

# Financial Intermediation, Exchange Rates, and Unconventional Policy in an Open Economy\*

Luis Felipe Céspedes<sup>†</sup>      Roberto Chang<sup>‡</sup>      Andrés Velasco<sup>§</sup>

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## Abstract

We study the effects of unconventional policies in an open economy where financial intermediaries face occasionally binding collateral constraints. The model highlights interactions among the real exchange rate, interest rates, and financial frictions. The exchange rate can affect international credit constraints via a net worth effect and a novel leverage ratio effect. Unconventional policies are non-neutral if financial constraints bind. Credit programs are most effective when targeted towards financial intermediaries. Sterilized foreign exchange interventions matter because the increased availability of tradables caused by sterilization relaxes financial frictions. This perspective is new in the literature.

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<sup>†</sup>Universidad Adolfo Ibañez. Email: [lfcespedes@uai.cl](mailto:lfcespedes@uai.cl)

<sup>‡</sup>Rutgers University and NBER. Email: [chang@econ.rutgers.edu](mailto:chang@econ.rutgers.edu)

<sup>§</sup>Columbia University, Oxford University, and NBER

# 1 Introduction

In response to the global financial crisis and its aftermath, central banks around the world have engaged in "unconventional" policies, creating liquidity and credit facilities, manipulating reserve requirements, and intervening in the foreign exchange market.<sup>1</sup> This is all very different from the textbook inflation-targeting regime, in which a central bank sets a single policy interest rate to hit a target level for the inflation rate.

These unconventional policies helped prevent an even deeper crisis. But why and how did they work? In standard models of perfect financial markets, unconventional policies are typically irrelevant or superfluous.<sup>2</sup> Unless we understand these policies and their effects better, central bankers cannot be sure whether to add them to their standard arsenal or, instead, put them back into an emergency toolkit, to be used only in extreme crisis situations.

So we need a theory –with financial frictions in center stage– in which unconventional policies can potentially matter. This paper contributes to the task by building an open economy model in which financial intermediation can be subject to binding collateral constraints. We keep the model as simple as possible, which allows us to derive analytical results. It is then straightforward to use the model to study unconventional policies, including credit facilities and foreign exchange intervention.

In our open-economy setup, the interaction between the real rate exchange rate and financial intermediation plays a central role. Firms produce capital by aggregating two goods, one tradable and the other nontradable. The real exchange rate is then defined as the relative price of the two goods.

To finance capital investment, firms borrow from domestic financial intermediaries or banks. Banks, in turn, can finance their loans out of their own net worth or by borrowing from the world market. A simple moral hazard problem gives rise, as in other models, to an international

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<sup>1</sup>A recent review of relevant developments and literature in Latin America is Cespedes, Chang and Velasco (2012). Chang (2007) provides a similar discussion, but focuses on the period preceding the global crisis.

<sup>2</sup>This is a consequence of Ricardian Equivalence (Barro 1974, Wallace 1981). For more recent discussion, see Eggertsson and Woodford (2003) and Cespedes, Chang and García Ciccó (2011).

collateral constraint: the amount that local bankers can borrow abroad is limited to a multiple of their net worth expressed in terms of tradables.

In this context, a real exchange depreciation, by reducing the tradables value of the non-tradables portion of banks' net worth, tightens the credit limit. That is the direct effect. There is also an indirect, general equilibrium effect: a real depreciation can increase lending interest rates and, as a consequence, increase the banks' maximum leverage ratio because, intuitively, higher lending rates improve the franchise value of domestic banks. The net worth impact of the real exchange rate on loan supply has been noted before in the literature, but the effect on leverage is novel. Taken together, the two opposite effects imply that loan supply can rise or fall as the real exchange rate depreciates.

The demand for domestic bank loans depends on firms' investment and, hence, on the real exchange rate and the interest rate on loans. These two variables must also ensure equilibrium in the market for nontradable goods. The economy's overall equilibrium is then characterized by two schedules giving the supply of and demand for bank loans as functions of the real exchange rate.

Depending on parameters and initial conditions, including the distribution of net worth, the collateral constraint may or may not bind in equilibrium. If it does not, the lending interest rate equal the world rate, and investment increases to the efficient point at which the marginal return to capital equals the world interest rate. But if the collateral constraint binds, the domestic lending rate is higher than the world interest rate and the real exchange rate is more depreciated than it would be in the absence of financial frictions, resulting in an inefficiently low level of financial intermediation, investment, and welfare. In such a situation, exogenous shocks are amplified by the endogenous response of interest rate spreads and the exchange rate, increasing macro vulnerability.

What effects do policies with "unconventional" flavor have in this model? Consider initially a redistribution of initial wealth from firms or households to banks, which can be interpreted as a bank recapitalization program financed with taxes. We show that the policy is inconsequential if

the collateral constraint does not bind in equilibrium. But if the constraint binds, the policy can lower domestic lending rates, appreciate the real exchange rate, and boost lending, investment, and welfare. That a wealth redistribution can be beneficial in models with financial frictions has been known at least since Bernanke and Gertler (1989), but our results go beyond that observation in at least two ways. First, the redistribution policy helps if and only if financial constraints are binding. This suggests the more general point that unconventional policies can be effective if and only if financial frictions bite.<sup>3</sup> Second, we show that redistributing domestically-owned nontradables towards banks can enlarge loan supply and improve efficiency. Amplification obtains because, in a financially constrained equilibrium, domestic banks leverage their net worth severalfold, so that taking away one unit of wealth (in tradables or nontradables) from firms to give it to banks increases the firm's loan demand by one unit but increases the banks' loan supply by more than one unit.

Next we discuss government credit facilities and exchange rate interventions. We assume that the government can borrow an exogenous amount of tradables at the world interest rate, which can be interpreted in various ways — for instance, as a credit line granted by an international institution, or as previously accumulated foreign exchange reserves.

The government can lend its tradables to the corporate sector or to financial institutions. Such government credit programs are irrelevant, again, if financial constraints do not bind in equilibrium. If they do, government credit programs are beneficial, and in that case —we also show— they are more effective if targeted towards the banks. The reason once more is that banks can leverage up government credit to raise their international credit limit, resulting in a larger increase in the supply and quantity of loans than if the government credit had been granted to firms.

In standard models with no financial constraints, *sterilized* foreign exchange operations have no real effects. Things are different here. We study what happens if the government uses its available tradable goods (which we can think of as foreign reserves) to purchase nontradables,

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<sup>3</sup>This is consistent with the often heard claim, by central bankers, that in a financial crisis unconventional policies can be justified as "the traditional monetary transmission mechanisms can break down".

offsetting this operation with a purchase of government debt or with a credit to firms or banks. We show that such an operation is equivalent to the government lending the tradables directly, with effects on loan supply and the real exchange rate. Here the effects of sterilized interventions are explained not by the impact of the intervention on asset prices but, rather, by the impact of the sterilizing credit on financial constraints. In this sense, the model offers a completely new perspective on the impact of sterilized foreign exchange intervention.<sup>4</sup>

We also show the model can give rise to multiple equilibria. An efficient equilibrium can coexist with a financially constrained one if the elasticity of the lending rate with respect to the exchange rate (which depends on the economy's fundamental parameters) is sufficiently low. In such a case, a "threat" to intervene in the foreign exchange market to prevent exchange rate depreciation can prevent self-fulfilling pessimism and switches from good to bad equilibria. This result is of interest since it can potentially rationalize recent episodes of reserves accumulation in emerging economies: the government must be ready to intervene if market expectations were to turn adverse, even if intervention need not happen in equilibrium.

This paper is related to several strands in the literature. In emphasizing the links among financial frictions, relative prices, leverage, and aggregate outcomes, it follows Bernanke and Gertler (1989), Kiyotaki and Moore (1997), and many others since. Recognizing that exchange rates can add a significant open-economy component to those links, it follows Krugman (2000) and Céspedes, Chang, and Velasco (2004).

Our focus on unconventional policies is shared with several recent contributions, including Curdía and Woodford (2009) and Gertler and Karadi (2011), which assume frictions in the financial intermediation process and investigate the role of government policy in alleviating them. Our paper is closest to Christiano and Ikeda (2011), which compares the implications of several simple financial frictions models for the impact of unconventional policies, including some that we also study. But two features of our model –the crucial interaction between exchange rates and interest rates and the interplay of these two variables with leverage and the

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<sup>4</sup>Our results can also potentially help understanding why empirical evidence on the effects of sterilized intervention is very mixed.

valuation of net worth— are absent in Christiano-Ikeda. As a consequence, we obtain richer and more nuanced policy inferences. In addition, our model goes further in allowing for the analysis of foreign exchange intervention and in showing that multiple equilibria, with the attendant policy consequences, can occur.

Finally, our paper is reminiscent of models of the interaction between international and domestic collateral constraints, exchange rates, and liquidity—particularly Caballero and Krishnamurthy (2003) and Holmstrom and Tirole (2011, chapter 6). While the theoretical approaches have elements in common, the concerns are quite different. A main focus of those papers is the determination and management of international liquidity, an issue about which our paper has little to say. On the other hand, our framework goes beyond theirs in allowing for levered financial intermediation and its subtle interplay with exchange rates and interest rates. This, in turn, yields an analysis of recent unconventional policies that has no counterpart in Caballero-Krishnamurthy or Holmstrom-Tirole.

The paper is organized as follows. Section 2 lays out the model, focusing on a simple version (with Cobb Douglas production of capital) for ease of exposition. We characterize equilibria in section 3. We then explore implications for unconventional policies in section 4. Section 5 discusses a more general version of the model, the possibility of multiple equilibria, and the policy implications of such multiplicity. Section 6 concludes.

## 2 The Model

We focus on a small open economy with two periods and two goods, one traded (also referred to as the *foreign* good) and another nontradable (or *home* good). The real exchange rate is the relative price of tradables in terms of nontradables.

The economy is inhabited by a representative household. It also has firms and banks that belong to the household. In the first period, tradables and nontradables can be combined to obtain capital that can be used for production in the second period. Firms buy capital, financing

investment out of inherited net worth or by borrowing from a set of domestic banks. Banks, in turn, finance their loans by borrowing from the international capital market subject to a collateral constraint which depends on their own net worth. The collateral constraint reflects underlying financial frictions and can result in credit rationing, as we will see.

