Financial Intermediation, Real Exchange Rates, and Unconventional Policies in an Open Economy*

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Abstract

We discuss 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 real 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 interventions matter because the increased availability of tradables associated with sterilization relaxes financial frictions.

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1 Introduction

In response to the global financial crisis and its aftermath, policymakers around the world have engaged in "unconventional" financial policies, creating liquidity and credit facilities, manipulating reserve requirements, and intervening in the foreign exchange market. [1] Such policies arguably helped prevent an even deeper crisis; but exactly how they worked remains an open question. In standard models, which assume perfect financial markets, unconventional policies are either irrelevant or superfluous.[2] Once one drops the assumption of perfect financial markets unconventional policies can bite, but other questions emerge. Which among those policies is most effective in alleviating financial constraints, and why? What are the tradeoffs involved? The questions multiply in open economies, since movements in exchange rates can affect balance sheets and hence the functioning of financial markets. In the absence of a better analytical understanding of unconventional policies –especially in open economies– policymakers cannot be sure whether to add them to their standard arsenal or, instead, to put them back into an emergency toolkit, to be used only in crisis situations.

This paper contributes to such an understanding by building a theory, with financial frictions at center stage, in which unconventional policies potentially matter. Specifically, we model an economy in which financial intermediation can be subject to binding collateral constraints. The economy is open and the interaction between the real rate exchange rate and financial intermediation plays a central role. We keep the model as simple as possible in order to derive analytical results, which we then use to study unconventional policies, including credit facilities and sterilized intervention.

In the model, 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

[1] These policies have mostly been implemented by central banks, so that "unconventional policies" stand in contrast with "conventional" monetary policy frameworks, in which a central bank sets a single instrument (e.g. a policy interest rate) to attain traditional objectives such as inflation and employment. For a recent review of relevant policy developments in the emerging markets of Latin America, see Céspedes, Chang and Velasco (2014). Chang (2007) provides a similar, earlier discussion of the period preceding the global crisis.

[2] This is essentially a consequence of Ricardian Equivalence (Barro 1974, Wallace 1981). For a more recent discussion, see Eggertsson and Woodford (2003) and Céspedes, Chang and García Cicco (2011).

finance capital investment, firms borrow from domestic financial intermediaries we call banks. Banks, in turn, can finance their loans from 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 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 the domestic lending interest rate and, as a consequence, increase the banks' maximum leverage ratio; this reflects, intuitively, that 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 impact on leverage is novel. Taken together, the two effects imply that the supply of domestic loans 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 described 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 equals the world rate, and investment increases to the efficient point at which the marginal return to capital equals the world interest rate. If the collateral constraint binds, in contrast, 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; this results in an inefficiently low level of financial intermediation, investment, and welfare. Under a binding collateral constraint, in addition, the endogenous response of interest rate spreads and the exchange rate amplifies exogenous shocks, increasing macro vulnerability.

What effects do policies with an "unconventional" flavor have in this model? We start with an analysis of a policy that redistributes 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 underscore that the redistribution 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.[3]

Moreover, we show that redistributing domestic wealth from nonfinancial agents towards banks can enlarge loan supply and improve efficiency. This reflects the interaction between binding financial constraints and leverage: in a financially-constrained equilibrium, domestic banks leverage their net worth severalfold, so that taking away one unit of wealth 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. This is an important takeway from our model.

Next, consider government credit facilities. 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 international reserves); the government can then lend its own tradable goods to the corporate sector or to financial institutions. We find that government credit programs are irrelevant, again, if financial constraints do not bind in equilibrium. If the constraints do bind, on the other hand, government credit programs are beneficial, and in that case they are more effective when targeted towards banks. The reason, once more, is that banks can leverage up government credit in order to raise their international credit limit, resulting in a larger increase in the volume of loans than if the government credit had been granted to firms.

[3] 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".

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, 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 follow not from the impact of the intervention on asset prices but, rather, from the impact of the sterilizing credit on financial constraints. In this sense, the model offers a new perspective on the impact of sterilized foreign exchange intervention.[4]

Finally, we discuss conditions under which the interplay between financial constraints and exchange rates in the model can result in 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 reserve accumulation in emerging economies: the government must be ready to intervene if market expectations become 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 real 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

[4] In a similar spirit, García (2016) has recently argued that any impact of sterilized intervention can only be understood in terms of its implications for the supply of domestic credit. García's analysis, however, is quite different from ours. In particular, he posits a model with imperfect asset substitutibility, and his analysis is based on portfolio balance effects. In contrast, our arguments are solely grounded on financial constraints, which are derived from complete microfoundations.

Curdía and Woodford (2009), Gertler and Kiyotaki (2010), Christiano and Ikeda (2011), and Gertler and Karadi (2011), which assume frictions in financial intermediation and investigate the role of government policy in alleviating them. As do Christiano and Ikeda (2011), we emphasize basic theoretical aspects, so that our model is quite stark;[5] in particular, it features no nominal rigidities. Recent work by two of us (Chang and Velasco, 2016) extends the ideas of the present paper to an infinite horizon model with prices fixed in advance. That paper shows how our basic results here carry over to a dynamic setting; the paper also discusses the interaction between unconventional policies and traditional, conventional monetary policy. [6]

Finally, our paper is reminiscent of models of the interaction among international and domestic collateral constraints, exchange rates, and liquidity –particularly those by 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 the work of 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 develops a more general version of the model, the possibility of multiple equilibria, and the policy implications of such multiplicity. Section 6 concludes.

[5] Our paper differs from Christiano and Ikeda (2011) in several ways, however, most importantly in featuring an interaction between exchange rates and interest rates, with significant implications for leverage and policy analysis.

[6] Some other recent papers have also studied unconventional policies in open economy models with financial intermediation, basing the modeling of latter on Bernanke, Gertler, and Gilchrist (1999) and Gertler and Karadi (2011). In particular, Ueda (2012), Dedola, Karadi, and Lombardo (2013), Nuguer (2015), and Aoki, Benigno, and Kiyotaki (2016) discuss the implications of different unconventional policy rules in calibrated or estimated versions of such models. Our work differs from those efforts, and complements them, in emphasizing analytical, closed form results.

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 defined as the relative price of tradables in terms of nontradables. The economy is inhabited by a representative household. There are also firms and banks that belong to the household. In the first period, tradables and nontradables are combined to obtain capital that is 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.

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: $C^T = \Pi^b + \Pi^f$. 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, γ 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 nontradables must be

$$I_H = \gamma Q K = \gamma S^{1-\gamma} K \tag{3}$$

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

2.3 Firms

The representative firm purchases capital in the first period in order to produce Y tradables in the second period according to $Y = AK^{\alpha}$, where A and α are positive constants, with $\alpha \leq 1$.

In the first period, the firm has inherited endowments 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

$$\frac{QK}{S} = L + T_f + \frac{N_f}{S} \tag{4}$$

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

$$\alpha A K^{\alpha-1} = RQ/S \tag{5}$$

$$= RS^{-\gamma} \tag{6}$$

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, 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 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:

$$RL - R^*D \geq \theta RL \tag{7}$$

where θ 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 θ of the payments made to the bank by firms. Then the collateral constraint is necessary to prevent absconding.

