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Currency crises and monetary policy: the role of foreign inputs

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Abstract

The present paper analyzes the role of imports in the occurrence of a currency crisis. For this, it extends a third generation model with balance sheet effects by introducing imports as foreign inputs in the production function. The results show that when imported inputs are financed by foreign debt the probability of a currency crisis increases for two reasons. First, the currency depreciation creates negative balance sheet effects if the price elasticity of imports is low. Second, the currency depreciation lowers the capital available for production and hence implies a direct negative effect on output. Moreover, in order to avoid a crisis monetary policy must be more aggressive compared to the case without foreign inputs.

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1. Introduction

Recently two emerging market countries, Argentina and Turkey, have seen their currencies depreciate significantly against the major foreign currencies[1]. This depreciation could be the first stage of a currency crisis with a risk of causing an output recession.

Since the 80s, three generations of currency crisis models emerged in order to explain the occurrence of currency crises and to define the adequate policy. Third generation models are especially suitable for the analysis of crises in emerging markets as they put emphasis on the private sector behaviour as well as on the role of foreign currency debt. Moreover, those models allow for the analysis of a monetary policy reaction in order to prevent or remedy the currency crisis. Among the third generation models, the framework of Aghion, Bacchetta and Banerjee (2000, 2001), (henceforth ABB) present several advantages indicated by Bergman and Hassan (2008).

Using the currency crisis framework of ABB (2001), the present paper analyzes the role of imported goods in the occurrence of a currency crisis. For this, the present framework introduces imports into the production process through intermediate goods and capital goods in order to assess the role of imports in triggering a currency crisis. The assumption of foreign inputs is especially plausible for many emerging market countries where production depends heavily on imports such as Turkey, Korea and Malaysia[2]. This reliance on imported working capital renders the countries especially vulnerable to a sudden increase in the exchange rate. Indeed, in addition to the standard balance sheet effect, an exchange rate depreciation implies a negative effect on output by reducing the imports and thereby the working capital available for production.

The present paper relates and builds on the third generation currency crisis framework of ABB (2001) and the extensions that followed. ABB (2001) finds a negative relation between the current exchange rate and the future output showing clearly the role of adverse balance sheet effects on the occurrence of a currency crisis. The authors conclude that the best reaction to the crisis is a tight monetary policy (an increase in the interest rate or a reduction of the money supply) similarly to the prescriptions of the IMF. However, this result cannot be considered as general since a monetary tightening revealed ineffective in reducing the exchange rate recently in several countries[3]. Moreover, ABB (2001) admit that in order for the interest rate increase to produce the desired effect, it should not lead to a credit-crunch and the resulting appreciation of the currency should lead to a significant fall in the burden of foreign debt. ABB (2004) introduce the banking system into ABB (2001) along with the possibility of a central bank that pursues open-market and short term lending operations, which allows to consider alternative policy actions for the monetary authority. Following ABB (2001), Bergman and Hassan (2008) report that the conclusions of ABB (2001) change if the interest rate parity condition does not hold. Indeed, the authors show that an interest rate hike might amplify the currency depreciation following a shock. Nakatani (2017) keeps the assumption of interest rate parity but extends ABB (2001) by introducing the possibility of foreign currency earnings through exports. The author shows that the occurrence of a currency crisis depends on the size and elasticity of exports since an increase in the exchange

[1] The Argentine peso depreciated by more than 50 % against the euro between July 2017 and July 2018. Similarly, the Turkish lira depreciated nearly by 40 % against the euro during the same period.

[2] As of 2017, more than 87% of imports are either capital or intermediate goods in Turkey according to the TÜIK database. According to the TiVA database, the share of intermediate goods in total imports is respectively around 77% and 81% in Malaysia and Korea in 2011.

[3] The Central Bank of Argentina increased the policy rate three times in 2018 before setting it to 40% in May 2018 as a reaction to a 18% depreciation of the national currency since the beginning of the year. The result is only a slight alleviation of the upward pressure on peso in the following months. The Central Bank of Turkey increased its policy rate to 17.75% in June 2018. Following the monetary tightening, a short period of appreciation against the euro is observed followed by a new period of depreciation in the following months.

rate will boost exports, which could at least partially compensate for the fall in investment. In contrast to Nakatani (2017), Miller et al. (2006) consider that exports respond to exchange rate fluctuations only after a lag and argue that this will create a demand shortage following a currency crisis. The authors follow ABB (2001) for the supply side and introduce demand side effects inspired from Krugman (1999) in order to show the role of demand failure in currency crises. While Miller et al. (2006) take imports into account, they assume that imports are independent of the exchange rate and therefore overlook the effect of imports on the occurrence of a currency crisis.