## 2.1 Households

For simplicity, the household consumes only traded goods and in the second period only. Since the household owns banks and firms, its consumption in the second period equals the representative bank's and the representative firm's profits:

$$C = \Pi^b + \Pi^f$$

There is no fundamental uncertainty, so firms and banks maximize second period profits.

## 2.2 Capital Production

In the first period, capital can be obtained by combining tradables and nontradables through a conventional aggregator function. For the time being, we assume that the aggregator is Cobb Douglas:

$$K = \kappa I_H^\gamma I_F^{1-\gamma} \tag{1}$$

where  $I_H$  and  $I_F$  respectively denote inputs of nontradables and tradables,  $\gamma$  is a constant in the unit interval, and  $\kappa = 1/\gamma^\gamma(1-\gamma)^{1-\gamma}$ . It follows that the price of capital in terms of the home good,  $Q$ , is given by

$$Q = S^{1-\gamma} \tag{2}$$

where  $S$  is the price of tradables in terms of nontradables, which we will refer to as the real exchange rate.

It also follows that, if  $K$  is the aggregate demand for capital, the optimal input of nontra-

dables must be

$$I_H = \gamma QK = \gamma S^{1-\gamma} K \quad (3)$$

For simplicity, we will mostly assume that nontradables have no other role, so the preceding expression gives the aggregate demand for nontradables.

### 2.3 Firms

The representative firm can purchase capital in the first period in order to produce  $Y$  tradables in the second period according to

$$Y = AK^\alpha$$

where  $A$  and  $\alpha$  are positive constants, with  $\alpha \leq 1$ .

In the first period, the firm has some inherited endowment of tradables ( $T_f$ ) and nontradables ( $N_f$ ). In addition, it can borrow from banks. Without loss of generality, assume that bank loans are denominated in tradables. Hence the firm's budget constraint in the first period, expressed in tradables, is

$$\frac{QK}{S} = L + T_f + \frac{N_f}{S} \quad (4)$$

where  $L$  is the amount borrowed by the firm. In turn, second period profits are

$$\Pi^f = Y - RL$$

where  $R$  is the interest rate on bank loans.

The firm's demand for capital is then given by

$$\alpha AK^{\alpha-1} = RQ/S \quad (5)$$

$$= RS^{-\gamma} \quad (6)$$

the last equality following from 2. This expression emphasizes that the firm's demand for capital



depends on the real exchange rate and the cost of borrowing.

Note that the firm's demand for capital is independent of its endowments, although the latter determine the amount borrowed from banks. Also, note that we allow  $T_f$  or  $N_f$  to be negative, in whose case they represent inherited corporate debt.

## 2.4 Banks

As mentioned, firms borrow from domestic banks, which in turn can borrow from the world capital market subject to a collateral constraint. The assumption that firms cannot borrow directly from the world market can be rationalized as an extreme version of Holmstrom and Tirole (1997) and others.

Letting  $D$  denote the amount that the bank borrows from the world market in the first period, the quantity of loans that the bank can extend to firms is

$$L = D + T_b + \frac{N_b}{S}$$

where  $T_b$  and  $N_b$  denote the bank's endowment of tradables and nontradables.

We denote the interest rate on foreign loans by  $R^*$ , so that the bank's profits are

$$\Pi^b = RL - R^*D$$

The bank maximizes profits subject to its first period budget constraint and to a collateral constraint:

$$RL - R^*D \geq \theta RL$$

where  $\theta$  is a parameter,  $0 < \theta < 1$ .

The collateral constraint can be rationalized in several ways. For example, we can follow Gertler and Kiyotaki (2010) and assume that, in period 2, bankers can default on the foreign debt and abscond with a fraction  $\theta$  of the payments made to the bank by firms. Then the

collateral constraint is necessary to prevent absconding.

The collateral constraint may or may not bind in equilibrium. If it does not,  $R$  must equal  $R^*$ , and amount of loans is determined by demand. The incentive constraint then reduces to  $L - D \geq \theta L$  or, using the budget constraint,

$$L \leq \frac{1}{\theta} \left[ T_b + \frac{N_b}{S} \right] \quad (7)$$

On the other hand, if the collateral constraint binds, combining it with the budget constraint gives the bank's supply of loans:

$$L = \frac{R^*}{R^* - (1 - \theta)R} \left[ T_b + \frac{N_b}{S} \right] = \frac{1}{1 - \phi(1 - \theta)} \left[ T_b + \frac{N_b}{S} \right] \quad (8)$$

where we have defined  $\phi = R/R^*$  as the (gross) *spread*.

Remarkably, loan supply is a multiple of the bank's *net worth*  $T_b + N_b/S$ , which we assume to be positive. The multiplying factor is the *leverage ratio*  $1/[1 - \phi(1 - \theta)]$ , which must be greater than one and finite in equilibrium; the latter requires  $\phi < 1/(1 - \theta)$ . The interpretation is the same as in Kiyotaki and Moore (1997) and other models with collateral constraints:  $(1 - \theta)R$  is the portion of its loan portfolio that the bank can pledge to foreign investors; the bank has to finance the difference between this value and the cost of capital,  $R^*$ , out of its own resources. In other words,  $R^* - (1 - \theta)R$  is a measure of the bank's "down payment" for the credit it obtains. The equation tells us that the bank leverages its capital as much as possible to finance loans.

As in many recent models, relative prices can affect the supply of loans through their impact on the bank's net worth: here, if  $N_b$  is positive, a real depreciation (an increase in  $S$ ) reduces the value of the bank's endowment of nontradables and hence net worth in terms of tradables. A more novel aspect of our specification is that relative prices, here the loan rate  $R$ , can in addition affect the leverage ratio: an increase in  $R$ , or equivalently in the spread  $S$ , increases the pledgeable value of the bank's loans and, hence, the leverage ratio.

### 3 Equilibrium

This section shows that equilibrium can be characterized in a relatively simple but insightful way. Market clearing for nontradables yield an intuitive link between the real exchange rate and the demand for capital. This and optimal investment conditions then give a relation between the real exchange rate and the interest rate. Finally, the firm's budget constraint gives the corporate demand for loans as a function of the real exchange rate or, equivalently, of the interest rate spread. Equilibrium is then given by the demand and supply of loans, the latter given by the analysis in the last section.

The demand for nontradables is given by 3. Supply is equal to the aggregate endowment of nontradables,  $N_f + N_b \equiv N$ . Hence,

$$S^{1-\gamma} = N/\gamma K \tag{9}$$

This links the real exchange rate to the demand for capital: an increase in the latter implies an increase in the demand for nontradables and hence, given that the supply is fixed, an increase in their relative price (a fall in  $S$ , or a real appreciation).

Now, recall that 6 gives the firm's demand for capital as a function of the real exchange rate and of the interest rate  $R$ . Combining it with the preceding equation we obtain

$$R = S^{\gamma+(1-\alpha)(1-\gamma)} \alpha A \left( \frac{\gamma}{N} \right)^{1-\alpha}$$

This is a key link between interest rates and the real exchange rate. An increase in the interest rate  $R$  reduces the firm's demand for capital, and hence demand for nontradables, leading to a real depreciation.

It is useful to define a particular value of  $S$ , say  $S_0$ , by

$$R^* = S_0^{\gamma+(1-\alpha)(1-\gamma)} \alpha A \left( \frac{\gamma}{N} \right)^{1-\alpha}$$

That is,  $S_0$  is the value of the real exchange rate in the absence of financial frictions (i.e. if  $R = R^*$ ). The previous two expressions then yield a much simpler one:

$$\phi = \frac{R}{R^*} = \left( \frac{S}{S_0} \right)^{\gamma+(1-\alpha)(1-\gamma)} \quad (10)$$

We are now ready to characterize equilibrium in the market for loans. Demand for loans is given by 4:

$$\begin{aligned} L^d &= \frac{QK}{S} - \left( T_f + \frac{N_f}{S} \right) \\ &= S^{-\gamma} \frac{N}{\gamma S^{1-\gamma}} - \left( T_f + \frac{N_f}{S} \right), \text{ that is,} \\ L^d &= \frac{N}{\gamma S} - \left( T_f + \frac{N_f}{S} \right) \end{aligned} \quad (11)$$

where we have used 2 and 9 for the second equality. The first term in the last expression,  $N/\gamma S$ , is the tradables value of investment. Under our maintained assumptions, this value must fall if  $S$  increases. The second term is the tradables value of the firm's endowment. If  $N_f > 0$ , this falls with an increase in  $S$ , so the impact of a real depreciation on loan demand can be ambiguous. However, the first term dominates is, in particular,  $N_b > 0$ , i.e. if the bank has a positive endowment of nontradables. Focusing on this case for now, 11 gives the demand for loans as a decreasing function of the real exchange rate.

The supply of loans is given by 7-8 of the previous section, rewritten here for convenience:

$$\begin{aligned} L^s &\in \left[ 0, \frac{1}{\theta} \left( T_b + \frac{N_b}{S_0} \right) \right] \text{ if } S = S_0 \\ &= \frac{1}{1 - \phi(1 - \theta)} \left[ T_b + \frac{N_b}{S} \right] \text{ if } S > S_0 \end{aligned} \quad (12)$$

with  $\phi$  given by 10. In words, if  $S = S_0$ ,  $\phi = 1$ , and banks are content with lending up to a multiple  $1/\theta$  of their net worth, the latter valued at the exchange rate  $S_0$ . If  $S > S_0$  the spread  $\phi$  is greater than one and the banks are financially constrained. Then they lend a multiple of

their net worth, the leverage ratio being determined by  $\phi$  and therefore, via 10, by the real exchange rate.<sup>5</sup>

In the region  $S > S_0$  banks are credit constrained. A real depreciation then changes loan supply via two *opposite* channels. If  $N_b$  is positive, a depreciation reduces the tradables value of the typical bank's net worth and, hence, pushes loan supply down. But a depreciation also increases the spread  $\phi$  via 10 and, hence, it increases the leverage ratio. Hence, when banks are constrained, a real depreciation has ambiguous effects on loan supply. The elasticity of  $L^s$  with respect to  $S$  is, in fact, not too hard to obtain:

$$\frac{S}{L^s} \frac{\partial L^s}{\partial S} = - \left[ \frac{N_b/S}{T_b + N_b/S} \right] + \frac{\phi(1 - \theta)}{1 - \phi(1 - \theta)} [\gamma + (1 - \alpha)(1 - \gamma)]$$

The two terms in the RHS correspond, respectively, to the net worth effect and the leverage effect, and have obvious interpretations. The net worth effect is large, in particular, when the bank's nontradables endowment is large as a fraction of its total endowment. The leverage effect is large if the spread,  $\phi$ , is large or if the financial frictions parameter  $\theta$  is small.

