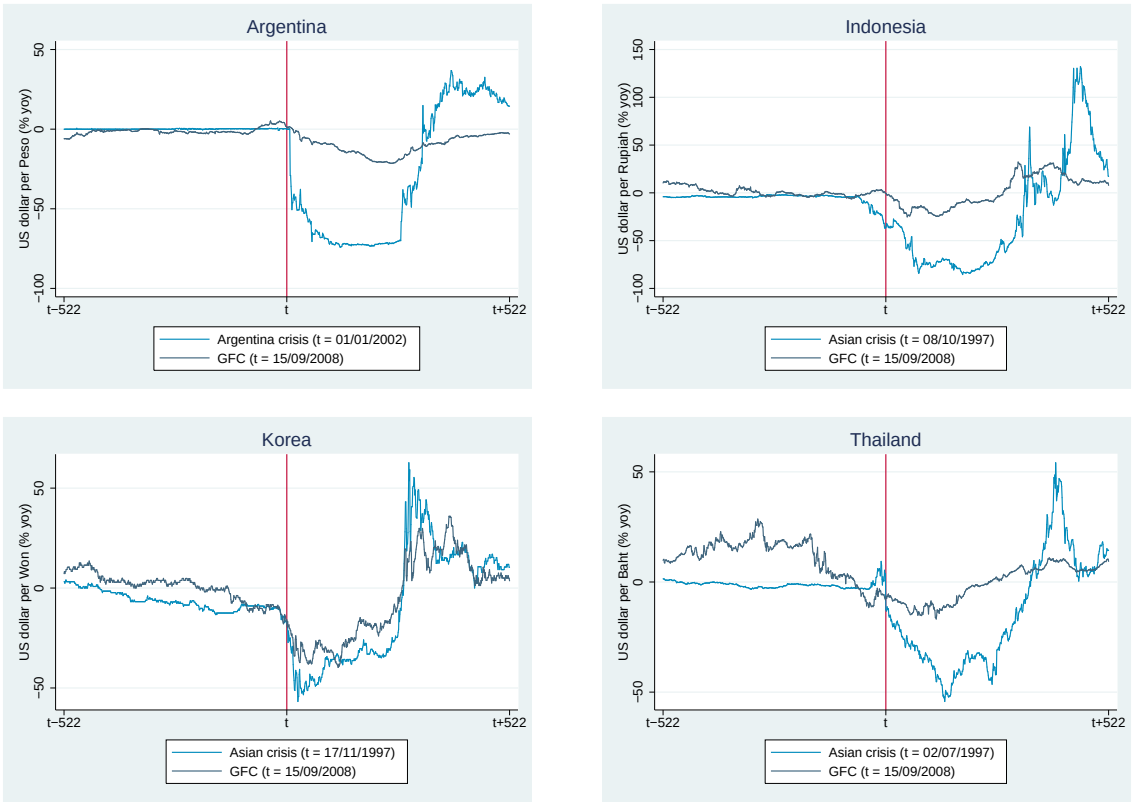

Figure 1: Nominal exchange rate depreciation in times of crises: Using daily data, the series are expressed in year-on-year growth rate (percentage point). A negative value indicates depreciation. Time t indicates the date of crisis occurrence that is chosen according to Obstfeld (2014) and other relevant literature on emerging market crises. The unit on the x-axis is day. Data source: DataStream, GTIS - FTID/TR

to a dynamic open economy setting with a micro-foundation. Among policy solutions to alleviate balance sheet effects, the existing papers focus on the choice of exchange rate regimes (e.g. Céspedes et al. 2004), optimal monetary policy (e.g. Aghion et al. 2000 and Aghion et al. 2001), or both (e.g. Chang and Velasco 2001 and Céspedes et al. 2002).

However, not much attention has been paid to the role of foreign reserves and fiscal policy in dealing with balance sheet effects. This is to some extent understandable, as EMEs did not have a large stock of foreign reserves or enough fiscal space to deal with external shocks back in the early 2000s. To my knowledge, only Céspedes et al. (2012) have provided a recent theoretical framework examining the role of foreign reserves in an economy facing strong depreciation pressures and constrained access to external financing. They argue that 'a 'threat' to intervene in the foreign exchange market to prevent exchange rate depreciation can prevent self fulfilling pessimism.' Notwithstanding its originality, the analysis on foreign reserves is only at the margin in Céspedes et al. (2012) and the authors do not distinguish the different ways to use reserves. My paper aims to fill the gap in the literature and to show how holding international reserves can eliminate the bad equilibrium, associated with negative expectations for a country's (real) exchange rate. This is a relevant question in the context of the GFC, as a gloomy world economic outlook may trigger investors to adjust downward their expectations of a country's exchange rate, especially when this country has a large export sector and is more likely to be affected by the 'global trade collapse (Baldwin 2009).' A negative perspective on a country's currency would then increase entrepreneurs' foreign debt service costs, lower their net worth or even make them temporarily insolvent. I argue in this paper that the government can use foreign reserves to restore lenders' confidence in the country's currency. There are, however, several ways in which reserves work to eliminate the unfavorable equilibrium. On the one hand, the government can lend or commit to lending its foreign reserves to the private sector when external funding is cut off. This is equivalent to giving foreign creditors a government guarantee to repay foreign debt held by the private sector. On the other hand, the country's authorities can also choose to stabilize domestic absorption via an increase in government spending. This expansionary fiscal policy can be financed, for example, by selling foreign reserves (e.g. expenditure switching policy). This is equivalent to public intervention in the foreign exchange market.

Comparing these two ways to stabilize the economy described above, my paper shows that although both policies can eliminate the bad equilibrium, they work through two different mechanisms. In the case of targeted lending, foreign reserves can be regarded as state-contingent insurance. Their value expressed in domestic terms increases with domestic currency depreciation. The government's commitment to lending in foreign currency strengthens lenders' confidence in domestic entrepreneurs' wealth and thus sustains foreign capital inflows to the domestic economy. The bad equilibrium can thus be removed even without an actual

depletion of reserves as long as the stock of reserves in the economy is sufficient to cover the private sector's foreign debt. In contrast, fiscal spending increases the demand for domestic goods in the goods market. This actually appreciates the domestic real exchange rate and accordingly raises entrepreneurs' wealth. The size of reserve depletion depends on the magnitude of domestic exchange rate depreciation.

The insurance role of foreign reserves, which is depicted in my model, is closely related to the literature on the precautionary motive of foreign reserve accumulation.[4] From a theoretical perspective, the precaution that foreign reserves provide can be understood in several different ways. Jeanne and Rancière (2011) show that foreign reserves can smooth domestic output and consumption by providing foreign goods liquidities in an event of 'sudden stops (Calvo 1998)'. Bianchi et al. (2012) demonstrate that reserves constitute cheap savings in foreign currency in peacetime and can be used when the government faces increasing costs of external financing or default risks in the future. In contrast, I focus on the role of reserves in dealing with currency mismatches and the resulting balance sheet effects. Curiously, this aspect of the insurance role of reserves has not been thoroughly analyzed in the context of the GFC. My current work can also be regarded as a theoretical underpinning to a few recent empirical papers[5] that relate foreign reserve accumulation to (short-term) external debts. Moreover, my work not only sheds light on the motives of reserve accumulation, it also analyzes and compares different ways of 'using' reserves. This is a new angle from which to study foreign reserves. I argue that depending on the policy tool used, foreign reserves may or may not need to be actually depleted. This supports the empirical finding of Bussière et al. (2015) who document that reserves are 'nuclear power' rather than real 'gunpowder.'