The present setup extends Miller et al. (2006) and thereby ABB (2001) by introducing imports into the production process through intermediate goods and capital goods. The results show that the probability of a currency crisis following a financial shock increases when the price elasticity of imports is low and the marginal product of capital including imported inputs is high. Accordingly, in order to avoid a possible crisis, a more aggressive monetary reaction is required when foreign inputs are included into the analysis. Moreover, taking imports into account as an input for production allows to shed light on a trade-off that is omitted in the literature: future output decision of the firm following an increase in the exchange rate will depend on the marginal revenue the firm will receive by varying its use of imported working capital and the cost of foreign debt which is used to finance imports.

The present paper is organized as follows: section 2 presents the setup while section 3 analyzes the effect of an expectational shock to the exchange rate as well as the monetary policy reaction. Section 4 concludes.

2. The Model

The present setup is an extension of ABB (2000, 2001) describing a small open economy with flexible exchange rates. The model is an infinite horizon setup. However, following ABB (2001) the analysis will focus on the first two periods. Indeed, ABB (2001) argue that after the economy is hit by a shock in the first period, the following periods will be identical to the second period provided that there are no further shocks. It is assumed that capital is perfectly mobile.

Firms are identical and have the possibility of borrowing both in domestic and foreign currency in order to finance investment. However, the firms are assumed to be subject to exogenous credit constraints. The central bank can affect the nominal exchange rate and the nominal interest rate by varying the money supply.

2.1. The Monetary Sector

The present framework keeps the standard IPLM curve of ABB (2001) which gives a negative relation between the current exchange rate (the price of one unit of foreign currency in terms of domestic currency) and the future output:

$$E_1 = \frac{(1+i^*)(1+\eta)}{1+i_1}\frac{M_2^s}{M^d(y_2,i_2)} \tag{1}$$

Equation (1) is obtained from the combination of the purchasing power parity $P_2 = E_2^e$, for a constant and unitary foreign price index, with the equilibrium condition in the money market at *t*=2 which equates the money supply M_2^s to the money demand $P_2 M_2^d(y_2,i_2)$ along with the following interest rate parity equation:

$$(1+i_1) = (1+i^*)(1+\eta)\frac{E_2^e}{E_1} \tag{2}$$

where η is the risk premium that the country has to pay on domestic bonds due to an increased uncertainty on the future exchange rate and E_2^e is the expected exchange rate in *t=2*. As

indicated by Bergman and Jellingsø (2010), a constant and exogenous risk premium on the domestic bond will lead to an exchange rate depreciation without altering the foreign currency composition of debt.

Bergman and Hassan (2008) give one of the few examples of an alternative IPLM curve due to the relaxation of the interest rate parity condition. The absence of the interest parity modifies (1) and defines the current exchange rate as the ratio of money supply to money demand. However, this assumption does not change the mechanism which leads to the occurrence of a crisis.

2.2. Production and Investment

The model is similar to the ABB model (2001) other than the productive structure of domestic firms. Following ABB (2001), the present setup assumes that firms use working capital as the only input for production as implied by the production function given below:

$$y_t = f(k_t) \tag{3}$$

where y denotes output and k stands for working capital. By definition, working capital contains capital goods and stocks of intermediate goods used in the production process, which may be produced within the country or imported from abroad. Accordingly, in contrast to ABB (2001), the present setup distinguishes between the domestic and imported capital and intermediate goods by assuming that a fraction of the working capital is produced at home while the rest is produced abroad and imported. Therefore the total working capital k_t is assumed to have the following composition:

$$k_t = a_t + H_t(E_t / P_t) \tag{4}$$

In equation (4), a_t represents the physical working capital produced at home and H_t denotes the physical imported capital and intermediate goods. The imports are a negative function of the nominal exchange rate E_t deflated by the home price index P_t: $H_t(E_t / P_t)<0$.

Similarly to ABB (2001), the investment in working capital in period $t+1$ can be financed with two types of sources. The first source of funds for investment purposes consists of the entrepreur's wealth W which corresponds to the retained earnings in period t available for investment in $t+1$:

$$W_{t+1} = (1-\alpha)\frac{\Pi_t}{P_t} \tag{5}$$

where Π_t and α are respectively the total profit and the share of distributed profit.