For concreteness, for now we will focus on the case in which the leverage effect dominates the net worth effect, and so the supply of loans increases with  $S$  in the constrained region. But we will see later that it is not too hard to find conditions under which  $L^s$  falls with  $S$  in that region.

Figure 1 depicts the supply of loans for the baseline case.<sup>6</sup> The quantity of loans is measured along the horizontal axis; the point  $L_0$  is given by  $\frac{1}{\theta}(T_b + \frac{N_b}{S_0})$ . The real exchange rate is measured against the vertical axis.

In Figure 2, a downward sloping demand for loans is added. The figure assumes that the demand curve cuts the supply schedule at a loan amount,  $L^e$  in the figure, less than  $L_0$ . Then the equilibrium exchange rate is  $S^e = S_0$ , and the economy is financially unconstrained. In this case, of course,  $R = R^*$  and  $\phi = 1$ .

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<sup>5</sup>Note that the necessary condition  $\phi < 1/(1 - \theta)$  together with 10 impose a corresponding upper bound on the set of  $S$  consistent with equilibrium.

<sup>6</sup>Figures are collected at the end of the paper.

Alternatively, Figure 3 depicts a case in which the demand curve cuts the supply schedule at a loan amount  $L^e$  that exceeds  $L_0$ . The equilibrium real exchange rate is then given by  $S^e > S_0$ . The interest spread  $\phi$  is then given by 10 and must be greater than one; equivalently,  $R > R^*$ . In this situation the economy is financially constrained, in the sense that the collateral constraint must bind.

The comparative statics of this model are now easy to trace. Consider, in particular, a fall in  $\theta$ , representing less stringent collateral requirements. This moves the point  $L_0$  to the right, and, by via the leverage ratio, it also increases the slope of the loan supply curve if  $S > S^0$ . The result is depicted in Figure 4. If the economy was initially constrained, a fall in  $\theta$  results in a real exchange rate appreciation and higher intermediation. It also implies a fall in  $R$  and  $\phi$ . In this sense, financial frictions can result in excessively weak exchange rates.

More generally, this stripped down model sheds light on the subtle interactions between international borrowing constraints, interest rates, and the exchange rate. If the collateral constraint binds in equilibrium the domestic lending interest rate is above the world rate. Domestic banks would like then to borrow more tradables but cannot: tradables are too scarce (relative to a situation with no financial frictions). In turn, since tradables are combined with nontradables for capital production, the scarcity of tradables reduces the marginal product of nontradables, and hence their price, below efficient levels. And the inefficiently weak real exchange rate can lower the net worth of the banks, tightening the borrowing constraint even further.

The feedback loop between asset prices and borrowing constraints is present in many related papers, following Kiyotaki and Moore (1997). The relevant price in our model is not, however, the value of stocks, as in much of the literature, but the real exchange rate. And changes in the real exchange rate matter not only through their effect on the net worth of banks but also through the leverage ratio. This has been studied less often.<sup>7</sup>

Because the tightness of the borrowing constraint depends on relative prices, policy induced

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<sup>7</sup>A recent notable exception is Benigno, Chen, Otrok, Rebucci and Young (2011).

changes in the domestic economy can have implications for international capital flows. We turn now to this issue.

## 4 Some Policy Implications

### 4.1 Redistribution and Banks' Net Worth

If the collateral constraint is binding in equilibrium, a policy induced redistribution of initial resources can improve matters. Gains are possible because domestic banks can only post their own net worth as collateral for borrowing internationally, but the banks' net worth is smaller than the resources that the economy as a whole has access to.

Suppose, in particular, that the government taxes away some of the firms' nontradables endowment and gives the proceeds to the banks. This can be regarded as a bank recapitalization policy financed with a corporate tax. In our notation, this entails a reduction in  $N_f$  matched by an increase in  $N_b$ , keeping  $N$  fixed.

Our expressions for loan demand and supply, 11 and 12, imply that the impact of the policy must be as depicted in Figure 5. Both loan demand and supply move horizontally to the right, but the supply schedule moves farther. In fact, 11 and 12 reveal that the horizontal displacement of the supply schedule is equal to the displacement of the demand curve multiplied by the leverage ratio, and hence greater than one.

The intuition is simple. At any fixed value of  $S$ , and hence of  $\phi$  and  $R$  (because of 10), a one unit reduction in  $N_f$  has no effect on the firm's demand for capital, and hence it induces the firm to increase its borrowing by  $1/S$  tradables. In contrast, a one unit increase in  $N_b$  increases the bank's net worth by  $1/S$  but bank loans increase by  $1/S$  times the leverage ratio.

In Figure 5, the equilibrium moves from  $E^{old}$  to  $E^{new}$ , with increased financial intermediation and a stronger exchange rate (lower  $S$ ). Concomitantly, the spread  $\phi$  and the lending interest rate  $R$  fall. Domestic consumption and welfare improve.

Clearly, a sufficiently large redistribution can potentially bring about an equilibrium in

which the collateral constraint does not bind. Whether this is possible or not depends on the different parameters of the model, particularly the relative size of the nontradables endowment and their initial distribution.

That wealth redistribution can be welfare improving in the presence of financial frictions has long been known (see e.g. Bernanke and Gertler 1989). What may be more surprising in this context is that redistributing nontraded endowments can be useful even though the economy faces an *international* collateral constraint, which involves only traded goods. The reason, of course, is that transferring nontraded goods to the bank increases its net worth, which can be levered up to result in a net increase in financial intermediation.

## 4.2 Government Credit Programs

The recent use of *unconventional* monetary policies has motivated much recent research. One example of such policies are central bank lending facilities to the private sector. To examine this issue, let us assume that the government has the opportunity of borrow a given amount  $F$  of tradables in the world market at the world interest rate  $R^*$ . We do not ask how the government acquires such opportunity, although it is not hard to think of explanations.<sup>8</sup> Instead we focus on how the government can best use its credit.

Clearly, the credit line  $F$  is irrelevant if the collateral constraint does not bind in equilibrium, so we focus on the interesting case in which it does. Consider, first, the possibility that the government borrows  $F$  in the first period to lend that amount to firms at the market interest rate  $R$ . In the second period, the government collects  $RF$  in debt repayments, cancels its foreign debt, and transfers any difference  $(R - R^*)F$  to the household as a lump sum subsidy.

The reader can easily check that this policy leaves the private demand and supply of loans, 11 and 12, unaffected. The only change is that the equilibrium in the market for loans is given not by  $L^d = L^s$  but by  $L^d = L^s + F$ . For a graphical interpretation, the *total* supply of loans

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<sup>8</sup>For example, one can assume that the government can borrow in the world market subject to a collateral constraint that is less stringent to the one applying to banks. Alternatively,  $F$  can be thought of as a credit line available from international financial institutions.



can be added to Figures 1 to 3 and is simply given by the schedule  $L^s$  displaced horizontally by the amount  $F$ . As mentioned, the policy does not affect equilibrium outcomes if the collateral constraint did not initially bind (except that it does reduce the amount of private intermediation by  $F$ ).

If the constraint was initially binding, the policy results in increased total intermediation, a stronger real exchange rate, and a lower interest spread. Note that, on the other hand, private intermediation must fall, since the exchange rate appreciates and  $R$  and  $\phi$  fall. In this sense there is some crowding out, even in the case in which the equilibrium is initially inefficient. Figure 6 depicts this case.

If  $F$  is large enough, the resulting equilibrium involves no inefficiency, with  $R = R^*$ . In fact, it is instructive to compute the smallest  $F$  that does the trick, which we denote by  $F^{DL}$  (the  $DL$  for "direct lending"):

$$F^{DL} = \frac{N}{\gamma S_0} - \left( T_f + \frac{N_f}{S_0} \right) - \frac{1}{\theta} \left( T_b + \frac{N_b}{S_0} \right)$$

This follows easily from 11, 12, and the market clearing condition  $L^d = L^s + F$ . The intuition is simple. If there were no financial frictions, firms would borrow the difference between their demand for capital and the value of their net worth: these are the first two terms in the RHS. But at the frictionless exchange rate domestic banks can at most raise the multiple  $1/\theta$  of the value of their net worth. To bring about the frictionless outcome, the government credit must at least cover the shortfall.

Alternatively, suppose that the government borrows  $F$  and lends that amount to the banks at cost, that is, at the world interest rate  $R^*$ . Crucially, we assume that the government can enforce repayment of its loan perfectly.

Analyzing this policy is just a little more involved. Bank profits are now

$$\Pi^b = RL - R^*(D + F)$$

where, as before,  $D$  denotes the amount borrowed by the bank from international lenders, and  $L$  the amount the bank lends domestically. The first period budget constraint of the bank becomes:

$$L = D + F + \left(T_b + \frac{N_b}{S}\right)$$

Finally, the collateral constraint is now

$$RL - R^*(D + F) \geq \theta RL - R^*F$$

Combining the last two expressions, we obtain:

$$L \leq \frac{1}{1 - \phi(1 - \theta)} \left[ \left(T_b + \frac{N_b}{S}\right) + F \right]$$

This tells us that the bank's loan supply increases by  $F$  times the leverage ratio. This is depicted in Figure 7: because the leverage ratio is greater than one, the horizontal displacement of the bank's loan supply curve is greater than  $F$ . As a consequence, financial intermediation is greater and the exchange rate stronger than when the government lends  $F$  directly to the firms.