Currency mismatches are key for the balance sheet effect to work. In the scope of this paper, I take currency mismatches in the private sector as given. This is because my objective is to illustrate how different public policies may be used to stabilize the domestic economy rather than to explain why entrepreneurs want to hold foreign-currency liabilities *ex ante*. There are nevertheless various well-founded motives in the literature explaining the demand for foreign-currency liabilities. Burnside et al. (2001) and Schneider and Tornell (2004) argue that foreign-currency borrowing results from a risk-overtaking behavior of domestic firms when they know that the government will bail out domestic banks in case of default. In the same spirit, Korinek (2011) shows that domestic borrowers tend to favor foreign-currency debt as it is cheaper in peacetime, but does not internalize the pecuniary externality of their collective holding of foreign debts on exchange rates. Jeanne (2000) and Jeanne (2003) point to the signaling and commitment effect of borrowing

[4]For an overview of the precautionary motive for foreign reserve accumulation, please see Aizenman and Lee (2007). For additional references, please see Alfaro and Kanczuk (2009), Obstfeld et al. (2010), Aizenman and Hutchison (2012), Benigno and Fornaro (2012), Calvo et al. (2013) and Alberola et al. (2014).

[5]See Llaudes et al. (2010), Catao and Milesi-Ferretti (2014) and Bussière et al. (2015).

in foreign currency. Namely, by allowing the private sector to hold foreign debts that are subject to exchange rate fluctuations, the government sends out a signal about its commitment not to inflate the economy or depreciate the currency. The need for foreign debts can also be explained by the fact that the domestic financial market is underdeveloped, namely there are insufficient domestic savings to be channeled to firms that need funding, as Aghion et al. (2000) argue.

Regarding how to reduce the impact of currency mismatches, Jeanne and Korinek (2010) propose using pigouvian taxation to limit excessive foreign-currency liabilities. Jeanne and Zettelmeyer (2002) compare the pros and cons of using monetary policy and different exchange rate regimes. They conclude that monetary policy has conflicting outcomes in dealing with balance sheet effects. I explore in this paper the policy choices that were mentioned but not analyzed in Jeanne and Zettelmeyer (2002): how fiscal measures and foreign reserves can play a role when monetary policy is not effective in dealing with multiple equilibria. Jeanne and Wyplosz (2003) take a different angle to analyze how an international lender-of-last-resort can be useful in dealing with the issue of currency mismatches. The GFC has unfortunately demonstrated that international coordination for crisis management is far from established nowadays. Many EMEs still prefer holding a buffer stock for self-insurance instead of resorting to the assistance of international financial institutions.

This paper is organized as follows. Section 2 describes the model setting. Section 3 derives the conditions defining multiple equilibria in a decentralized economy. Section 4 introduces a government and studies its public policies. Section 5 concludes.

2 The model

The aim of this paper is to provide a theoretical framework showing how foreign reserves can be used to stabilize domestic economies exposed to currency mismatches and the resulting external financing strains. For this purpose, I have developed a small open real economy model with an infinite time horizon, enriched from Krugman (1999). The framework remains a stylized model but spells out all the implicit assumptions contained in Krugman (1999).

The decentralized economy is populated by a representative 'hand-to-mouth' worker, a representative entrepreneur,[6] as well as domestic and foreign creditors. A government will be introduced in Section 4. The economy produces a single domestic good but domestic agents can also consume or borrow foreign goods. All foreign-good related variables in the decentralized economy are denoted with a superscript F.

[6] In this paper I talk about balance sheet effects for an entrepreneur who can be understood to represent the entire private sector. The analysis can also be applied to banks exposed to foreign liabilities, such as in Jeanne and Zettelmeyer (2002).

The timing of events can be summarized as follows: at the beginning of time t, the entrepreneur harvests an output using the capital and labor bought a period earlier. He repays creditors and buys new labor for the production in $t+1$. The difference between what the entrepreneur earns and spends goes to his net worth. Backed by his net worth, the entrepreneur borrows from both domestic and foreign creditors to invest in capital stock. Creditors make their lending decisions at the beginning of each period based on their expectations for the relative price of foreign goods and the entrepreneur's net worth. Creditors' expectations for the domestic real exchange rate will ultimately be confirmed, within the same period, as soon as the lending decisions are made and capital flows into the domestic economy. There is thus no uncertainty in the economy over time.

2.1 Worker

In period t, the worker provides labor N_{t+1} to the entrepreneur and receives a wage $\omega_t N_{t+1}$.[7] The worker uses all his contemporaneous income $\omega_t N_{t+1}$ to consume both domestic goods C_t^H and foreign goods C_t^F every period. Domestic goods serve as the numéraire with a unitary price and therefore the price of foreign goods in terms of domestic goods, p_t, denotes the real exchange rate. An increase in p_t means a decrease in the relative price of the domestic goods, i.e. real depreciation loosely speaking.

As in Krugman (1999), I assume that the elasticity of substitution between domestic goods and foreign goods is one for the consumption basket. Namely, the worker allocates his total consumption C_t to domestic goods and foreign goods according to the following program. Total consumption is denominated in domestic goods, too.

$$\text{Maximize } C_t = (C_t^H)^{1-\mu}(C_t^F)^{\mu} \tag{1}$$

$$\text{s.t. } \omega_t N_{t+1} = \ C_t = C_t^H + C_t^F p_t \tag{2}$$

This generates:

$$C_t^H = (1-\mu)C_t \tag{3}$$

$$C_t^F = \frac{\mu C_t}{p_t} \tag{4}$$

[7] The time subscript refers to when the input is actually used for production.

2.2 Creditors

There are both domestic and foreign creditors in the model economy. Domestic creditors provide loans in domestic goods while foreign creditors provide loans in foreign goods. In the scope of this paper, I model the supply of credits as exogenous. That is, there are sufficient and exogenous resources to ensure that the supply of domestic and foreign credits will always match the borrowing need of the entrepreneur. It will be interesting to relax this assumption by introducing participation constraints for both domestic and foreign creditors in future research work.

In order to concentrate on balance sheet effects that only concern foreign goods denominated liabilities and real exchange rates, it is further assumed that there are always committed resources for the entrepreneur to repay domestic creditors.

As for foreign creditors, they make their lending decision at the beginning of each period based on their expectations for the relative price of the domestic good and the entrepreneur's net worth.