Crucially, 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,

$$L \leq \frac{1}{\theta}\left[T_b + \frac{N_b}{S}\right] \tag{8}$$

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

$$L = \frac{R^*}{R^* - (1-\theta)R}\left[T_b + \frac{N_b}{S}\right] = \frac{1}{1-\phi(1-\theta)}\left[T_b + \frac{N_b}{S}\right] \tag{9}$$

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 $\phi < 1/(1-\theta)$, which we assume from now on. 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 ϕ, increases the pledgeable value of the bank's loans and hence the leverage ratio.

3 Equilibrium

This section shows how to characterize equilibrium in a relatively simple but useful way. Market clearing for nontradables yields an intuitive link between the real exchange rate and the demand for capital. Combining it with optimal investment conditions then gives 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,

$$S^{1-\gamma} = N/\gamma K \tag{10}$$

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 on loans. 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:

$$\phi = \frac{R}{R^*} = \left(\frac{S}{S_0}\right)^{\gamma+(1-\alpha)(1-\gamma)} \equiv \phi(S) \tag{11}$$

This expression emphasizes that, in equilibrium, the spread is a function of the real exchange rate.

We are now ready to characterize equilibrium in the market for loans. Loan demand is given by (4):

$$
\begin{aligned}
L^d &= \frac{QK}{S} - (T_f + \frac{N_f}{S}) \\
&= \frac{N}{\gamma S} - (T_f + \frac{N_f}{S}) \qquad (12)
\end{aligned}
$$

where we have used (2) and (10) 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 if $N_b > 0$, i.e. if the bank has a positive endowment of nontradables. Focusing on this case for now, (12) gives the demand for loans as a decreasing function of the real exchange rate.

The supply of loans is given by (8)-(9) of the previous section, rewritten here for convenience:

$$
\begin{aligned}
L^s &\in [0, \frac{1}{\theta}(T_b + \frac{N_b}{S_0})] \text{ if } S = S_0 \\
&= \frac{1}{1-\phi(S)(1-\theta)}\left[T_b + \frac{N_b}{S}\right] \text{ if } S > S_0 \qquad (13)
\end{aligned}
$$

with $\phi(S)$ given by (11). In words, if $S = S_0$, $\phi = 1$, and banks are content with lending any amount 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 ϕ 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 ϕ and therefore, via (11), by the real exchange rate. [7]

[7] Note that the necessary condition $\phi < 1/(1-\theta)$ together with (11) impose a corresponding upper bound on the set of S consistent with equilibrium.

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 ϕ via (11) 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:

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

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, ϕ, is large or if the financial frictions parameter θ is small.

For concreteness, for now we focus on the case in which the leverage effect dominates the net worth effect, 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.[8] 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 we add a downward-sloping demand for loans. 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 $\phi = 1$.

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 ϕ is then given by (11) and must be greater than one; equivalently, $R > R^*$. In this situation the economy is financially constrained, in the sense that the collateral constraint

[8] Figures are collected at the end of the paper.

must bind. Financial frictions can result in excessively high spreads and weak real exchange rates.

The comparative statics of this model are now easy to sort out. Consider, in particular, a fall in θ, 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 in Figure 4. If the economy was initially constrained, a fall in θ results in a real exchange rate appreciation and higher intermediation. It also results in a fall in R and ϕ.

While our model is extremely stylized, it sheds light on the subtle interactions among international borrowing constraints, interest rates, and the real 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 the firm must combine tradables 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 difference is that in our model the relevant price is not 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 latter effect has seldom been studied.[9] Because the tightness of the borrowing constraint depends on relative prices, domestic policy changes can have implications for international capital flows. We turn now to this issue.

[9] One paper that has is Benigno, Chen, Otrok, Rebucci and Young (2013).

4 Policy Implications

4.1 Redistribution and Banks' Net Worth

If the collateral constraint binds 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 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, (12) and (13), imply that the impact of the policy must be as in Figure 5. Both loan demand and supply move horizontally to the right, but the supply schedule moves farther. In fact, (12) and (13) 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 ϕ and R (because of (11)), 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 allows bank loans to 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 ϕ and the lending interest rate R fall. The constraint is relaxed. Firms borrow and invest more. Output is higher and domestic consumption and welfare improve.[10]

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

[10]Because domestic firms were borrowing "too little" to begin with, the benefit of additional borrowing (in terms of larger output) must be larger than the cost (in terms of larger debt repayment). It follows that consumption in the final period must rise, and so must welfare.

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 is leverage: transferring nontraded goods to the bank increases its net worth, which can be levered up to cause a net increase in financial intermediation.

4.2 Government Credit Programs

The recent use of *unconventional* policies has motivated much recent research. One example of such policies are lending facilities aimed at 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. [11] 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.[12]

The reader can easily check that this policy leaves the private demand and supply of loans, (12) and (13), 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

[11] 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.

[12] This is what Gertler and Kiyotaki (2010) call "direct lending".

of loans 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 ϕ fall. In this sense there is some crowding out in the credit market, 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"):

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

This follows easily from 12, 13, 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.

As an alternative policy, suppose that the government borrows F and lends that amount not to firms but to the banks.[13] In this case, we assume that government loans are provided 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

[13] Or, in terms of Gertler and Kiyotaki (2010), the government provides "liquidity facilities".

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:

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

This tells us that the bank's loan supply increases by F times the leverage ratio. The relationship 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 firms.

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

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

From the previous expression we conclude that $F^{LB} < F^{DL}$, which confirms that government lending to banks is more effective than government lending to firms. The key to understanding 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, with the multiplier being the leverage ratio.

4.3 Exchange Market Intervention

Foreign exchange market intervention can be regarded as a special kind of unconventional policy. Our model does not feature currency but it does feature a real exchange rate which is determined in the market for nontradables, so we can examine a policy that resembles actual intervention policy.

To examine this option, it is useful to reinterpret F not as a credit line available to the government but as a stock of international reserves. In a 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, an intervention operation is one in which, in the initial period, the government uses its reserves F to buy nontradables in the market, and *sterilizes* this move 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. Moreover, 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 tradable goods to firms.

The description just given is somewhat awkward because, in a sterilized intervention, the government lends nontradables in the first period but is repaid tradables in the second period.

This is because our baseline model assumes that nontradables play no role in the second period. But this feature of the model is easily fixed. Modify the model so that households consume nontradables as well as tradables in the last period. Then, following Holmstrom and Tirole (2011), assume that the two goods are perfect substitutes in consumption, and 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 the sterilizing operation is a credit denominated in nontradables with interest rate R/S (i.e. firms are lent nontradables in the first period and, in the last period, repay R/S units of nontradables per unit borrowed). Then the analysis is the same as before, 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.