The second source of funds for investment purposes consists of borrowing (both foreign and domestic) where there is an upper limit for borrowing L_t, proportional to the firm's wealth:

$$L_t = l_t + l_t^* \frac{E_t}{P_t} = \mu W_t \tag{6}$$

where μ is the credit multiplier. It is assumed that foreign credit l^* is used for imports only whereas other types of capital are financed with domestic credit l_t. This assumption is only for simplification purposes; the results do not change when we allow for both types of borrowing to finance imports.

Given the cost of borrowing for investment in home working capital (l_t) and foreign working capital ($l_t^* = H_t$), the firm's profit in t can be written as follows in nominal terms:

$$\Pi_t = P_t y_t - l_t(1+i_{t-1})P_{t-1} - H_t(1+i^*+\eta)E_t \tag{7}$$

where i_{t-1} is the home nominal interest rate and i^* the foreign nominal interest rate which is assumed to be constant over time.

At the end of the period *t*, the physical capital is assumed to depreciate totally and the stock of intermediate goods is equal to zero. This implies that the stock of capital available for the next period is equal to the sum of retained earnings of the current period and the borrowing which is proportional to the firm's wealth:

$$k_{t+1} = (1+\mu)(1-\alpha)\frac{\Pi_t}{P_t} \tag{8}$$

Introducing (7) into (8) using (3) yields the following expression for the output level in period *t*=2 :

$$y_2 = f\left((1+\mu)(1-\alpha)\left[f(k_1) - l_1(1+r_0) - H_1(1+i^*+\eta)\frac{E_1}{P_1}\right]\right) \tag{9}$$

where *r* is the real (domestic) interest rate.

Equation (9) gives a relationship between the current exchange rate and the future output. This relation is defined as the wealth curve in ABB (2001). The wealth curve implied by (9) differs from the wealth curve in ABB (2001) since exchange rate fluctuations affect the profits (and thereby period-2 output) not only through their effect on the burden of foreign currency denominated borrowing, but also on the firm's production. This idea is similar to Nakatani (2017) where the exchange rate variations affect the firm's profit not only through the cost side but also through the revenue side since the firm's sales are composed of not only the domestic consumption but of exports as well.

Taking the first derivative of (9) with respect to E_1 will give the sign of the slope of the wealth curve as follows:

$$\frac{dE_1}{dy_2} = \frac{P_1}{(1+\mu)(1-\alpha)H_1\left\{\varepsilon_H\left[f_{k_1} - (1+i^*+\eta)\right] - (1+i^*+\eta)\right\}} \cdot \frac{1}{f_{k_2}} \tag{10}$$

The expression given in (10) contains imports in volume and the demand elasticity of imports with respect to the real exchange rate ε_H. The slope of the wealth curve given by (10) can be positive or negative depending on the factors which affect the trade-off between the marginal product of capital including imports and the marginal cost of foreign borrowing. When the marginal product exceeds the marginal cost $(f_{k_1} - (1+i^*+\eta) \geq 0)$, the wealth curve slopes downwards (negative slope), as in ABB (2001), regardless of the size of imports (foreign debt). The intuition behind is the following: when the marginal revenue from extra imports through higher production exceeds the marginal cost of extra imports through foreign borrowing, the firm could increase profits by using more foreign capital (imports). In this case, any reduction in imports due to an increase in the exchange rate lowers profits and thereby investment, which implies a lower level of future output regardless of the demand elasticity of imports.

In the opposite case, when the marginal revenue is lower than the marginal cost $(f_{k_1} - (1+i^*+\eta) < 0)$, the wealth curve slopes upwards (positive slope) for high values of import elasticity. In this case, lowering imports following an increase in the exchange rate will raise the firm's profits and thereby investment, leading to a higher level of future output. However, this cut in the imports must be sufficiently high (the demand elasticity of imports should be high) in order to compensate for the rise in the burden of foreign debt due to higher exchange rate.