2.3 Entrepreneur

The key actor in the decentralized economy is a representative entrepreneur. At the beginning of period t, he uses labor N_t and capital K_t to produce an output Y_t. Both N_t and K_t are chosen in period $t-1$. It is further assumed that the labor supply is ample and thus perfectly inelastic, with $N_t = 1$ for all $t \in \{1, 2, 3, ...\}$. The production function is a standard neoclassical production function, i.e. increasing in both inputs with decreasing marginal returns and homogeneous of degree one. Namely, $Y_t = F(K_t, N_t) = K_t^{\alpha} N_t^{1-\alpha}$. α is the share of capital in the production function.

Three features characterize the entrepreneur's behavior: foreign goods input in capital investment, currency mismatches and credit constraints.

Foreign goods requirement In each period t, the entrepreneur needs investment both in domestic goods and foreign goods to create the capital stock. Namely, akin to total consumption C_t, total investment I_t is composed of a domestic component I_t^H and a foreign component I_t^F. The elasticity of substitution between I_t^H and I_t^F is assumed to be one, with $(1-\mu)$ the share of the domestic component. Capital fully depreciates at the end of each period, namely $K_{t+1} = I_t$. Capital is also supposed to be perfectly mobile across borders. The entrepreneur thus faces the following allocation program between the domestic and foreign component of the investment:

$$\text{Maximize } I_t = (I_t^H)^{1-\mu}(I_t^F)^{\mu} \tag{5}$$

$$\text{s.t. } K_{t+1} = \ I_t = I_t^H + I_t^F p_t \tag{6}$$

This generates:

$$I_t^H = (1-\mu)I_t \tag{7}$$

$$I_t^F = \frac{\mu I_t}{p_t} \tag{8}$$

Foreign goods liabilities In period t, the investment in foreign goods I_t^F is made entirely by borrowing D_{t+1}^F from foreign creditors, namely, $I_t^F = D_{t+1}^F$. The investment in domestic goods is made through borrowing from domestic creditors D_{t+1}^H and the retained earnings (net worth) W_t that the entrepreneur receives from period $t-1$. The total demand for investment can thus be written as

$$I_t = D_{t+1}^F p_t + D_{t+1}^H + W_t \tag{9}$$

As the production and the resulting income are denominated in domestic goods while the liabilities are denominated both in domestic and foreign goods, the entrepreneur is exposed to currency mismatches.

Credit constraints The entrepreneur's maximum borrowing capacity in period t is conditional on his contemporaneous real wealth W_t and cannot go beyond the pledgeable income ψW_t, in the spirit of Bernanke and Gertler (1989) and Bernanke et al. (1999). $\psi \in [0,1]$ measures the tightness of the credit market. The higher ψ, the less the entrepreneur is constrained, the more he is able to leverage using his real wealth. In line with the literature on credit constraints, the value of ψ depends on the stage of financial development in a given country. $\psi = 0$ means that no borrowing is possible. This can be the case in least-developed countries. In this extreme case, balance sheet effects are not at work as there is no borrowing at all, let alone borrowing in foreign goods. In another extreme case, when $\psi = 1$, there are no credit frictions at all. Advanced economies, for instance, are supposed to have a high ψ. The emerging market economies (middle-income countries) that I focus on in this paper should have a ψ in between the two former cases and have a strong demand for foreign credits.

The credit constraints in my model can be written as follows:

$$D^F_{t+1} p_t + D^H_{t+1} \leq \psi W_t \tag{10}$$

Combining (9) and (10), the total investment that the entrepreneur can make in each period is thus capped: $I_t = D^F_{t+1} p_t + D^H_{t+1} + W_t \leq (1+\psi) W_t$

Now let us look at the entrepreneur's optimization program. The entrepreneur does not consume and maximizes his wealth W_t subject to his budget and credit constraints in each period t. This is equivalent to maximizing the production of domestic goods in $t+1$, as Y_{t+1} is monotonically increasing in K_{t+1} that is in turn uniquely pinned down by the total investment I_t and I_t is capped by the entrepreneur's wealth W_t through the credit constraint (13). The entrepreneur's program can be written as follows:

$$\text{Maximize } Y_{t+1} = (K_{t+1})^{\alpha} (N_{t+1})^{1-\alpha} \tag{11}$$

$$\text{s.t. } D^H_{t+1} + p_t D^F_{t+1} + Y_t = D^H_t R_t + D^F_t R^*_t p_t + I_t + N_{t+1} \omega_t \tag{12}$$

$$I_t = D^F_{t+1} p_t + D^H_{t+1} + W_t \leq (1+\psi) W_t \tag{13}$$

Using the inelastic labor supply $N_{t+1} = 1$, the first order condition on the labor demand N_{t+1} generates unambiguously $\omega_t = (1-\alpha) Y_t$. Solving the rest of the entrepreneur's program, however, depends on whether the credit constraint (13) is binding.

When the constraint is unbinding, one can derive the Uncovered Interest Parity with $R_t = R^*_t p_{t+1}/p_t$. R_t and R^*_t denote *gross* domestic and world interest rates respectively. In the steady state, we have $R = R^*$. Therefore, I_t is uniquely pinned down by equalizing the marginal product of capital and the marginal cost, $F_k(K) = R = R^*$, where $F_k(\cdot)$ denotes the marginal product of capital. Using the production function stated above, one can derive $I = \bar{I} = \left(\alpha / R^*\right)^{1/(1-\alpha)}$. This is the first-best level of the total investment. As the interest rates do not play a role in this model without monetary policy, let us assume $R = R^* = 1$ hereafter.

When the constraint is binding, $I_t = (1+\psi) W_t$. The total investment in the economy is a linear function of the entrepreneur's real wealth.

Substituting $N_{t+1} = 1$, $\omega_t = (1-\alpha) Y_t$, $R = R^* = 1$ and equation (9) in the entrepreneur's budget constraint (12), one can derive the entrepreneur's wealth function:

$$W_t = \alpha Y_t - D_t^H - p_t D_t^F \tag{14}$$

The entrepreneur's net worth W_t is equal to his capital income αY_t minus the repayment of domestic debt D_t^H and the repayment of foreign debt valued at the current exchange rate $p_t D_t^F$. Y_t, D_t^H and D_t^F being all predetermined at the beginning of period t, there is a linear relationship between the entrepreneur's net worth and the real exchange rate. This is the source of balance sheet effects in the model.

Therefore, when the credit constraint is binding, $I_t = (1+\psi)(\alpha Y_t - D_t^H - p_t D_t^F)$.

Based on the above analysis, regardless of the credit constraint, one can write the entrepreneur's demand for investment as follows. It is a truncated function of the (expected) real exchange rate p_t.

$$I_t = \begin{cases} 0 & p_t > \bar{p}_t \\ (1+\psi)(\alpha Y_t - D_t^H - p_t D_t^F) & \underline{p_t} < p_t < \bar{p}_t \\ \bar{I} = \alpha^{\frac{1}{1-\alpha}} & p_t < \underline{p_t} \end{cases} \tag{15}$$

$\bar{p}_t = (\alpha Y_t - D_t^H)/D_t^F$ denotes the threshold value of the exchange rate beyond which the entrepreneur's wealth is reduced to zero or negative values. The total investment is equal to zero as a result. $\underline{p_t} = [\alpha Y_t - D_t^H - \bar{I}/(1+\psi)]/D_t^F$ denotes the threshold value of the exchange rate below which the entrepreneur's wealth is high enough so that the credit constraint (13) no longer binds. The total investment reaches the first-best level $\bar{I}$. Between $\underline{p_t}$ and $\bar{p}_t$, the credit constraint always binds and the investment is a negative function of the current exchange rate.