For a slightly different perspective, compute the minimum  $F$  that brings spreads to one:

$$\begin{aligned} F^{LB} &= \theta \left[ \frac{N}{\gamma S_0} - \left(T_f + \frac{N_f}{S_0}\right) - \frac{1}{\theta} \left(T_b + \frac{N_b}{S_0}\right) \right] \\ &= \theta F^{DL} \end{aligned}$$

From the previous,  $F^{LB} < F^{DL}$ , which confirms that government lending to banks is more powerful than government lending to firms. The key to understand this result is to realize that a government loan to the bank not only allows the latter to lend more, but also to borrow further from the world capital market and to increase lending by even more. Effectively, the bank does not use  $F$  to expand lending directly, but rather to post it as collateral and lever it up, which allows loan supply to increase by more than  $F$ , the multiplier being the leverage

ratio.

### 4.3 Exchange Market Intervention

A different variety of unconventional policies is foreign exchange market intervention, which has come back into fashion in Latin America and elsewhere. Our model does not feature currency but it does feature an exchange rate which is determined in the market for nontradables, so we can examine a policy that looks pretty much like actual intervention policy.

To examine this, it is useful to reinterpret  $F$  not as a credit line available to the government but as a stock of international reserves. In some sense this is just a semantic issue, because the opportunity cost of holding reserves is still the world rate  $R^*$ . But regarding  $F$  as reserves enhances the correspondence of the policy to be examined with foreign exchange intervention.

Hence, in this context, a intervention operation is one in which, in the initial period, the government uses  $F$  to buy nontradables in the market, and *sterilizes* this by using the nontradables thus obtained in an offsetting operation, such as providing credit to the private sector or purchasing government securities. We look at these alternatives in turn.

Suppose, first, that the sterilizing operation is a credit to firms, and that the government charges firms  $R/S$  units of tradables in period 2 for each unit of nontradables lent to them. Then a little thought should convince the reader that the outcome must be the same as if the government had lent the  $F$  tradables directly to the firms, charging them an interest rate  $R$ . (To see this, note that after receiving the borrowed  $SF$  nontradables the firms can just sell them immediately for  $F$  tradables in the spot market. Also, the cost of borrowing for the firms is exactly the same as under direct lending.) In other words, this flavor of sterilized foreign exchange interventions is equivalent to a policy of directly lending tradables to firms.

The description just given is still somewhat awkward because, in a sterilized intervention, the government lends nontradables in the first period but collects tradables in the second period. This is necessary because we assumed that nontradables play no role in the second period. But it is also easily fixed, following e.g. Holmstrom and Tirole (2011). Specifically, modify the

model so that households consume nontradables as well as tradables in the last period, and that the two goods are perfect substitutes. Also, assume that households have a sufficiently large endowment, say  $N'$ , of nontradables in the second period so that, in any equilibrium, the real exchange rate is one. Then, in the description of the previous paragraph, one can suppose that firms are asked to repay  $R/S$  units of nontradables in the last period per unit of nontradables borrowed in the first period. Then the analysis is exactly the same (with the added feature that, in the second period, firms must sell  $RF/S$  units of tradables to the household to obtain the  $RF/S$  nontradables they need to repay their debt to the government; in turn, the government sells the  $RF/S$  nontradables back to the household.)

The analysis then has two notable implications: sterilized foreign exchange intervention can affect real outcomes, alleviate financial frictions, and improve welfare; and the kind of intervention just discussed is equivalent to a direct lending policy. In the real world, of course, the equivalence can break down in favor of intervention or direct lending. For example, it may be relatively more costly for a government to lend tradables than to lend nontradables (think about government lending in foreign currency versus home currency). Then sterilized intervention would have an edge.

The analysis is similar if the government sterilizes foreign exchange intervention by increasing credit to the bank rather than to firms. If the government charges the bank  $R^*/S$  (tradables or nontradables, in the extension discussed above) per unit of nontradable lent, the outcome must be the same as in the case of lending the  $F$  tradables to banks.

Finally, what if the government sterilizes a foreign exchange intervention by purchasing its own debt? To allow for this possibility, assume that the domestic bank initially holds some government securities, each unit of securities being a promise to  $R^*$  tradables in the second period. Also, assume that the bank has financed its securities holdings by borrowing the needed amount abroad at the world's interest rate  $R^*$ . Finally, assume that the holding of government securities does not affect the bank's incentive constraint; this is indeed appropriate if, for instance, in the second period the government cancels its securities after the bank repays

its own foreign debt.<sup>9</sup>

The assumptions just made imply that the bank's holding of government securities has no impact on its profits nor its decision problem. Now assume that, as before, the government uses the  $F$  tradables it has in the first period to purchase nontradables, and that it uses the nontradables thus raised to retire its own securities. Then it is only a matter of accounting to verify that the outcome is exactly the same as if the sterilizing operation had been a credit to the bank.<sup>10</sup> The conclusion is that sterilizing the foreign exchange intervention via retiring government securities is equivalent to sterilizing it via a credit to banks. And, *a posteriori*, this kind of sterilized foreign exchange intervention is also equivalent to just giving  $F$  as a direct credit to the bank.

The conclusion is that sterilized intervention can be effective, but that the details can matter a lot. Here the key detail is whether the sterilizing operation ends up allocating the  $F$  tradables to the firms or the banks. It is more powerful to give  $F$  to the banks because this allows them to lever that amount in the international capital market.

Finally, let us stress that the perspective just offered on sterilized interventions is distinctively new. The extant literature<sup>11</sup> offers two basic theories on how sterilized intervention can affect real outcomes: a portfolio balance view, which relies on the assumption that assets are imperfect substitutes in terms of risk and return, so that sterilized intervention can affect real allocations by changing the relative supply of currencies; and a signaling view, which starts by positing asymmetric information between policymakers and the public, so that sterilized intervention can matter if it conveys information about future policy. Our model assumes no uncertainty and features assets that are perfect substitutes, so there are no portfolio balance

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<sup>9</sup>We are not concerned here what was the origin of the government debt. We assume, however, that the service of the debt in the last period is financed with lump sum taxes on households. Otherwise we would have to discuss how changes in the amount of debt are related to distortionary taxation effects, which would needlessly cloud the discussion of sterilized intervention.

<sup>10</sup>In particular, the operation leaves the bank with an amount of nontradables worth  $F$  tradables in the first period (the tradables value of the retired public debt), and reduces the bank's second period income by  $R^*F$  tradables (because of the reduction in the bank's holding of public debt). These are the same implications of a credit of  $F$  tradables or  $SF$  nontradables to the bank at (tradables) interest rate  $R^*$ .

<sup>11</sup>See e.g. Obstfeld and Rogoff (1996, especially pages 593-595). For a more recent discussion with emphasis on recent developments, see Disyatat and Galati (2007).

effects of sterilized intervention. And intervention has no signaling value either, as the model features no asymmetric information.

## 5 Generalizations and Multiple Equilibria

For the sake of clarity and concreteness, we have imposed strong assumptions on the model. In this section we speculate on interesting issues that arise under more general assumptions.

Much of our analysis has relied on the form of the loan supply function 12, and in particular on the fact that loan supply increases with the real exchange rate  $S$  if collateral constraints bind, that is, if  $S > S_0$ . Recall that this reflects the relative strength of two opposing effects, one on net worth and another on the leverage ratio: a real depreciation reduces net worth (assuming  $N_b > 0$ ) but increases the leverage ratio to the extent that the spread  $\phi$  increases. In our basic formulation, the leverage effect dominates the net worth effect, so that  $L^s$  increases with  $S$ . But we see that, for this to be the case, the elasticity of the spread to  $S$  (given by 10) must be large enough. Since the link between  $\phi$  and  $S$  reflects optimal production and investment decisions, changes in fundamentals can easily affect it and, hence, the shape of the loan supply curve.

To examine this conjecture, in this section we generalize 1 so that capital is produced instead via a C.E.S. aggregator function:

$$K = \left[ \gamma^{1/\lambda} I_H^{1-1/\lambda} + (1 - \gamma)^{1/\lambda} I_F^{1-1/\lambda} \right]^{\lambda/(\lambda-1)}$$

where again  $I_H$  and  $I_F$  denote inputs of nontradables and tradables. This implies that the price of capital must be

$$Q = [\gamma + (1 - \gamma)S^{1-\lambda}]^{1/(1-\lambda)} \tag{13}$$

generalizing 2, while the demand for nontradables must be

$$I_H = \gamma Q^\lambda K$$

In equilibrium, of course,  $I_H = N$ , so that the demand for capital is linked to its price by

$$K = N/\gamma Q^\lambda$$

In turn, the firm's demand for capital is still given by 5, which combined with the previous expression gives

$$\alpha A (N/\gamma Q^\lambda)^{\alpha-1} = RQ/S$$

Finally, combining the preceding expression with 13 and rearranging, we obtain the key relation between the spread and the real exchange rate:

$$\phi = R/R^* = \frac{\alpha A}{R^*} \left(\frac{\gamma}{N}\right)^{1-\alpha} \Psi(S) \quad (14)$$

where we have defined

$$\Psi(S) \equiv \frac{S}{[\gamma + (1 - \gamma)S^{1-\lambda}]^{[1-\lambda(1-\alpha)]/(1-\lambda)}}$$

This generalizes 10. Note that the elasticity of  $\phi$  with respect to  $S$  is equal to the elasticity of  $\Psi$ , and the latter is

$$\frac{S\Psi'}{\Psi} = 1 - (1 - \lambda(1 - \alpha)) \frac{(1 - \gamma)S^{1-\lambda}}{\gamma + (1 - \gamma)S^{1-\lambda}}$$

which is always positive but less than one. When  $\lambda = 1$ , the elasticity reduces to  $\gamma + (1 - \gamma)(1 - \alpha)$ , as in the baseline case (see 10). If  $\lambda$  is smaller, the elasticity also falls.

Now the loan supply curve is given again by 12, but with  $\phi$  given by 14 instead of 10 (and with  $S_0$  defined as the value of  $S$  such that the last term of 14 equals one).