In fact, the Holmstrom-Tirole assumption that the exchange rate is one in the second period is inessential. To see this, consider a further modification: in the second period, the household's utility from consumption of tradables (C_T, as before) and nontradables (C_N) is given by a well-behaved utility function $U(C_T, C_N)$ (for example, a C.E.S. function). Letting S' denote the real exchange rate in the second period, the household's budget constraint in that period is

$$C_T + \frac{1}{S'}C_N = \Pi^f + \Pi^b + \frac{1}{S'}N'$$

where N' is the household's second period endowment of nontradables.

In any equilibrium, $C_N = N'$, and the household's optimality conditions pin down the second period exchange rate: $S' = U_1(C_T, N')/U_2(C_T, N')$. [14] Hence the exchange rate in the second period depends on C_T : it is no longer one but it now depends on the outcome of the first period and, in particular, it may depend on policy (since C_T may). But the equivalence between sterilized intervention and direct lending still holds: a policy of directly lending F tradables (at the equilibrium interest rate R) and a sterilized intervention in which the government lends

[14] $U_i(C_T, C_N)$ denotes the partial derivative of U with respect to its ith argument, evaluated at (C_T, C_N).

nontradables (at nontradables interest rate RS'/S) imply the same outcomes in equilibrium.

Our analysis then indicates that a sterilized intervention of this kind, by which the government acquires nontradables with its reserves of tradables, sterilizing by means of lending the nontradables just acquired to firms, is equivalent to directly lending the reserves to the firms. It follows that sterilized intervention can affect real outcomes, alleviate financial frictions, and improve welfare; but it can do so for the same reasons and only under the same circumstances as a direct lending policy: by alleviating financial constraints if these bind.

The analysis is similar if the government sterilizes foreign exchange intervention by increasing credit to the bank rather than to firms. In this case, the outcome must be the same as in the case of lending the F tradables to banks.[15] And, as in the previous section, lending to banks has the additional advantage that banks can lever up the additional resources they receive and increase loan supply more than proportionately. Financial intermediation is greater and the exchange rate stronger than when the government sterilizes the intervention by lending directly to firms.

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. Assume also that the bank has financed its holdings of securities 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.[16]

[15] Provided, as before, that the interest rate on the sterilizing credit is the same as the credit to banks, when both rates are measured in tradables. In particular, in the setting in which the household has a utility function U in the second period, an intervention sterilized with a nontradables loan to the bank at rate R^*S'/S is equivalent to a direct loan of tradables to the banks at rate R^*.

[16] In other words, the bank's collateral constraint is still (7). Under the interpretation that the constraint arises from the possibility of absconding, this may reflect that, when the banker has the opportunity to abscond, he can steal θRL as before but not any money collected from government securities. This would be indeed appropriate if, for instance, in the second period the government repays its securities only after the bank cancels its own foreign debt. Also, we are not concerned here with the origin of the government debt. We do assume 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 stock of debt have distortionary taxation effects. This would needlessly cloud the discussion of sterilized intervention.

The assumptions just made imply that the bank's holding of government securities has no impact on its profits or on 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.[17] The conclusion is that sterilizing the foreign exchange intervention via a purchase of outstanding government securities is equivalent to sterilizing it via a credit operation extended to banks. And*, a posteriori,* this kind of sterilized foreign exchange intervention is also equivalent to providing F as a direct credit to the bank.

Summing up: in this model, sterilized interventions, involving purchases nontradables with reserves matched with an offsetting credit or debt repurchase, are equivalent to credit policy involving only tradables. This perspective sheds light on why and how interventions may or may not work. In particular, it tells us that sterilized interventions may have real effects, alleviate frictions, and improve welfare, if and only if financial constraints are binding.

This is intuitive: when such contraints bind, the economy is effectively rationed in terms of tradable goods. If the government has access to tradables (because, for instance, it holds international reserves), it makes sense to use them. Intervention then matters –and has beneficial effects– because it is a means for the authorities to inject additional tradables and alleviate their scarcity.

The analysis in this section also underscores that the details of an intervention can matter a great deal. The impact of sterilized intervention is determined by the nature of the sterilizing credit. The key factor 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 up in the international capital market.

The perspective just offered on sterilized interventions is worth contrasting with others.

[17] 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^*.

The existing literature[18] offers two main 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 effects of sterilized intervention. And intervention has no signaling value either, as the model features no asymmetric information.

Our analysis emphasizes that it is instructive to regard sterilized intervention as being equivalent to simpler credit policies, such as directly lending tradables. In the real world, the equivalence can break down in favor of intervention or direct lending. For example, it may be the case that it is 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. An analysis of this situation, in the context of the model presented here, would require stating more precisely the reasons why lending in nontradables is relatively cheaper than lending in tradables. Such an extension is feasible, we believe, but better left for future work.

More generally, our discussion suggests that it may be useful to identify and study reasons why the equivalence between sterilized intervention and simpler credit policies may break down. Such reasons may be of different kinds: for example technological (i.e. transactions costs) or institutional. We also leave this for future research. But it is worth noting that extending our analysis along this direction is likely to reinforce the conclusion that sterilized intervention works through mechanisms that differ greatly from conventional ones.[19]

[18] 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).

[19] As mentioned earlier, this is also a key message from Garcia (2016).

5 Generalizations and Multiple Equilibria

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

So far much of our analysis has relied on the form of the loan supply function (13), 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 $\phi = \phi(S)$ 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 with respect to S (given by (11)) must be large enough. Since the link between ϕ 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, 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

$$Q = \left[\gamma + (1-\gamma) S^{1-\lambda}\right]^{1/(1-\lambda)} \tag{14}$$

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 $\alpha A \left(N/\gamma Q^\lambda\right)^{\alpha-1} = RQ/S$. Finally, combining the preceding expression with (14) and rearranging, we obtain the key relation between the spread and the real exchange rate:

$$\phi = R/R^* = \frac{\alpha A}{R^*}\left(\frac{\gamma}{N}\right)^{1-\alpha}\Psi(S), \tag{15}$$

where we have defined

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

This generalizes equation (11). Note that the elasticity of ϕ with respect to S is equal to the elasticity of Ψ, 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. If λ is smaller, the elasticity also falls.

Now the loan supply curve is given again by (13), but with ϕ given by (15) instead of (11) (and with S_0 defined as the value of S such that the last term of (15) equals one).

As discussed, the extra parameters allow for configurations in which the elasticity of ϕ 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 a loan supply that is *decreasing* in S.

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

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

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, a change that 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.[20] If equilibria coexist in which financial constraints do and do not bind, 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. 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 it 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 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-

[20] As in virtually all of the related macro literature, we advance no general theory of equilibrium selection under multiplicity, but (more modestly) offer conjectures about particular ways in which agents could pick an equilibrium when more than one is feasible.

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

When are unconventional policies effective, and what are they effective at? Why do authorities intervene regularly in foreign markets 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? 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 in the context of an open economy. We consider an economy with only two goods, traded and non-traded, so that we define a real exchange rate as the relative price of these two goods. In this economy, financial constraints may or may not bind. They do in times of financial stress, and the real 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 if and only if 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, consider a sterilized intervention operation in which 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. The 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 follow from 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. When multiple equilibria are possible, 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 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 American countries prior to the global financial crisis (Céspedes, Chang, and Velasco 2014). Whether an alternative rationale can be developed is an interesting question for future research.