Table 1 provides comparative statics showing how the threshold values of the real exchange rate change with the underlying macroeconomic variables.

Table 1: Comparative Statics

	Y	D^H	D^F	ψ
$\bar{p}$	$\uparrow$	$\downarrow$	$\downarrow$	/
$\underline{p}$	$\uparrow$	$\downarrow$	$\downarrow$	$\uparrow$

2.4 Market clearing conditions

To close the model, both domestic and foreign goods markets need to respect their clearing conditions.

The aggregate demand for domestic goods needs to match the total domestic output produced by the entrepreneur Y_t. The aggregate demand consists of the worker's domestic consumption C_t^H, the investment in domestic good I_t^H and exports $p_t X_t^F$. X_t^F stands for the domestic goods that are consumed abroad and it is denominated in foreign goods.[8]

The clearing condition in the domestic goods market states: $Y_t = C_t^H + I_t^H + X_t^F p_t$. Using (3), (7) and $C_t = \omega_t N_{t+1} = (1-\alpha)Y_t$, one can derive:

$$Y_t = (1-\mu)(1-\alpha)Y_t + (1-\mu)I_t + p_t X_t^F \tag{16}$$

Given an exogenous external demand and a predetermined production of domestic goods, the domestic goods market equilibrium (16) pins down a linear relationship between the real exchange rate and the level of total investment, as illustrated in equation (17). An increase in total investment appreciates the domestic real exchange rate.

$$p_t = \frac{Y_t[\mu + (1-\mu)\alpha] - (1-\mu)I_t}{X_t^F} \tag{17}$$

Foreign goods are exogenously given in this model. The total demand for foreign goods matches the exogenous supply: $C_t^F + I_t^F = Y_t^F$.

Regarding domestic and foreign credits, as mentioned above, the supply is exogenous and always matches the demand, namely $D_{t+1}^H = R_t D_t^H + E_t^H$ and $D_{t+1}^F = R_t^* D_t^F + E_t^F$. E_t^H and E_t^F are exogenous endowments that help equalize the supply and the demand of credits in each period.

3 Multiple equilibria in a decentralized economy

This stylized model can be solved in an orthogonal plan of $p(p^e)$ and $I(I^e)$ using the equations (15) and (17). As the main trigger in the model is the expectation that foreign creditors form about the real exchange rate in the domestic economy, I add a superscript e hereafter whenever talking about expectations.

[8]The value of domestic exports in terms of foreign goods, X_t^F, is considered exogenous and fixed. This is to assume that the foreign elasticity of substitution is unitary. Allowing the elasticity of substitution to be bigger than one does not change the qualitative results presented in this paper. It is easy to extend the current model to include a CES trade framework with monopolistic competition.

First, equation (15) relates the *expected* exchange rate p_t^e to the *expected* investment I_t^e. This gives a truncated curve of the demand for investment (henceforth called II curve), as Figure 2 shows.

At the beginning of period t, foreign creditors form an expectation for the real exchange rate before making lending decisions. An expected depreciation of the real exchange rate would lower the entrepreneur's expected wealth because of higher debt service costs. Therefore, the entrepreneur's borrowing capacity would be lower as the collateral value for foreign creditors - a share of the entrepreneur's expected wealth - would be lower. When foreign creditors expect a large level of depreciation, meaning that $p_t^e > \bar{p}$, the burden of repaying foreign goods denominated debts becomes so heavy that the entrepreneur's wealth is driven to zero or beneath. In this case, no pledgeable income is available as collateral for foreign creditors. Therefore, rational creditors would never lend to the domestic economy. Thus, $I_t = I_t^e = 0$. This scenario is represented by the red vertical segment on the y-axis.

In contrast, when foreign creditors expect large appreciation, namely $p_t^e < \underline{p}$, the entrepreneur's wealth expressed in domestic goods increases significantly thanks to lower foreign debt service costs. As a result, the credit constraint (13) never binds. The domestic investment reaches the unbinding level: $\bar{I} = \alpha^{1/(1-\alpha)}$. This situation is represented by the red vertical segment at $I = \bar{I}$ for all $p_t^e < \underline{p}$.

When $\underline{p} \leq p_t^e \leq \bar{p}$, the credit constraint (13) is always binding, the demand curve of the investment is represented by a downward sloping line.

Second, once foreign creditors have made their lending decisions, foreign capital flows into the domestic economy. The realized total investment I_t will uniquely pin down the realization of the domestic exchange rate through the goods market equilibrium (17). The downward sloping line in Figure 2 (henceforth called the DD curve) represents this relationship. In rational expectation equilibrium, the actual realization of the exchange rate and investment coincides with the initial guesses. As everything is in reality determined within a period, the time subscript is dropped hereafter.

Combining the DD and II curves, one can observe in Figure 2 that there are two intersection points on the vertical segments of the II curve,[9] which correspond to the multiple equilibria in the model. Multiple equilibria are defined as the coexistence of a good equilibrium - appreciated real exchange rate and high investment - and a bad equilibrium - depreciated real exchange rate and low investment.

There are two necessary conditions to guarantee the existence of multiple equilibria. A bad equilibrium exists if $\bar{p} \leq [\mu + (1-\mu)\alpha]Y/X^F$. Additionally, a slope condition is needed to ensure that a good equilibrium exists: the DD curve needs to have a steeper slope than the II curve when the credit constraint is binding,[10]

[9] Notice that the middle intersection point is unstable. Please see Appendix A for a discussion.

[10] Notice that there is a corner solution for the good equilibrium: when the DD curve is very steep, it might intersect the x-axis before reaching the vertical segment $I = \bar{I}$ (namely $p < 0$). This is, however, not an interesting solution (as the equilibrium exchange rate needs to be extremely appreciated). For the purposes of this paper, this corner solution is ruled out.

namely $|-(1-\mu)/X^F| \geq |-1/[(1+\psi)D^F]|$.

Simplifying these two inequalities, one can deduce that as long as $D^F/X^F \geq max\Big(1/[(1-\mu)(1+\psi)], (\alpha - d)/[\mu+(1-\mu)\alpha]\Big)$, there are multiple equilibria in the economy ($d = D^H/Y$). It can be further proved that for small values of μ, $1/[(1-\mu)(1+\psi)]$ is always bigger than $(\alpha - d)/[\mu + (1-\mu)\alpha]$, namely the slope condition dominates.