As discussed, the extra parameters allow for configurations in which the elasticity of  $\phi$  with

respect to  $S$  is small enough so that the net worth effect of a real depreciation dominates the leverage ratio effect. This means, in particular, that the loan supply schedule can look like the one in Figure 8, with a flat portion at  $S_0$  and then loan supply being *decreasing* in  $S$ .

The derivation of loan demand is straightforward following the previous analysis. We leave the details to the reader and just note the result:

$$L^d = \frac{N}{\gamma} \left[ \frac{\gamma}{S} + \frac{1-\gamma}{S^\lambda} \right] - \left( T_f + \frac{N_f}{S} \right)$$

As in the baseline case, the demand for capital (the first term in the RHS) decreases with  $S$ . Hence the demand for loans decreases with  $S$ , unless  $N_f$  is large, a case that we ignore.

With a downward sloping loan supply schedule, the possibility arises of multiple equilibria, as in Figure 9. In the figure,  $E$  denotes an equilibrium in which the collateral constraint does not bind, while it does bind at  $E'$ . The financially constrained equilibrium features a weaker exchange rate, a positive interest spread, and less financial intermediation, production, consumption, and welfare.

In this case animal spirits, especially of foreign lenders, can determine the outcome. Suppose that foreign lenders believe that there will be a "good" equilibrium in which the exchange rate is "strong", as given by  $S_0$ . They then understand that the value of the bank's net worth is more than enough to warrant the bank's foreign debt, so they lend to the bank what the latter needs. The supply of loans is then relatively large, so that the lending rate is  $R^*$  and, with costs, investment and production expand. This increases the demand for nontradables, which raises their relative price, leading to a strong exchange rate, confirming expectations. If lenders believe, in contrast, that the equilibrium will be very "bad", with a weak exchange rate, they must also believe that the bank's net worth has little value in tradables, which leads to credit rationing. (In this equilibrium, the weak exchange rate is associated with a higher spread and hence a larger leverage ratio, but the effect must be small, as discussed.) Loan supply falls drastically, which increases the interest spread and results in a weak exchange rate, again



confirming expectations.

The possibility of multiple equilibria suggests additional policy implications of our model. If equilibria in which financial constraints do and do not bind coexist, as in Figure 9, a government commitment to "do all it takes" to prevent the real exchange rate from depreciating excessively can kill the bad equilibrium, leaving only the good one. Perhaps to make the claim believable, the government may find it necessary to have access to a large enough "war chest" of tradables (the  $F$  of the previous section) that they can use to intervene. As in other models with multiple equilibria, however, the government would not have to intervene and spend the war chest if it can convince the markets that its commitment is in fact credible.

Our analysis, then, suggests that it may well be the case that the potential for self fulfilling exchange rate crashes, and the associated credit crunches, that explains why many inflation targeting central banks include in their charters a commitment to intervene if the real exchange rate becomes unduly misaligned. It may also help understanding why those very same inflation targeters keep large reserve stocks and seek swap lines abroad, even though in theory they are not supposed to be intervening in the foreign exchange market.

## 6 Final Remarks

Why do central banks that claim to target the rate of inflation intervene regularly in foreign markets? Why do they intervene in spite of the scant empirical evidence in favor of intervention, the dearth of theories justifying it, and of the fact that inflation-targeting central banks are supposed to let the currency float?

A related paradox is that a central bank that floats the currency need not accumulate foreign exchange reserves. Yet in the last decade the world's central banks have gone on a massive reserve accumulation drive, both before and after the crisis.

Why is there a gap between what central banks do and what they say they do? When are unconventional policies effective, and what are they effective at? Why is there a newfound

enthusiasm for tweaking the value of exchange rates, in spite of so many unsuccessful experiences with fixed rates over the last few decades?

These questions can only be addressed within a theoretical framework. In this paper we build the simplest possible model that does this job. We consider an economy with only two goods, traded and non-traded, so that we define a real exchange rate. In this economy, financial constraints may or may not bind. They do in times of financial stress, and the exchange rate interacts in important ways with interest rates and financial imperfections.

We analyze the effects of different policies: capitalizing banks (with tax financing), lending to banks and lending directly to firms, as well as intervening in the exchange market. Three kinds of results merit highlighting.

First, government lending policies have real effects when financial constraints bind. In addition, while the government can lend its tradables to the corporate sector or to financial institutions, we find that government credit programs are more effective if targeted towards the banks. The reason is that banks can lever up the government credit to raise its international credit limit, with the result of a larger increase in the supply and quantity of loans, and a stronger relaxation of financial constraints, than if the government credit had been granted to firms.

Second, in a sterilized foreign exchange intervention operation the government uses its available tradables, which we can think of as foreign reserves, to purchase nontradables, offsetting this operation by purchasing its own debt or by lending to either firms or banks. This operation is equivalent to the government lending the tradables directly. This is, in fact, a new perspective on the impact of sterilized foreign exchange intervention: the effects of sterilized interventions are explained by the impact of the sterilization on financial constraints.

Third, the "threat" to intervene in the foreign exchange market, even if intervention does not happen in equilibrium, can help prevent self-fulfilling pessimism and a move from a "good" equilibrium to a "bad" outcome in which the exchange rate would be much depreciated. This is the case in the presence of multiple equilibria, in which case reassuring market participants

that the real exchange rate will always be at the level associated with the good equilibrium is indeed stabilizing.

So unconventional policies do matter —indeed, they can have beneficial effects— whenever financial constraints matter. In this sense, the observed use of such policies during crisis times is vindicated by the results of the model. Holding reserves also makes sense as a device to prevent a crisis (here, a jump from a good to a bad equilibrium) from occurring.

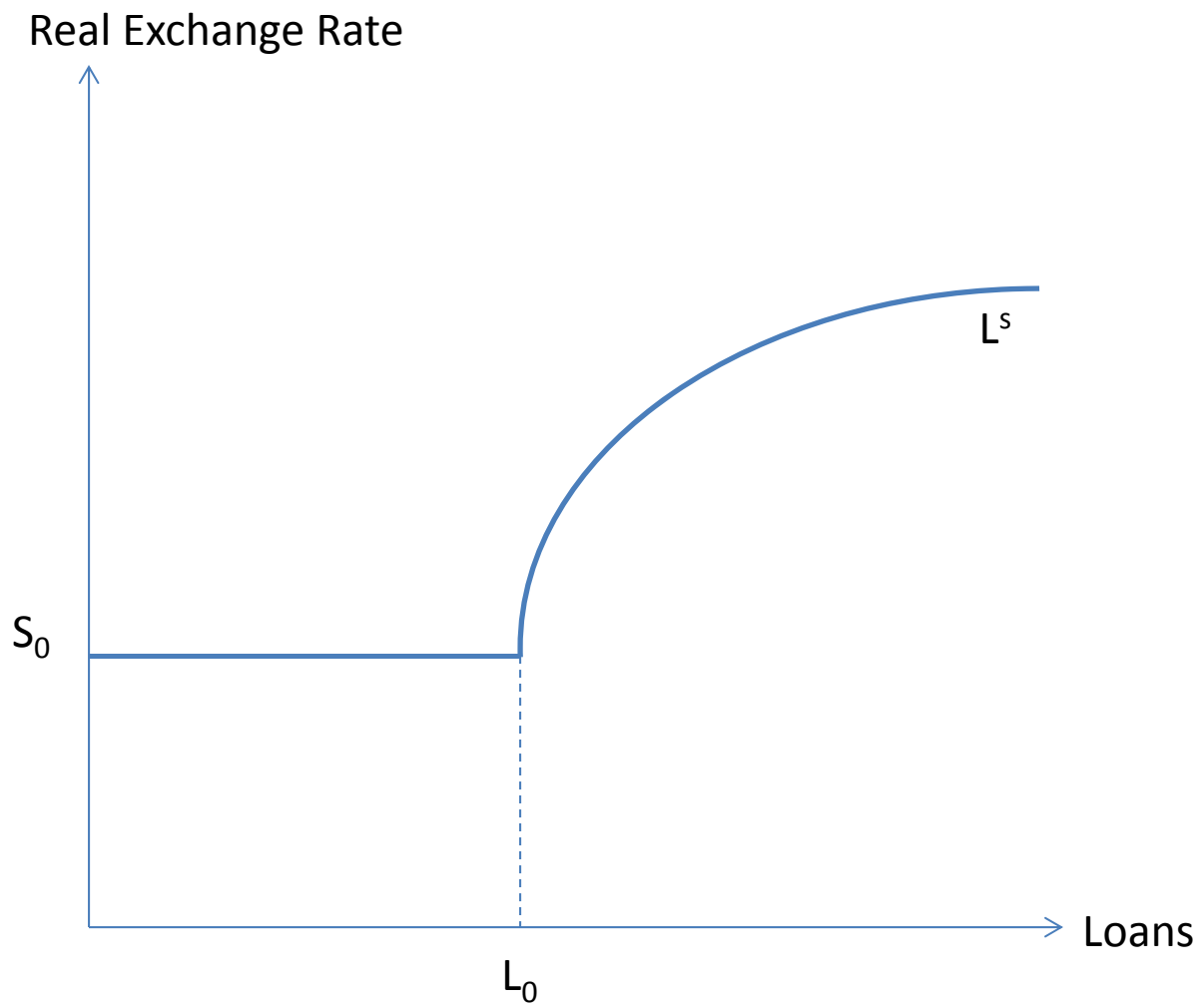
Conversely, if a non-crisis period is defined (somewhat arbitrarily) as one in which financial constraints are not binding, then the unconventional policies studied here are unnecessary in tranquil times. Hence our model does not provide a rationale for the pattern of intervention and reserves accumulation observed, for example, in some Latin countries prior to the global financial crisis.