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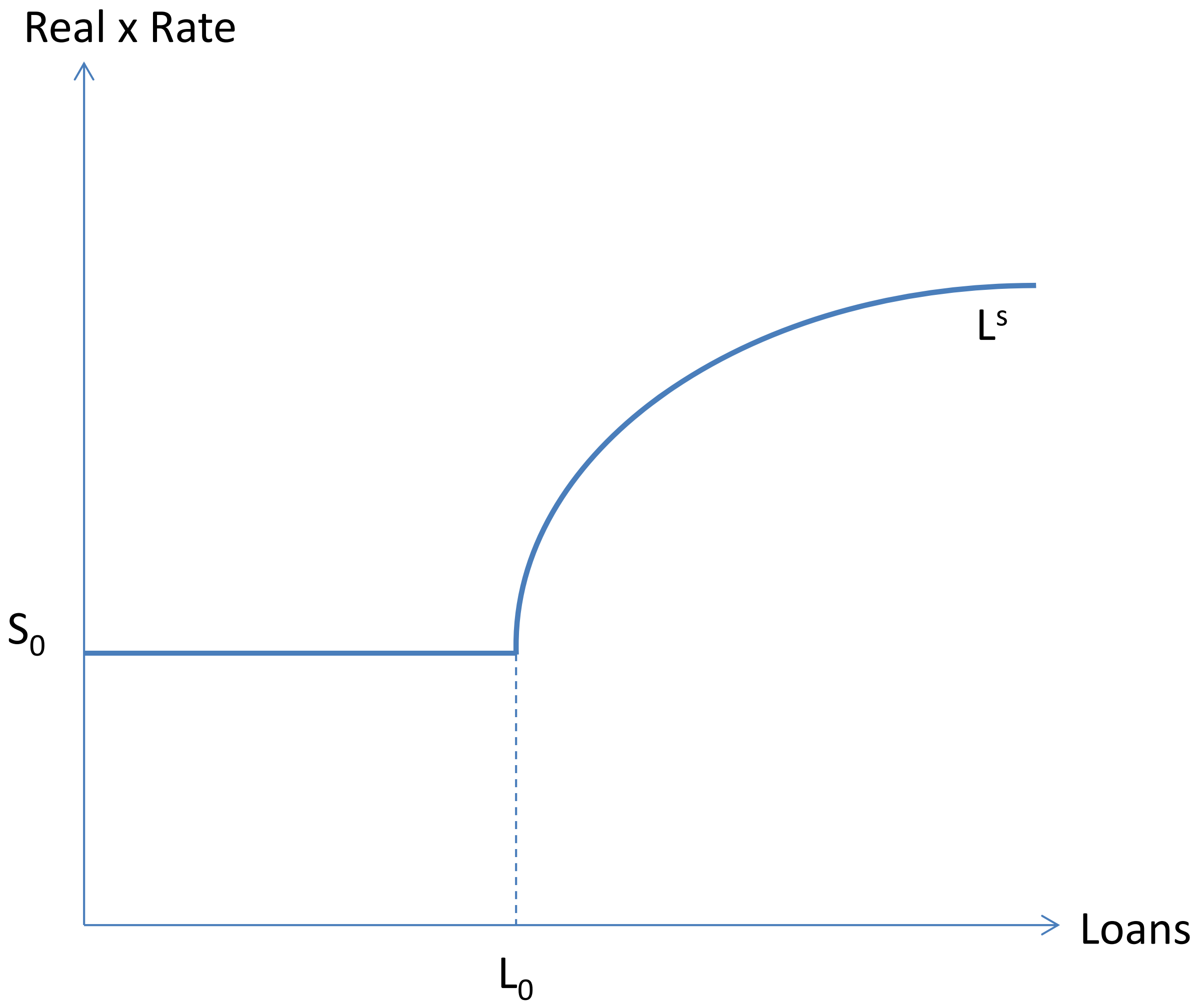