Using equations (15) and (17), one can calculate the benchmark bad and good equilibria that are also indicated in Figure 2:

$$I^{bad} = 0 \qquad I^{good} = \bar{I} = \alpha^{\frac{1}{1-\alpha}}$$

$$p^{bad} = \frac{Y[\mu + (1-\mu)\alpha]}{X^F} \qquad p^{good} = \frac{Y[\mu + (1-\mu)\alpha] - (1-\mu)\bar{I}}{X^F}$$

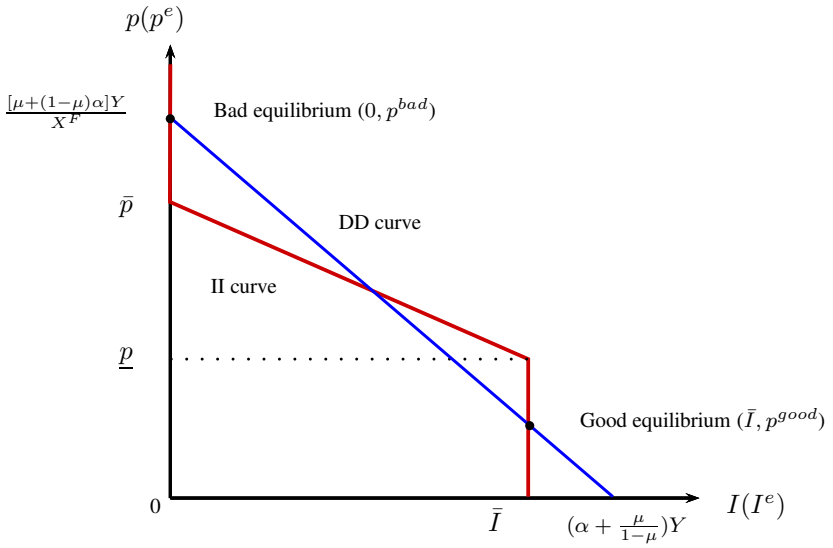

Figure 2: Multiple equilibria

I will show in the next section to what extent appropriate public policies can eliminate the bad equilibrium and stabilize the domestic economy, especially in the context of an unfavorable international economic environment.

4 Public policies

From this section, I introduce a benevolent government[11] to the model economy. The only objective of this government is to eliminate the bad equilibrium associated with large currency depreciation and low aggregate investment. Therefore, it is assumed that the government commits itself to intervening only when an unfavorable economic outlook is foreseen and investors' confidence is likely to be weakened.

At the beginning of period t, the government possesses some previously accumulated resources, either in the form of foreign reserve assets B^* or taxes T. For the purposes of analysis, these resources are considered given and the *ex ante* costs of resource accumulation are thus not taken into account.

With its resources, the government can, on the one hand, lend or commit to lending in foreign goods to the entrepreneur. By doing so, the government alters foreign creditors' expectations for the domestic exchange rate and the entrepreneur's reimbursement capacity, and thus sustains foreign capital investment. On the other hand, the government can increase public spending, thus raising the relative price of domestic goods against any depreciation expectations. A stable exchange rate will subsequently ensure that the entrepreneur's wealth and borrowing capacity are not tainted. The following sections of the paper will analyze these different strategies that the government can use to stabilize the domestic economy whenever it is necessary.

4.1 Targeted lending to the private sector

When the government has previously accumulated foreign reserves, B^*, it can commit to lending foreign goods directly to the private sector to insulate the entrepreneur's net worth from potential exchange rate depreciation. From this perspective, foreign reserves can be regarded as state-contingent insurance, as their value in domestic goods increases with potential depreciation of the domestic real exchange rate. Whenever the exchange rate is under pressure, the increased repayment burden from the foreign debt will be offset by the government's lending in foreign goods. This policy can thus alter foreign creditors' expectations for the entrepreneur's net worth, and sustain external financing under unfavorable macroeconomic conditions. Notice that this state-contingency of the domestic value of foreign reserves ensures that the government will only intervene when the bad state is likely to occur.

The new wealth function of the entrepreneur is written in equation (18).

[11] The model economy is a real economy; one may think of the government in the model as the consortium of a conventional government and a central bank. One may think that many central banks in emerging market economies are not fully independent.

$$W^e = \alpha Y - D^H - p^e D^F + p^e B^* \tag{18}$$

The aggregate resource function (16) that determines the actual level of the exchange rate does not change, as nothing changes the demand for domestic goods. As a result, the DD curve remains the same while the II curve shifts upward (with the first-best level of demand for investment $\bar{I}$ unchanged. The latter only depends on the international interest rate). Figure 3 shows the new equilibrium and compares it with the multiple equilibria in a decentralized economy.

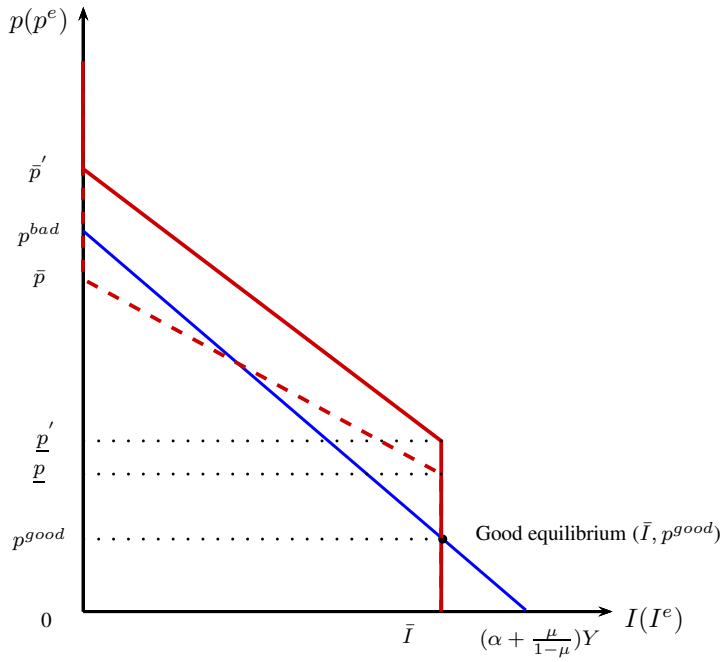

Figure 3: Equilibrium with targeted lending

Figure 3 clearly shows that when the government lends foreign goods to the private sector, it eliminates the bad equilibrium $(0, p^{bad})$. With the entrepreneur's new wealth equation (18), the slope of the II curve becomes steeper. The new threshold value of the real exchange rate beyond which the entrepreneur's wealth is driven to zero or beneath, $\bar{p}'$, is raised, making this less likely to happen. The bad equilibrium is removed as long as $0 < p^{bad} \leq \bar{p}' = (\alpha Y - D^H)/(D^F - B^*)$ with $B^* < D^F$. This gives:

$$D^F - \frac{\alpha - d}{\mu + (1-\mu)\alpha} X^F \leq B^* < D^F \tag{19}$$

Notice that the good equilibrium remains the same as in the decentralized market equilibrium. This is because the government's commitment to lending in foreign goods only aims at altering foreign creditors' expectations for the domestic real exchange rate. As long as the commitment is credible (i.e. backed by sufficient foreign reserves), the government does not even need to actually deplete its foreign reserves to stabilize the domestic economy.