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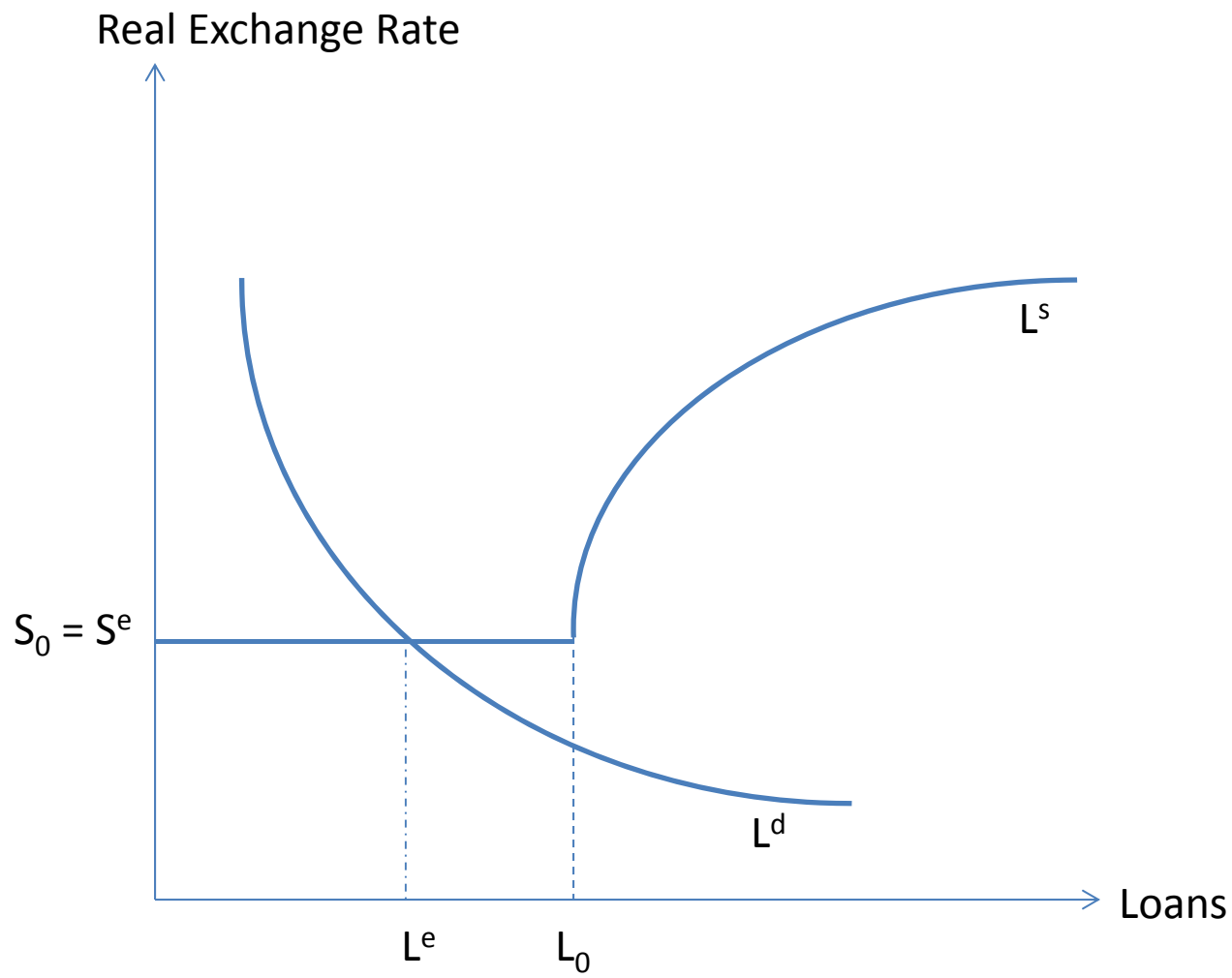
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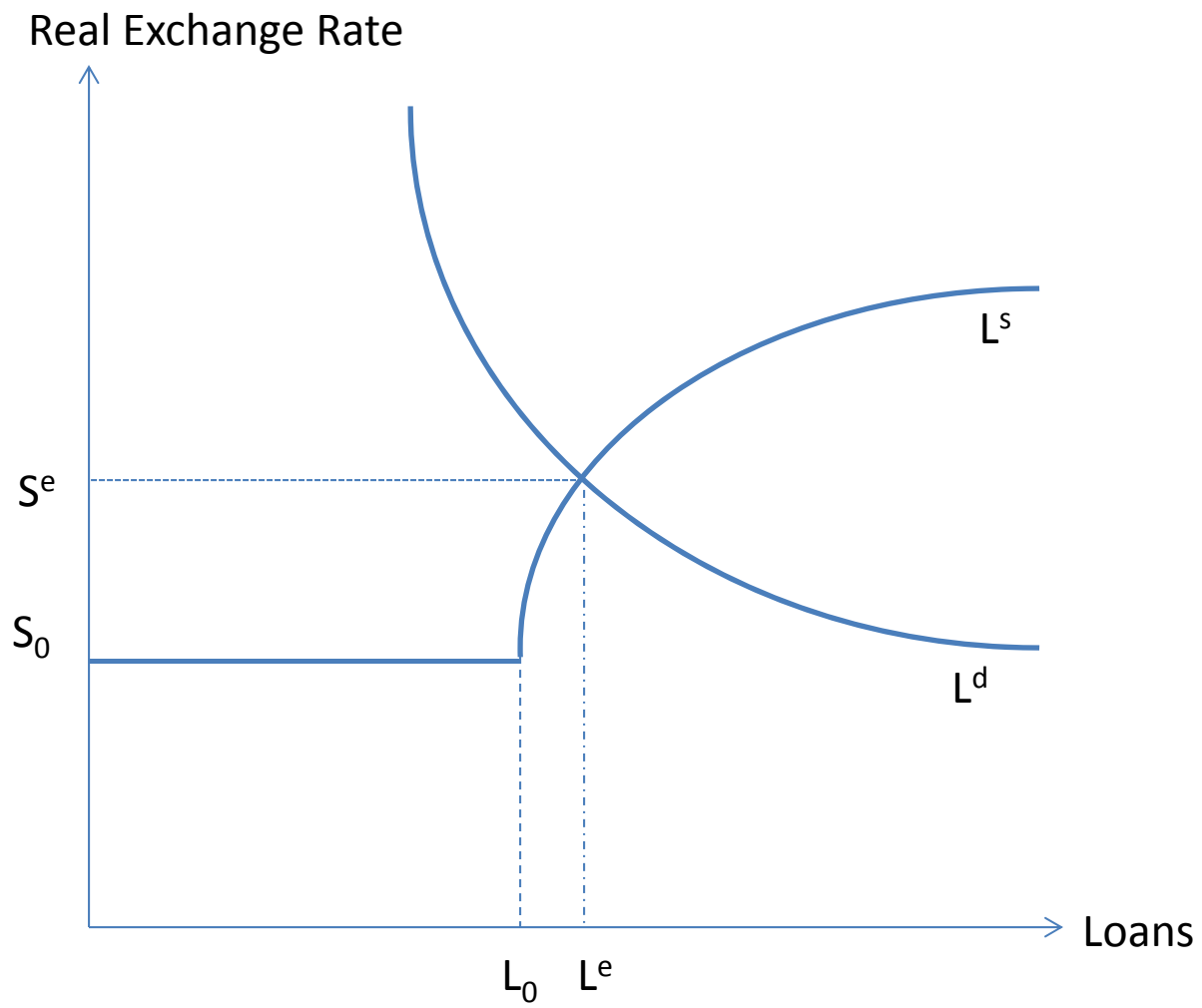
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**Figure 1**