Figure 1

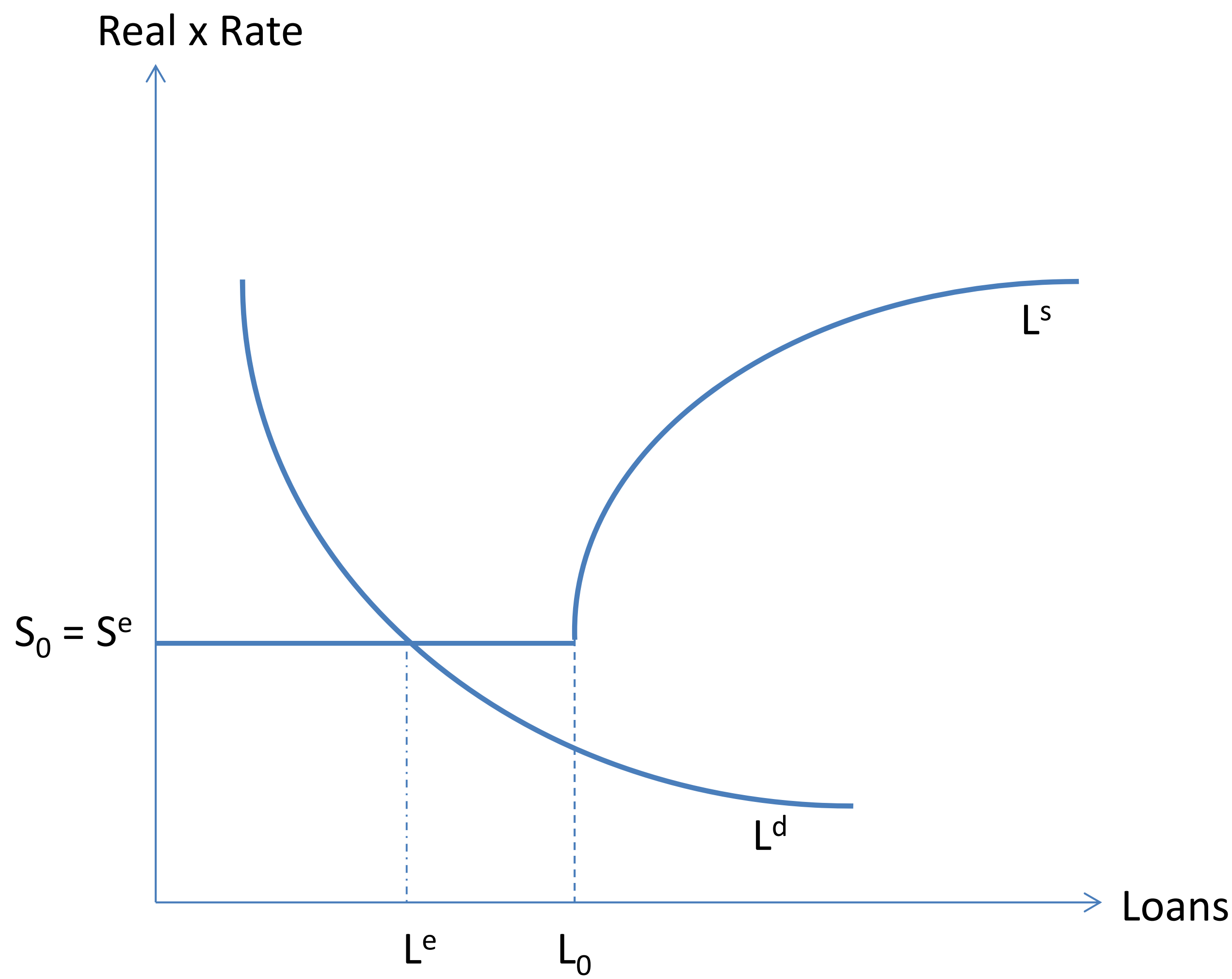

Figure 2

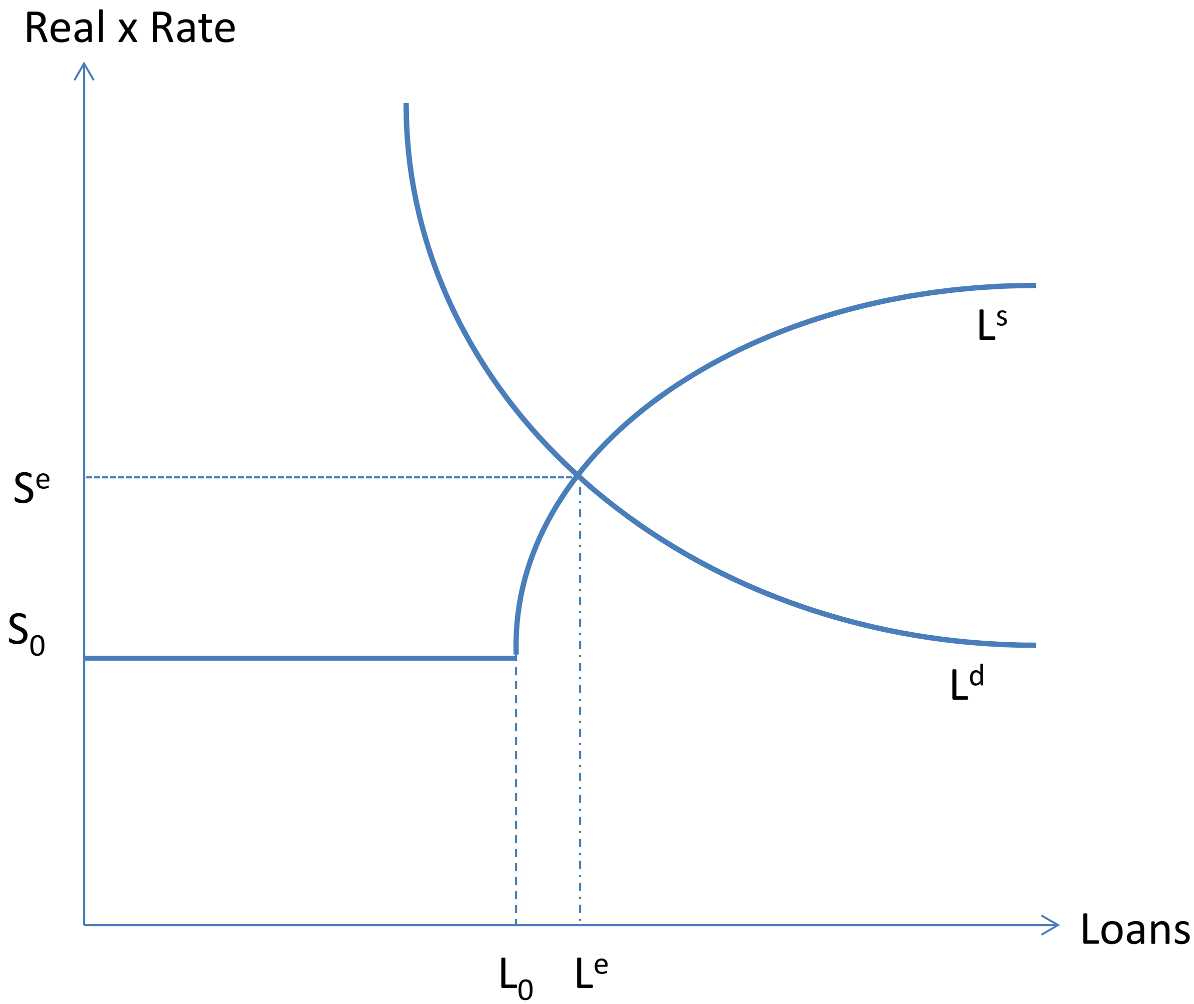