From equation (19), the minimum level of reserves needed for targeted lending is equal to $B^{*lend}_{min} = D^F - (\alpha - d)X^F/[\mu + (1-\mu)\alpha]$. As long as the conditions for the existence of multiple equilibria hold, one can prove that B^{*lend}_{min} is larger than zero. Namely, when the foreign goods income from exports cannot cover foreign liabilities, reserves are needed to make sure that the entrepreneur's expected wealth is above zero.

The amount of reserves needed [12] depends on the private sector's exposure to foreign goods debt (D^F). The higher the foreign debt, the more reserves are needed for targeted lending policy. The need for reserves is negatively correlated with foreign goods income earned through exports X^F. If at time t, the flow of exports (augmented by a coefficient) exceeds that of foreign liabilities, B^* might become negative, namely there is an accumulation of reserves. The amount of reserves for the targeted lending policy also depends on the marginal propensity to imports μ and the per GDP domestic lending ratio d. The higher μ, the more foreign goods are demanded, thus higher reserves are needed to pay out imported goods.

Notice that the targeted lending policy is equivalent to the situation where the government uses its own net worth W^G as a collateral to secure external funding for the sake of the entrepreneur. In the model, the government's net worth comes from its foreign reserve holdings valued at the current real exchange rate, namely, $W^G = p^e B^*$. The government's net worth moves in the opposite direction compared to that of the entrepreneur as a function of p^e. Expected depreciation of the real exchange rate would increase the government's net worth and reduce that of the entrepreneur. Therefore, while the entrepreneur has difficulties in sustaining external financing in the face of an adverse shock on the real exchange rate, the government can serve as a financial intermediary. In this case, the investment function (13) becomes:

$$\begin{aligned} I^e &\leq (1+\psi)(W^e + W^G) \\ &= (1+\psi)(\alpha Y - D^H - p^e D^F + p^e B^*) \end{aligned} \tag{20}$$

The second parenthesis in equation (20) is exactly the same as in equation (18), in the case of a targeted lending policy.

[12] This is a flow variable which refers to the amount of reserves required to conduct a certain public policy. This is different from the level of reserves which is a stock variable.

To give a concrete example, the Korean government used this type of lending policy to stabilize its domestic economy and to sustain external financing during the GFC (see Aizenman and Hutchison 2012). Based on the implications of the current model, if the exchange rate of Korean won was still very volatile during the GFC compared to other EMEs' currencies (see Figure 1), it was because the market thought Korea did not hold enough foreign reserves to preclude the bad equilibrium. According to Cho (2012), Korea's total foreign reserves can only cover 70% of the entire exposure of the Korean private sector to foreign-currency debt.

4.2 Expansionary fiscal policy

The second policy choice of the government consists of fiscal spending on domestic goods. Bearing in mind that in the framework of Krugman (1999), fiscal spending should not be understood in the Keynesian sense, as prices are fully flexible in this stylized model and the supply of domestic goods is predetermined at the beginning of each period. Therefore, an expansionary fiscal policy in period t raises domestic demand and appreciates the domestic exchange rate.

In order to ensure the comparability with the previous policy tool, it is assumed that the government commits to using fiscal spending policy only when economic conditions are likely to deteriorate (e.g. weakening of the market confidence, declining export revenue, etc). If the fiscal spending is financed by previously accumulated foreign reserves, this expansionary fiscal policy can be assimilated to an expenditure switching policy or direct intervention in the foreign exchange market. If the fiscal spending is financed by previously collected taxes, this instrument can be understood as a form of automatic stabilizers that are supposed to be triggered when economic conditions turn unfavorable.[13]

Unlike the targeted lending policy, fiscal spending truly affects the exchange rate through the aggregate resource constraint. Suppose that the fiscal spending is financed by previously accumulated foreign reserves, the aggregate resource constraint (16) becomes:

$$\begin{aligned} Y &= (1-\mu)(1-\alpha)Y + (1-\mu)I + G + pX^F \\ G &= pB^* \end{aligned} \tag{21}$$

The real exchange rate is pinned down by equation (21): $p = \{Y[\mu + (1-\mu)\alpha] - (1-\mu)I\}/(X^F + B^*)$. This implies a downward rotation of the DD curve around the point $\Big([\alpha + \mu/(1-\mu)]Y, 0\Big)$. The II curve

[13] During the good time, resources need to be accumulated for automatic stabilizers to function in the bad time.

remains unchanged as in the decentralized economy.

Figure 4 shows the new equilibrium and compares it with the multiple equilibria in the decentralized economy. It can be seen that a fiscal spending policy financed by foreign reserves can also eliminate the bad equilibrium $(0, p^{bad})$. However, the good equilibrium in this case also changes. In fact, although the realized investment achieves the same unbinding level $\bar{I}$, the corresponding exchange rate appreciates to $p^{good'}$, with $p^{good'} < p^{good}$. This is because fiscal spending immediately changes the demand for domestic goods and consequently determines a new level of exchange rate through the new aggregate resource constraint (21). Foreign reserves are depleted in this case.

The bad equilibrium is eliminated in this policy setting as long as $p^{'}$ is smaller than $\bar{p}$ (see Figure 4). Namely, $0 < p^{'} = \{Y[\mu + (1-\mu)\alpha]\}/(X^F + B^*) \leq \bar{p} = (\alpha Y - D^H)/D^F$. This gives:

$$D^F \frac{[\mu + (1-\mu)\alpha]}{\alpha - d} - X^F \leq B^* \tag{22}$$

The minimum level of reserves needed to conduct an expansionary fiscal policy is: $B^{*fisc}_{min} = D^F[\mu + (1-\mu)\alpha]/(\alpha - d) - X^F$. The conditions for the existence of multiple equilibria also guarantee that $B^{*fisc} > 0$.

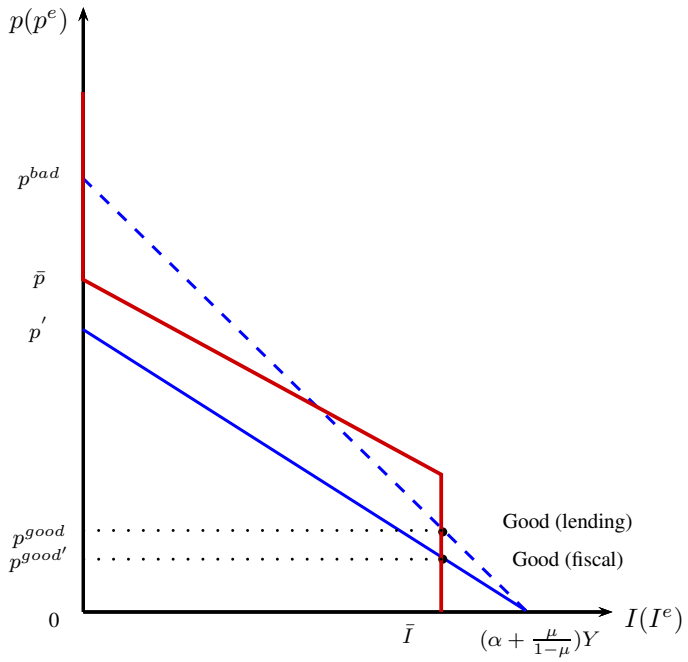

Figure 4: Equilibrium with fiscal spending financed by reserves

Suppose now that fiscal spending is financed by previously collected taxes. In this case, government resources are denominated in domestic goods only. The new aggregate resource constraint becomes:

$$\begin{aligned} Y &= (1-\mu)(1-\alpha)Y + (1-\mu)I + G + pX^F \\ G &= T \end{aligned} \tag{23}$$