**Figure 2**



**Figure 3**



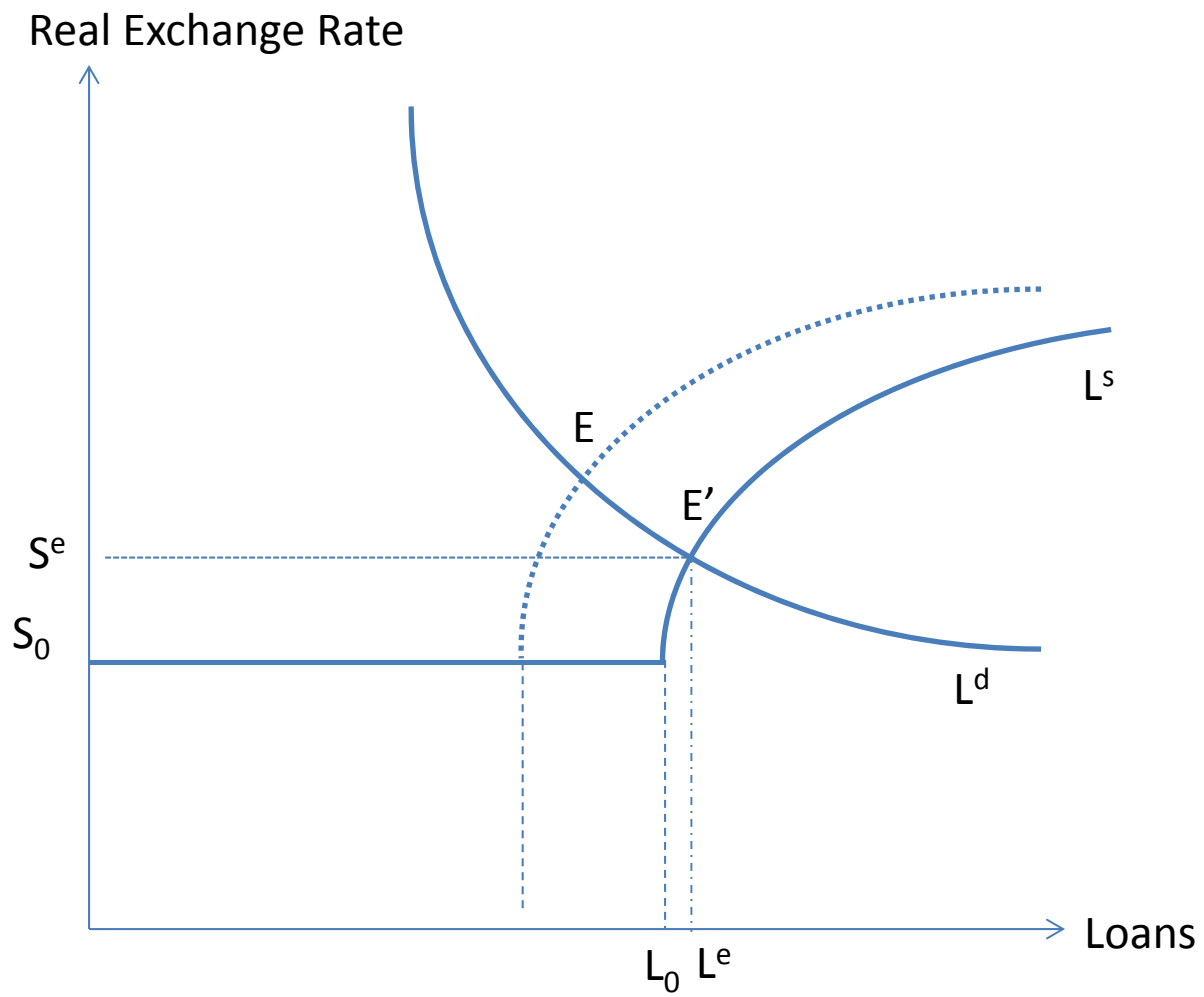


Figure 4

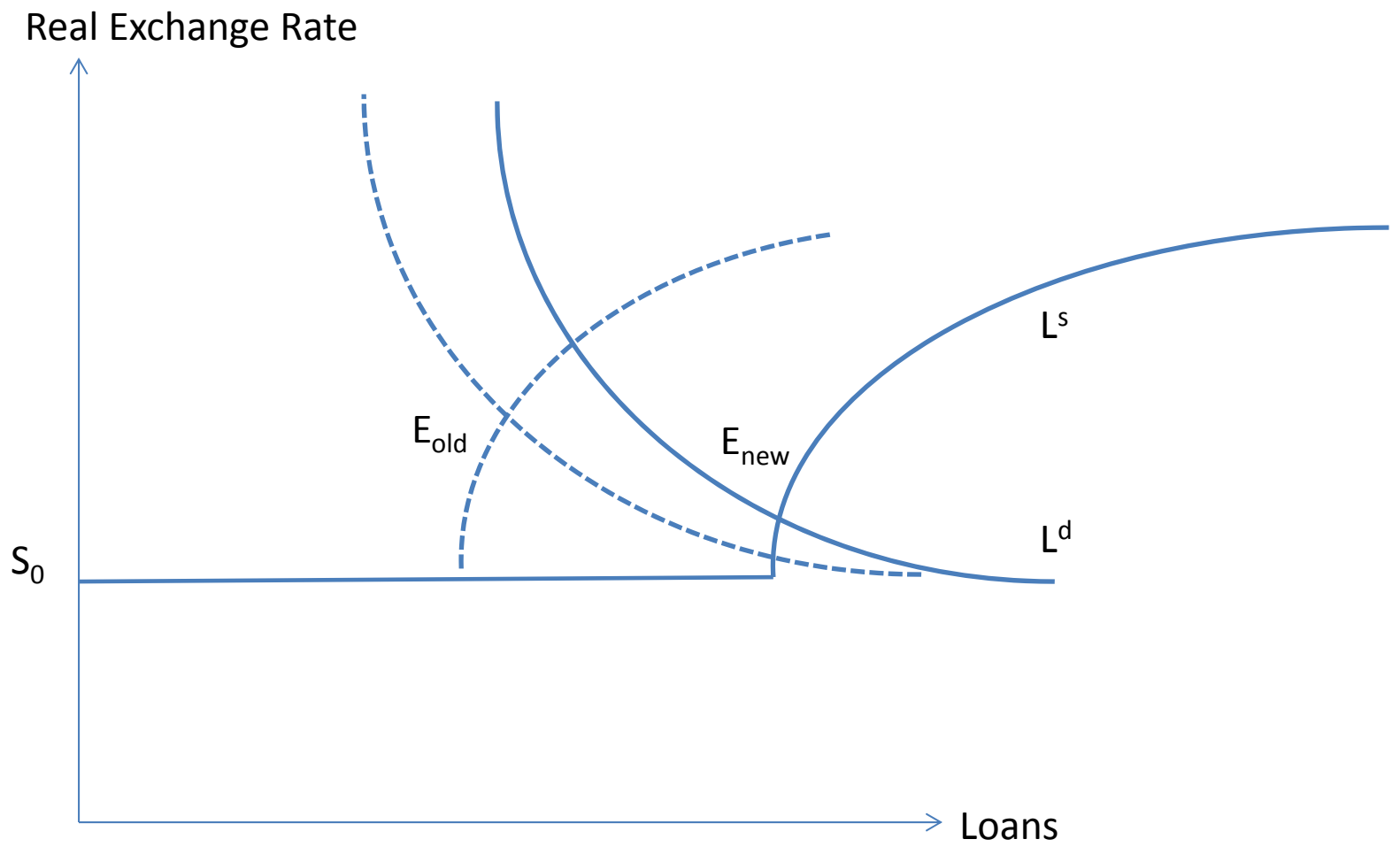


Figure 5

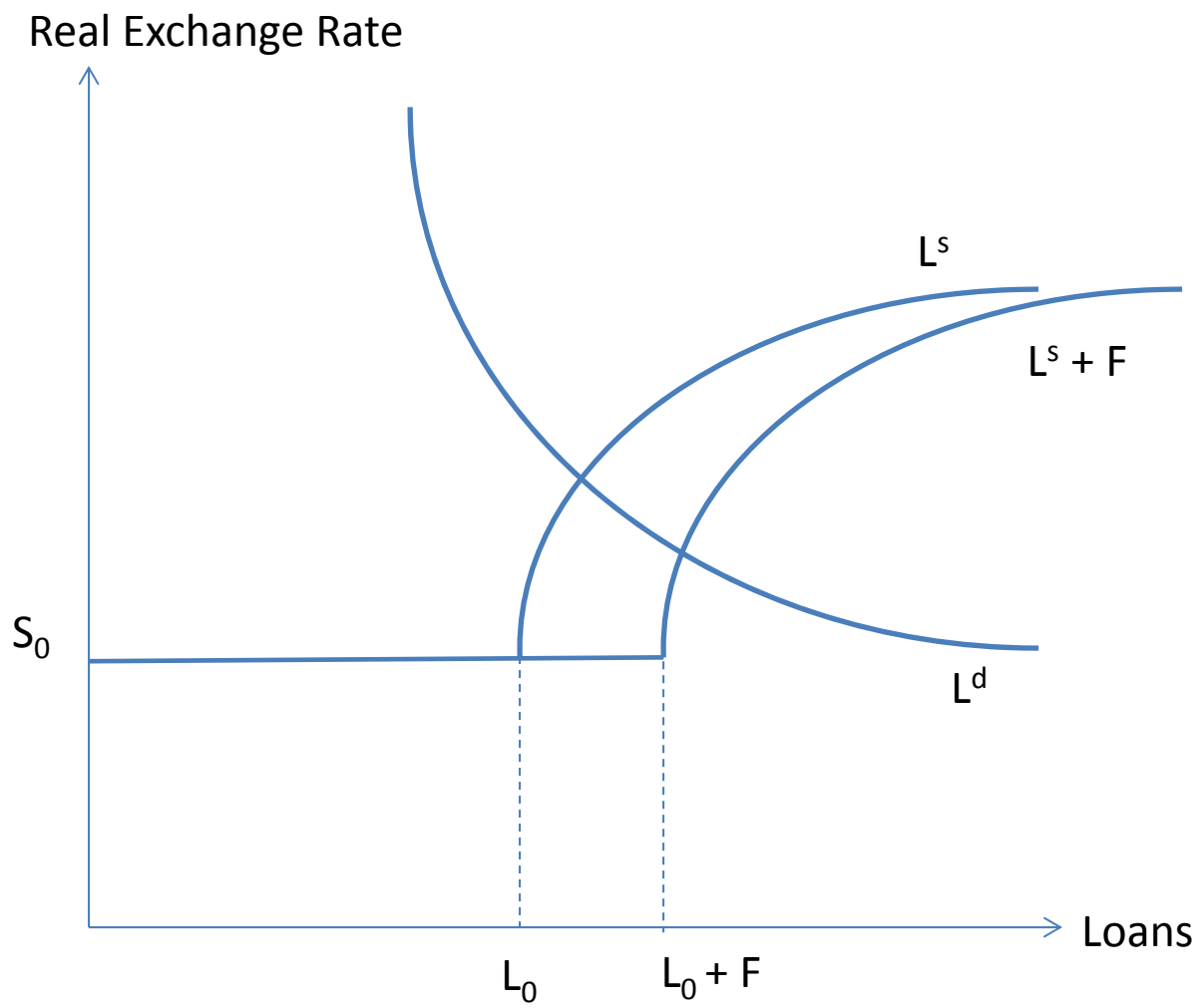