Figure 3

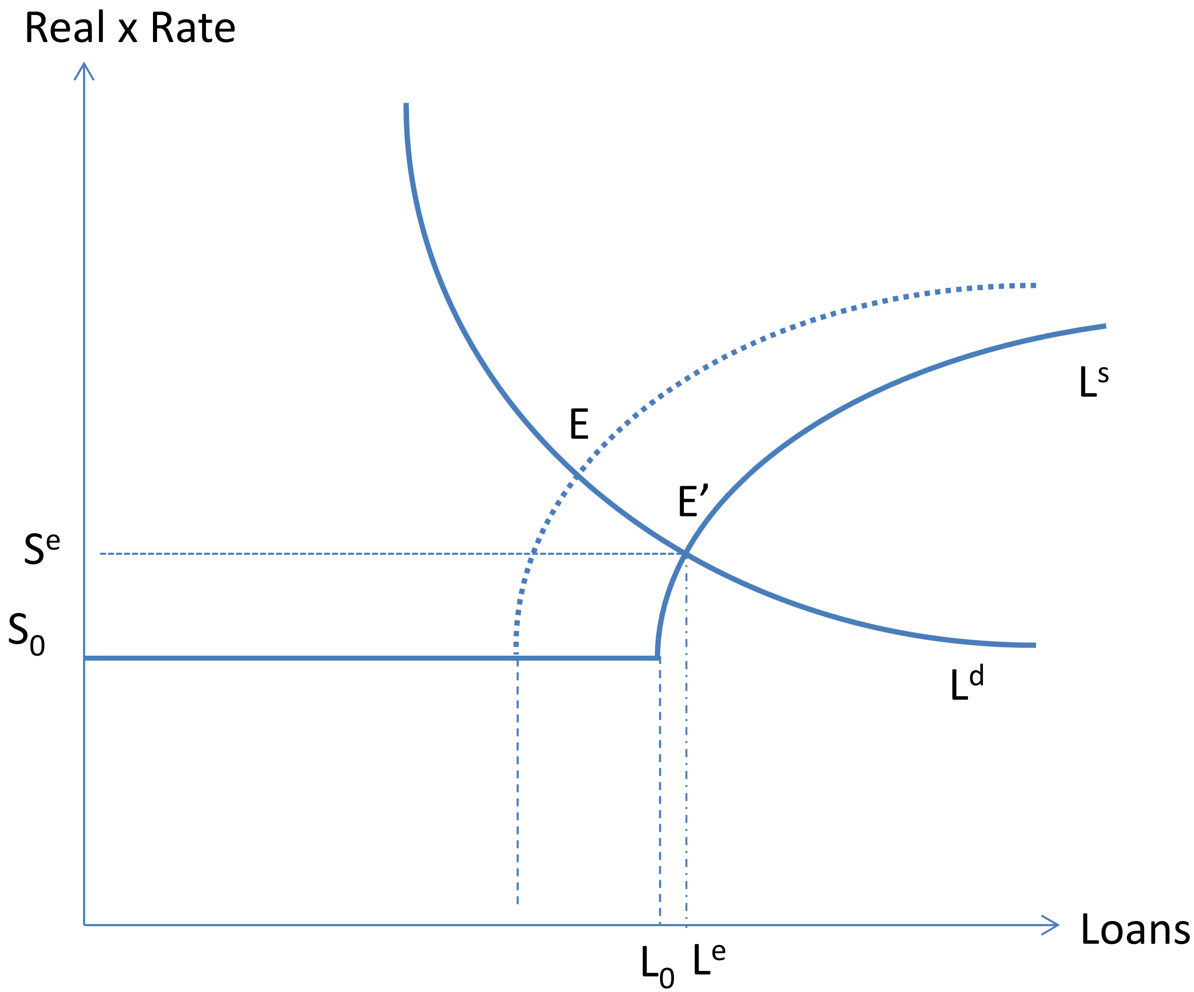

Figure 4

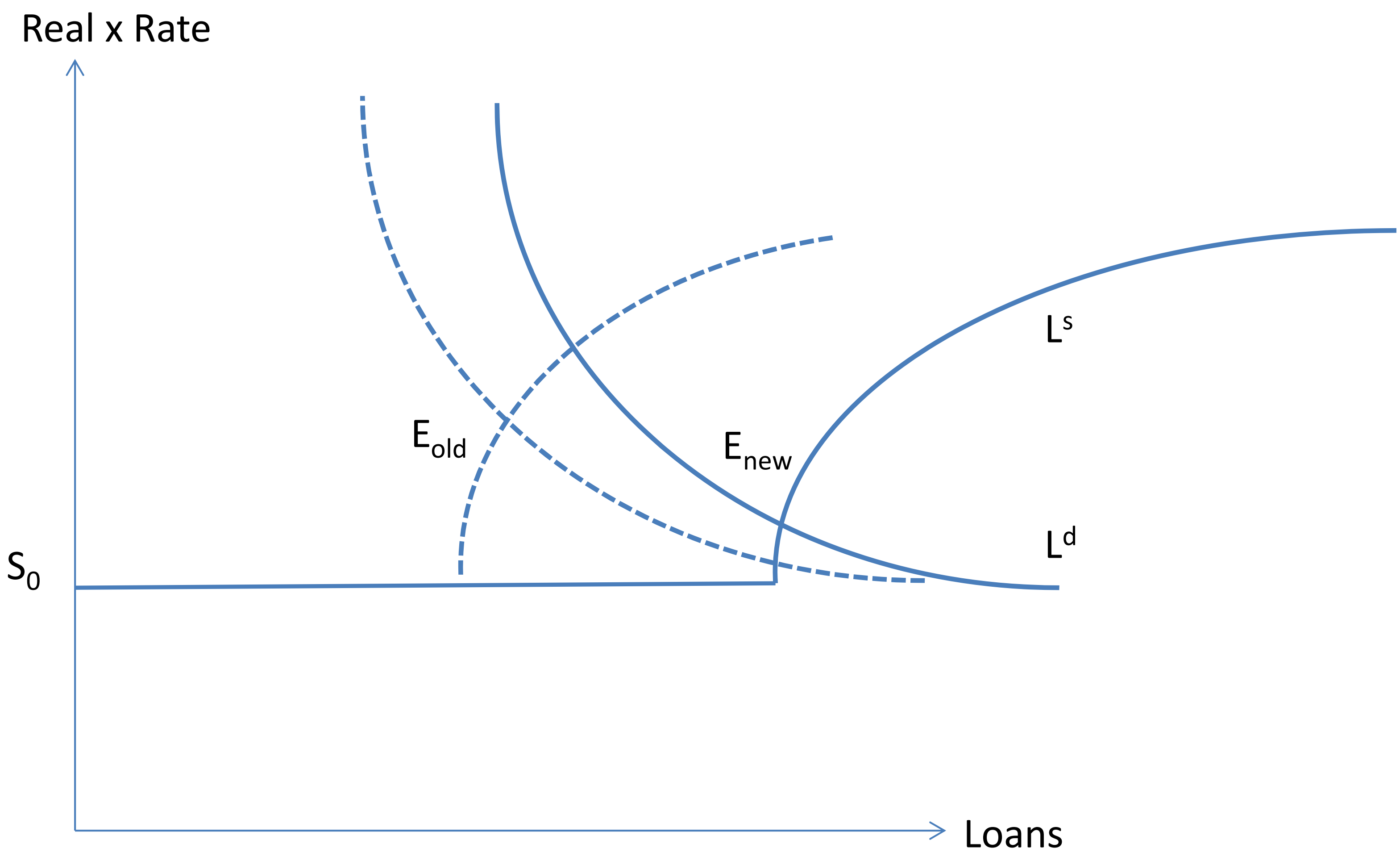