Equation (23) determines the exchange rate: $p = \{Y[\mu + (1-\mu)\alpha] - T - (1-\mu)I\}/X^F$. This time, the DD curve (black line in Figure 5) shifts downwards, parallel to the DD curve in the decentralized economy (dashed blue line). The II curve remains unchanged. As one can see from Figure 5, the bad equilibrium can also be eliminated, but the exchange rate appreciates in the good equilibrium more than in the case where fiscal spending is financed by foreign reserves.

The condition for removing the bad equilibrium requires: $p^{''} = \{Y[\mu + (1-\mu)\alpha] - T\}/X^F \leq \bar{p} = (\alpha Y - D^H)/D^F$. This gives a criterion for the minimum taxes that the government needs to stabilize the domestic economy:

$$Y[\mu + (1-\mu)\alpha] - \frac{(\alpha Y - D^H)X^F}{D^F} \leq T \tag{24}$$

.

Namely, the minimum amount of taxes needed to eliminate the bad equilibrium is $T_{min} = Y[\mu + (1-\mu)\alpha] - \frac{(\alpha Y - D^H)X^F}{D^F}$.

One counterfactual question that can naturally be asked is: if the public spending policy financed by taxes achieves the same equilibrium as fiscal spending financed by foreign reserves, will the bad equilibrium still be removed? This situation is represented by the black line in Figure 6. It can be proved that a fiscal spending policy that is financed by taxes cannot unambiguously remove the bad equilibrium. The minimum taxes that help the economy achieve the same good equilibrium as in the case of a fiscal spending financed by foreign reserves are smaller than T_{min}.[14]

The two approaches to financing fiscal expansion differ primarily in that using reserves not only raises the demand for domestic goods but also implies an exchange rate intervention by replacing foreign goods

[14]It can be shown that the minimum taxes requested to achieve the same good equilibrium as in the case of a fiscal spending financed by foreign reserves are equal to $p^{good'} B^{*fisc}_{min}$ (see Figure 6). $p^{good'}$ is determined by plugging the unbinding level of investment $\bar{I}$ into equation (21). One can then easily demonstrate that $p^{good'} B^{*fisc}_{min} < T_{min}$.

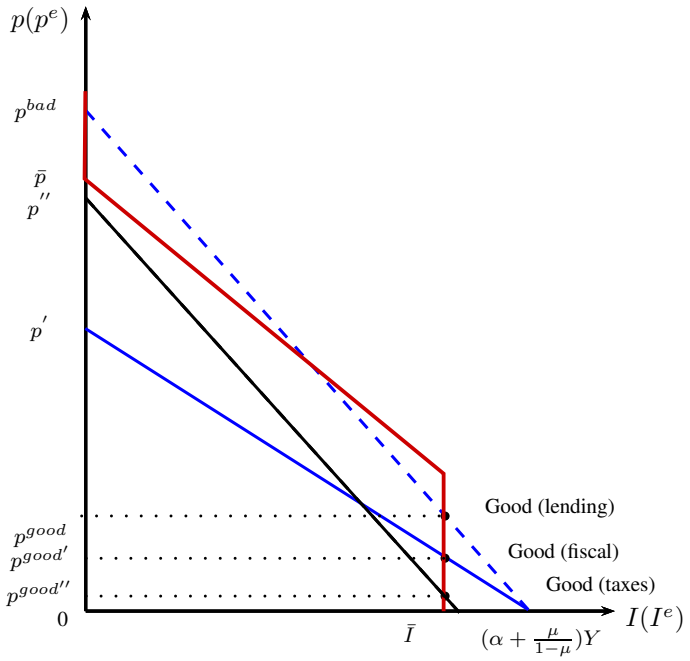

Figure 5: Equilibrium with fiscal spending financed by taxes

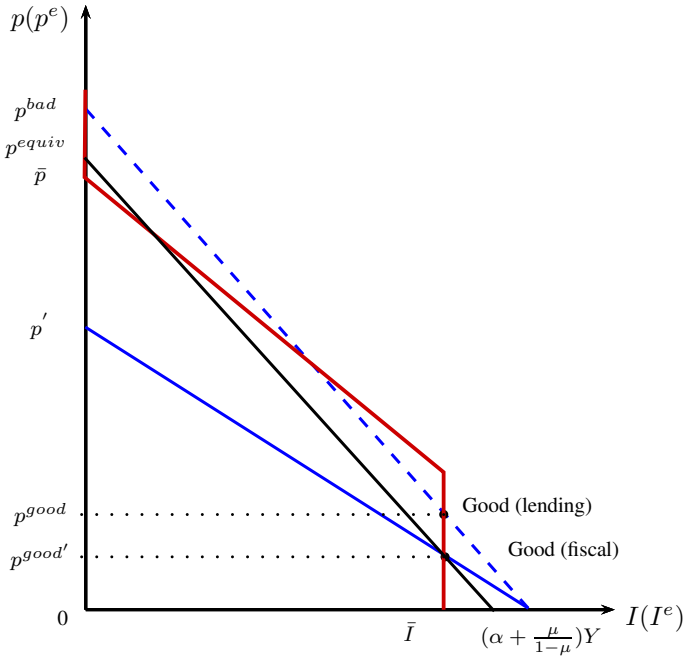

Figure 6: Fiscal spending: equivalence

with domestic goods. Therefore, it is easier to remove the bad equilibrium by using foreign reserves. There are concrete examples where countries use foreign reserves for fiscal expansion. China, for instance, used US$67.5 billion from its foreign reserve holdings to recapitalize four state-owned banks in 2003. Similarly, in 2007, US$200 billion were depleted to fund China Investment Corporation.

4.3 Differences between targeted lending and fiscal spending

A targeted lending policy and a public spending policy work through two different mechanisms, although both policies can remove the bad equilibrium. They also differ in terms of the minimum amount of resources required. I discuss these differences in this section.

A targeted lending policy is at work through lenders' expectations while fiscal spending truly changes the demand for domestic goods and appreciates the real exchange rate. The targeted lending policy affects the entrepreneur's wealth function through expectations. As one can see in Figure 3, the government's commitment to lending in foreign goods increases the threshold exchange rate for which the entrepreneur's wealth falls beneath zero ($\bar{p}^{'} > \bar{p}$). Similarly, this policy makes it easier for the credit constraint not to bind ($\underline{p}^{'} > \underline{p}$). As a result, foreign creditors will believe that the entrepreneur's wealth will remain positive for a wider range of values of the expected exchange rate. Therefore, lenders will be willing to provide funding to this economy. With the targeted lending, the government only needs to hold sufficient foreign reserves to cover the private sector's foreign liabilities so as to eliminate the bad equilibrium. Foreign reserves will only be deployed if the expected depreciation materializes (e.g. a realized shock on foreign demand X^F).