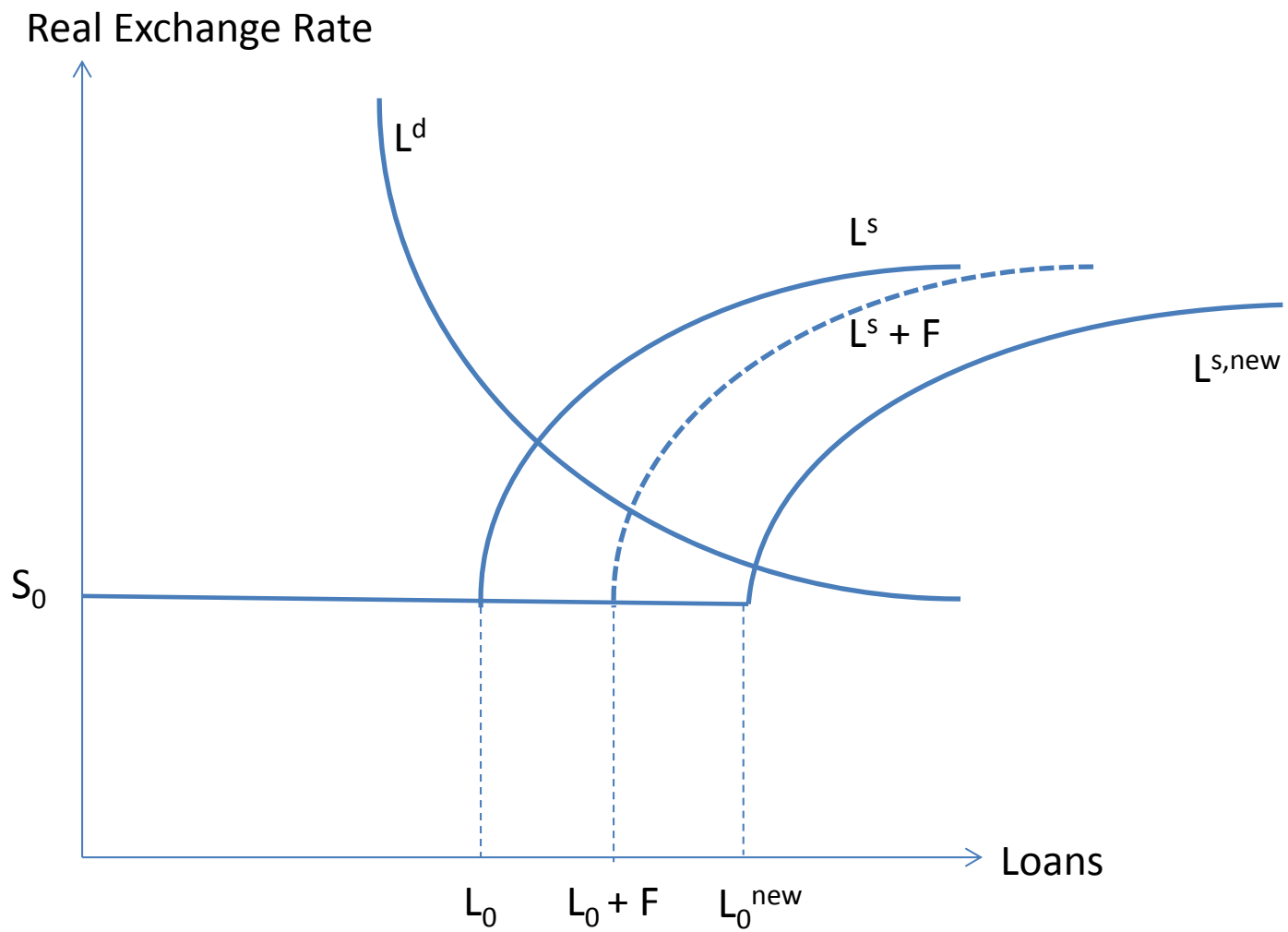
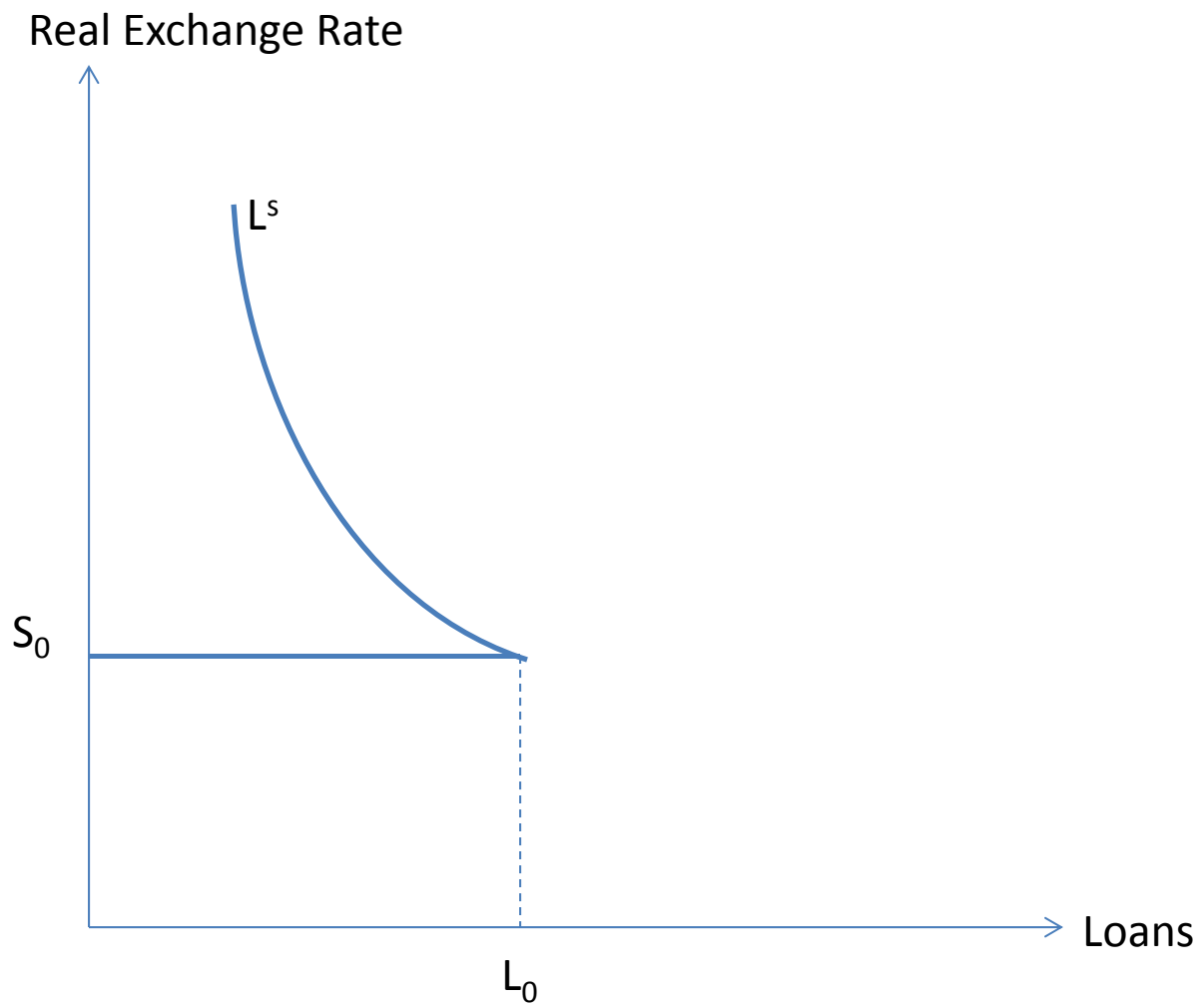


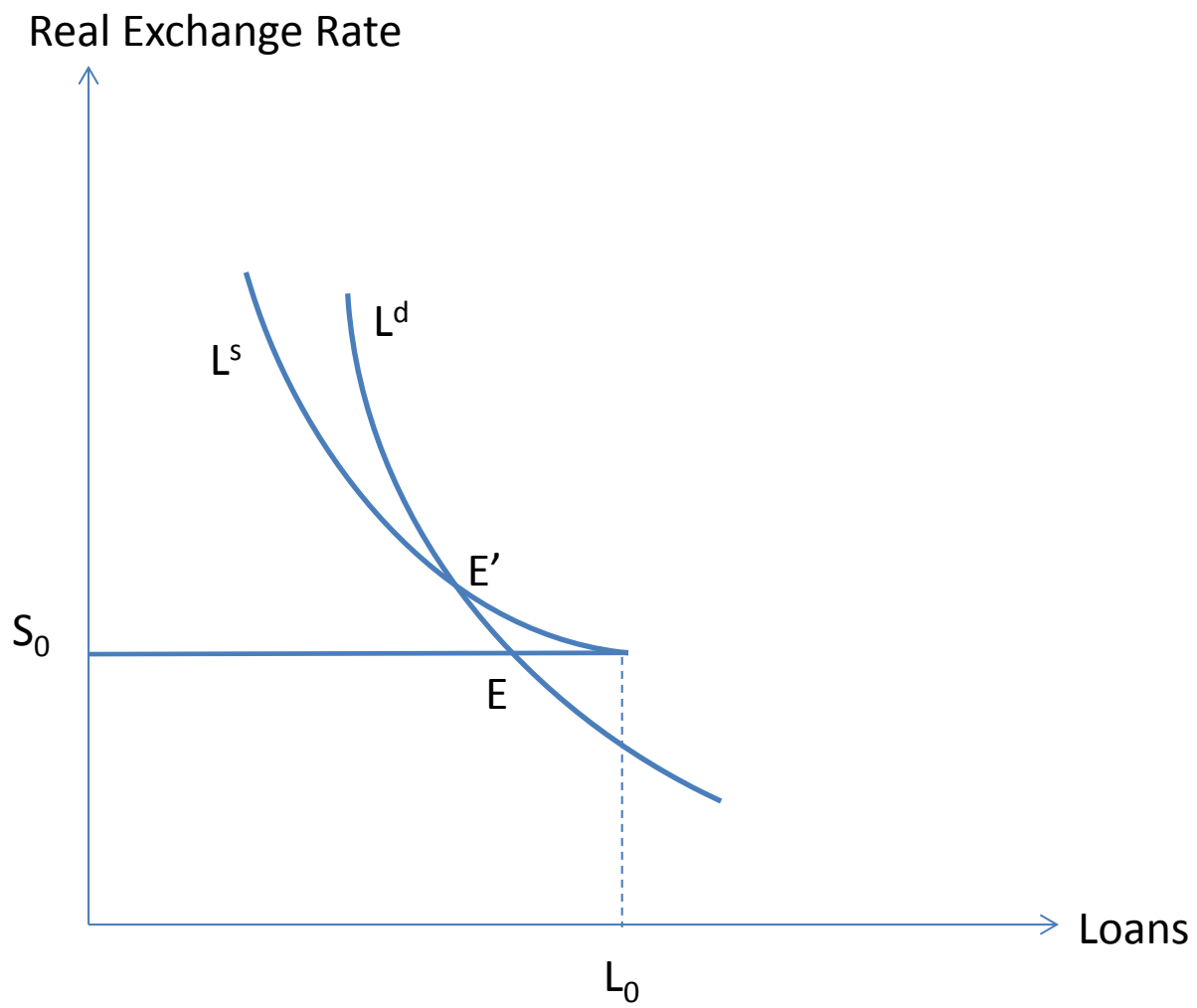
Figure 6



**Figure 7**



**Figure 8**



**Figure 9**