Figure 5

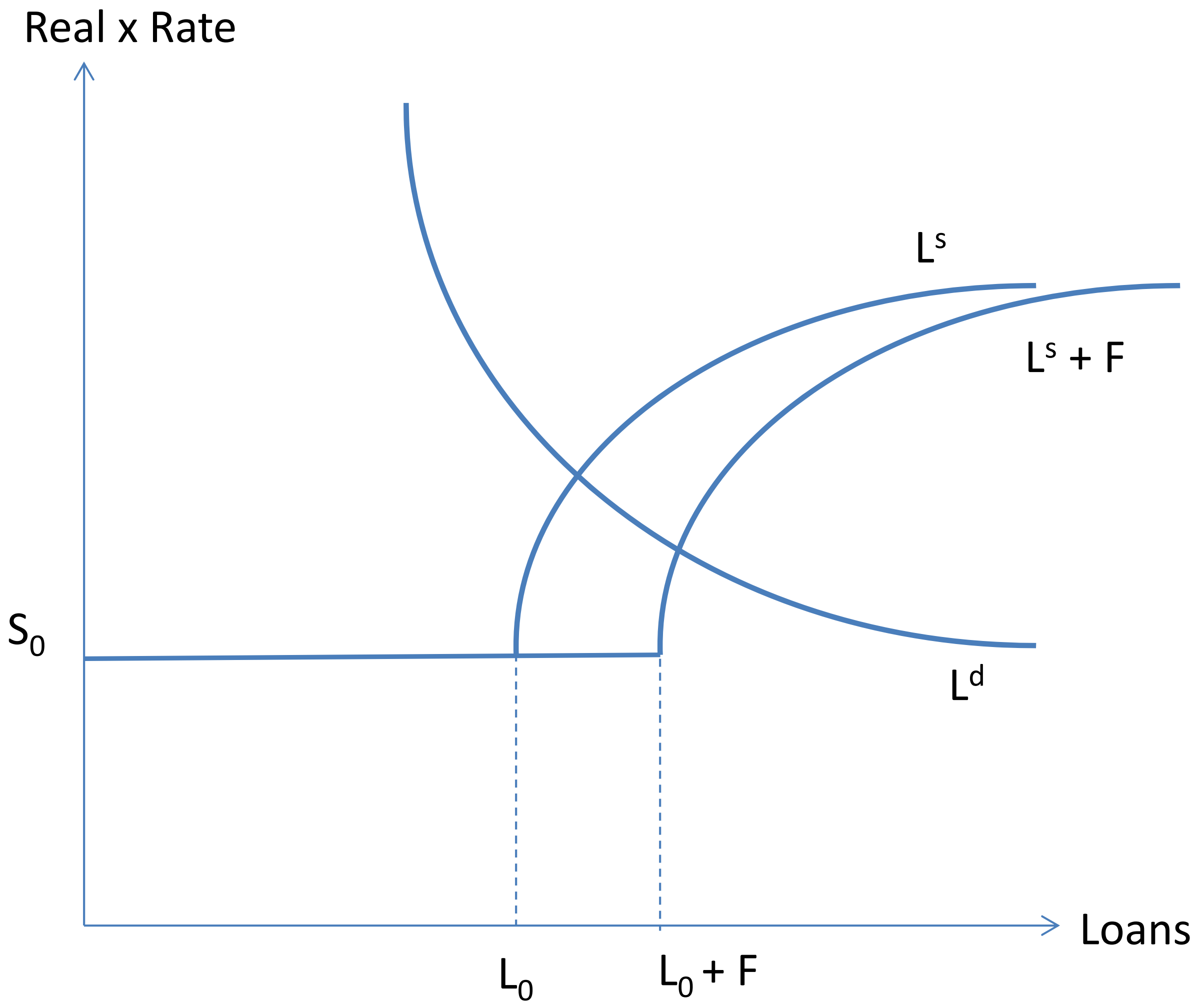

Figure 6

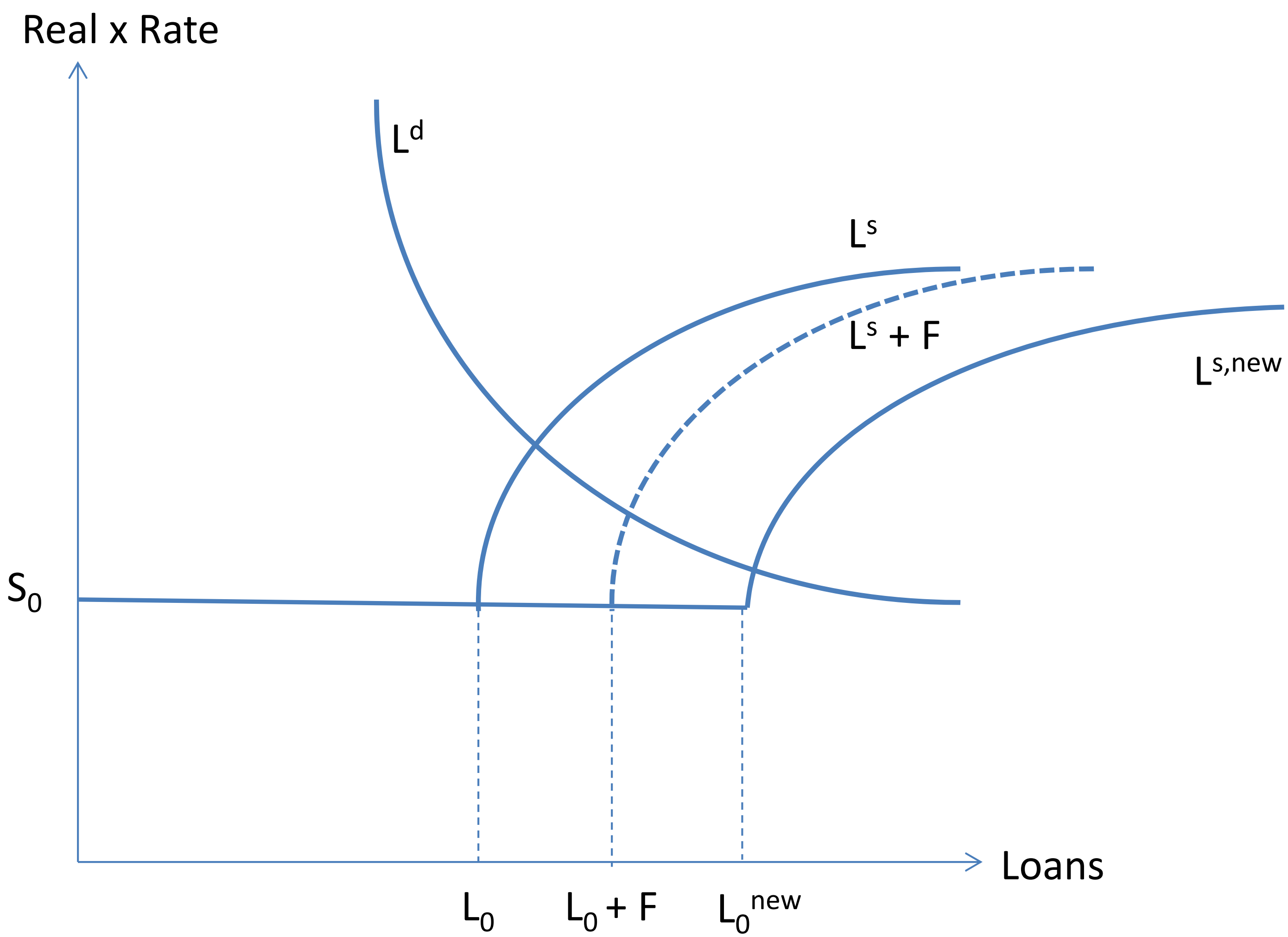

Figure 7