As for the fiscal policy, an increase in government spending will unambiguously change the exchange rate through the aggregate demand for domestic goods. To ensure the same amount of investment, the government needs to appreciate the price of domestic goods by increasing government consumption so as to stabilize the entrepreneur's wealth. If the insurance provided by a targeted lending policy works through the entrepreneur's wealth directly, fiscal spending affects the domestic exchange rate first and the entrepreneur's wealth only indirectly. I have also shown that the financing sources of fiscal spending matter. For the same amount of resources, the fiscal spending policy that is financed by foreign reserves (e.g. expenditure switching) can eliminate the bad equilibrium more easily than the fiscal spending financed by taxes (e.g. automatic stabilizers). More resources are needed in the latter case.

Moreover, with the targeted lending policy, the valuation effect of the exchange rate plays a role, giving the protection of foreign reserves a state-contingent nature. This feature ensures that the public lending will only be provided conditional on crises, i.e. weakening of investors' confidence and subsequent depreciation of the exchange rate. In contrast, fiscal spending is not state-contingent and is often at the discretion

of the government. In order to compare these two policy tools, especially in respect of the minimum amount of resources required, I assume throughout this paper the symmetry in the commitment power of the government. Namely, fiscal spending will only be provided conditional on the occurrence of the bad state of the world, too. One interesting extension of my current work will thus to loosen this assumption and to allow the government to violate its *ex ante* commitment.

I compare now the minimum levels of reserves needed to implement the targeted lending or fiscal spending financed by reserves. In fact, accumulating foreign reserves is not costless, the fewer the reserves needed to achieve the same policy objective the better.

Let us denote $\Gamma = B^{*lend}_{min} - B^{*fisc}_{min}$.

$$\begin{aligned}\Gamma &= D^F - \frac{(\alpha-d)X^F}{\mu+(1-\mu)\alpha} - [D^F\frac{[\mu+(1-\mu)\alpha]}{\alpha-d} - X^F] \\ &= \Big[d+(1-\alpha)\mu\Big]\Big[\frac{X^F}{\mu+(1-\mu)\alpha} - \frac{D^F}{\alpha-d}\Big] \\ &= -\Big[d+(1-\alpha)\mu\Big]X^F\frac{1}{\alpha-d}\Big[\frac{D^F}{X^F} - \frac{\alpha-d}{\mu+(1-\mu)\alpha}\Big]\end{aligned}$$

$\Gamma < 0$ unambiguously as long as there are multiple equilibria. That is, $D^F/X^F \geq max\Bigg(1/[(1-\mu)(1+\psi)], (\alpha-d)/[\mu+(1-\mu)\alpha]\Bigg)$.

As a result, $B^{*fisc}_{min} > B^{*lend}_{min}$. This means that an increase in government spending requires more reserves than the direct lending policy in foreign goods. This is because the lending policy can be regarded as a direct write-off of the private sector's foreign goods debt or a public guarantee on the private sector's debt. The need in terms of foreign goods is capped by the total amount of external debt facing the economy. However, for an expansionary fiscal policy to stabilize the domestic exchange rate, the amount of foreign reserves that the government needs to sell and with which it buys domestic goods depends on the magnitude of the depreciation. The more severe the depreciation, the more reserves are needed. Therefore, in terms of the level of reserves needed, targeted lending uses fewer resources than expansionary fiscal policy.

5 Conclusion

This work provides a simple theoretical framework to study different mechanisms through which foreign reserves can be useful in an economy where the private sector faces credit constraints and currency mis-

matches. It has been shown that foreign reserves can be considered as state-contingent insurance when the exchange rate valuation effect is taken into account. This is an aspect that has not yet been emphasized in the literature on foreign reserves. When there is a negative shock or negative expectations on a country's currency, the domestic value of foreign reserves increases such that they can be used to offset the increased foreign debt service costs. Foreign reserves can work either through direct lending to the private sector or through an expansionary fiscal policy. The former channel affects investors' expectations and requires fewer foreign reserves than the second. The underlying reason is that direct lending is equivalent to giving investors a government guarantee on the private sector's liabilities (especially foreign liabilities). Having sufficient foreign reserves alters investors' expectations and removes the bad equilibrium.

The current framework remains simple. As a next step, I am working to make the model fully dynamic with uncertainties by relaxing a number of assumptions presented in Section 2. The new model proposes an analysis of joint monetary, exchange rate and reserve policies in an economy facing financial constraints and currency mismatches.

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A Unstable middle intersection point

Based on Figure 7, I show here that the middle intersection point (point A) between the DD and II curves is unstable. There are only two stable multiple equilibria: good equilibrium (G) and bad equilibrium (B).

Suppose the lenders form an expectation at time t which locates at the point A^{-} on the II curve. The expected investment at the point A^{-} will then determine the exchange rate through the aggregate resource constraint, namely the DD curve. The economy goes from point A^{-} to $A^{-'}$. Given the new exchange rate at point $A^{-'}$, lenders will adjust their investment. The economy goes from $A^{-'}$ to $A^{-''}$. Again, the adjusted investment determines the exchange rate using the DD curve. This pushes the stable equilibrium to the B point (bad equilibrium). The same logic chain applies when the economy starts at the point A^{+}

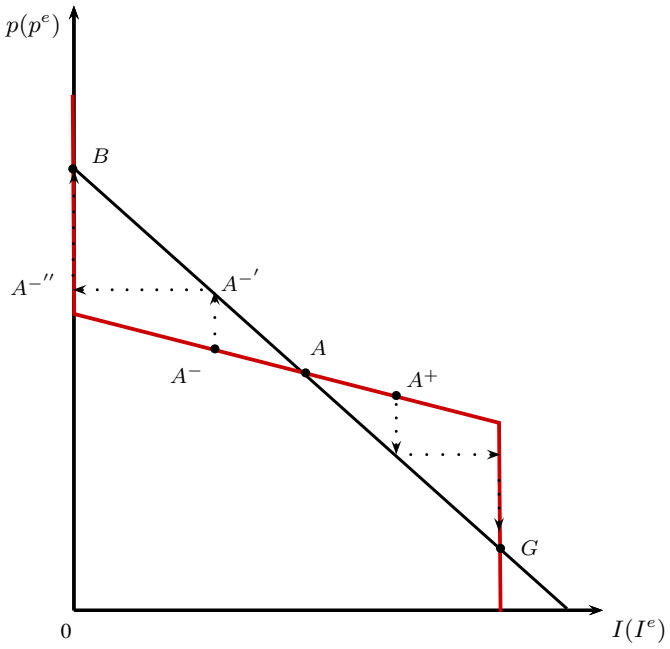

Figure 7: Unstable middle point

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