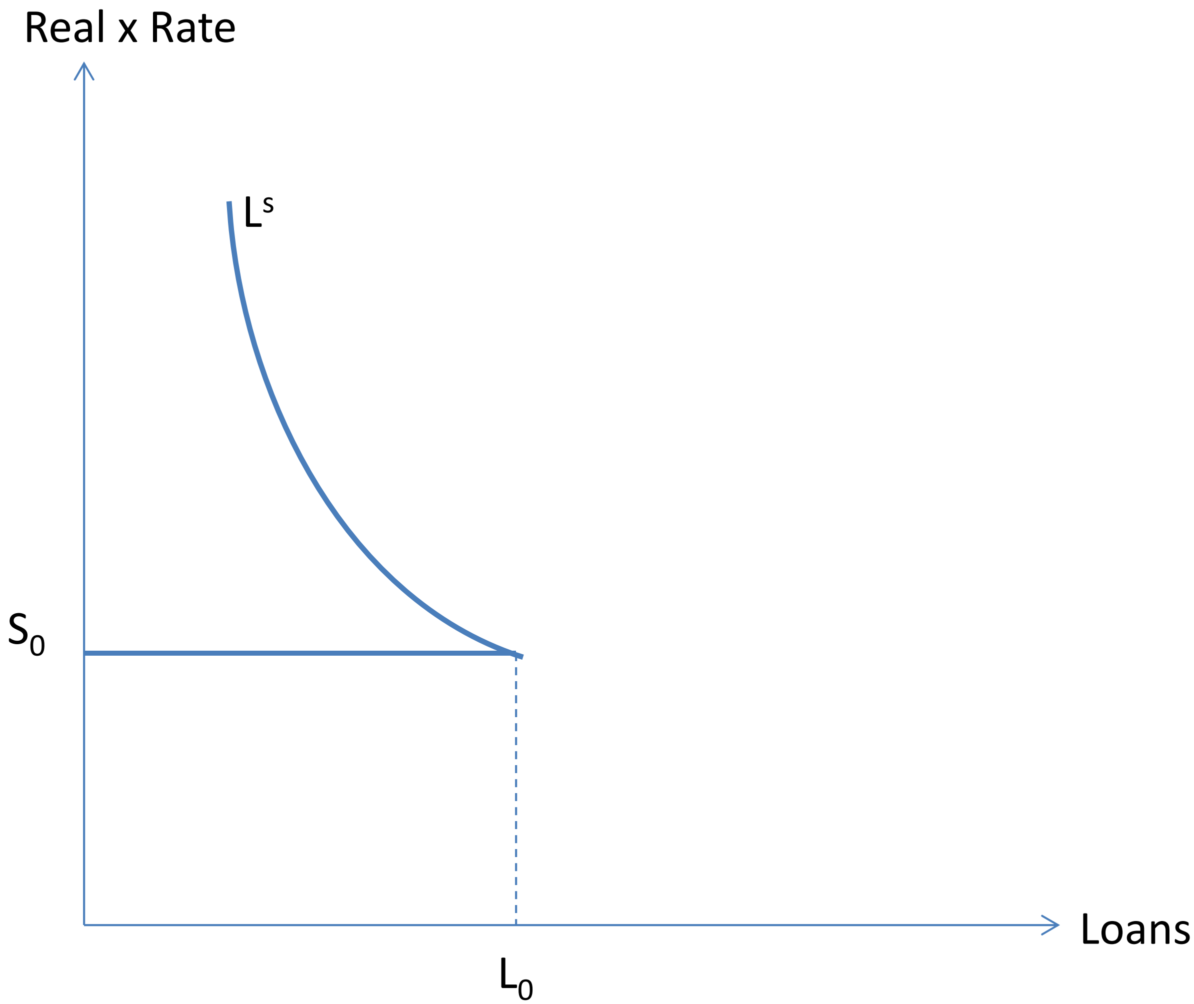

Figure 8

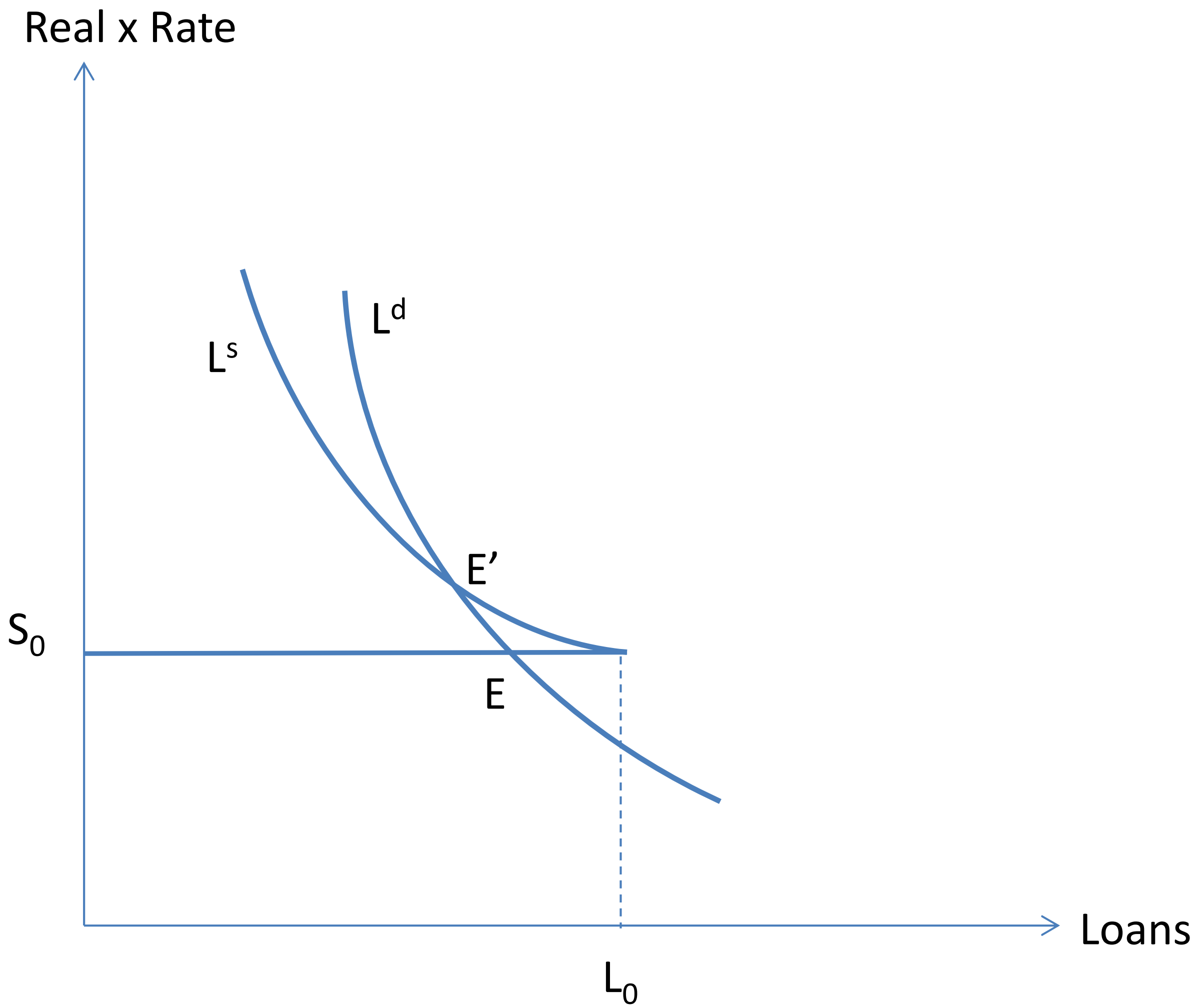

Figure 9