Nakatani (2017) also shows that the wealth curve can have a positive or negative slope. In that setup the slope of the wealth curve depends on the trade-off between the level

and the demand elasticity of exports and the size of the foreign debt. If, for example, the demand elasticity of exports or the level of exports is large enough relative to the size of the foreign debt, a currency depreciation will increase the profits and thereby future output implying that the wealth curve will have a positive slope. This is because the exchange rate depreciation increases exports unambiguously in Nakatani (2017). With imported intermediate goods as in the present setup, the effect of the exchange rate on exports would become ambiguous. Indeed, in addition to the positive effect, there would be a negative effect of the exchange rate depreciation on output (and therefore exports) due to the fact that imported goods are used for productive purposes. In order to keep things simple and to focus on the role of imports, the present setup abstracts from the interaction between imports and exports.

ABB (2001) concentrates on the case with a negative slope of the wealth curve but indicates that the slope could be positive if the credit multiplier depends on the real interest rate. Indeed, according to the authors, in that case, an increase in the current exchange rate would have two opposite effects on future output: the well-known balance sheet effect and the effect of an increase in the credit multiplier which increases the funds available for the next period. If the second effect dominates the first, the slope of the wealth curve will be positive.

Assuming that the second derivative of the import function with respect to the exchange rate is positive and the marginal product of capital is decreasing, the second derivative of the function given in (9) will be positive for high values of the exchange rate and become negative as the exchange rate falls. Moreover, (9) will imply a positive value for future output when the exchange rate is nil as long as profits remain positive. Therefore, the shape of the wealth curve given in (9) is similar to ABB (2001).

3. Exchange Rate Crises and Monetary Policy

The analysis of the impact of a financial shock on the exchange rate and production allows to define the conditions for the occurrence of a currency crisis following a financial shock as well as to assess the stabilization capacity of monetary policy. The occurrence of a currency crisis and the required monetary reaction can be illustrated using IPLM and wealth curves. In what follows, only the case of a downward sloping wealth curve will be considered. Indeed, a positive slope for the wealth curve implies a high elasticity of imports with respect to the exchange rate, which seems implausible for most of the emerging market countries[4].

3.1. The Effects of an Expectational Shock to the Exchange Rate and Production

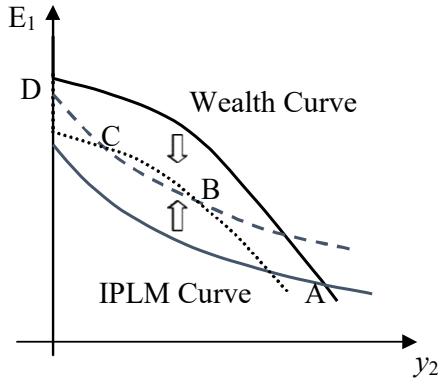
Figure 1 below illustrates the equilibrium as the intersection of the wealth curve and the IPLM curve on the (y_2, E_1) plane.

The slope for the wealth curve is negative, which implies that the marginal revenue of extra imports exceeds or equals the marginal cost $(f_{k_1} - (1 + i^* + \eta) \geq 0)$ or that the exchange rate elasticity of imports is low.

The initial equilibrium given by point A can be considered as a "good" equilibrium according to the definition given by ABB (2001) since at point A output is high and the exchange rate is low. When there is an increase in the risk premium following an unanticipated financial shock, exchange rate increases for a given level of output, which pushes the IPLM curve upwards according to (1). Moreover, the wealth curve shifts to the left, according to (9), since the risk premium increases the cost of foreign currency debt. The new equilibrium could appear either at point B, which is not defined as a currency crisis by ABB (2001) despite the depreciation or at point D which is a currency crisis situation.

[4] Aldan et al. (2012) find that the real exchange rate elasticity of imports for capital goods (except transportation vehicles) is around 0.5 in Turkey and report the absence of a statistically significant relation between the imports of non-energy intermediate goods and the real exchange rate

Figure 1. The Effect of an Expectational Shock to the Exchange Rate



The increase in the foreign currency debt burden reduces the profits in t=1 and hence the capacity to finance the working capital in t=2, which reduces the output in t=2 (ABB 2001, Nakatani 2017, Bergman and Hassan 2008). As indicated by Bergman and Jellingsø (2010), in order for a currency crisis to occur, the wealth curve must intersect the vertical axis below the IPLM curve so that point D corresponds to the equilibrium defined as the intersection of IPLM and wealth curves. This implies the following condition derived from (1), (4) and (9):

$$E_1\big|_{W,y_2=0} = \frac{P_1 f(H_1,a_1) - l_1(1+i_0)P_0}{H_1(1+i^*+\eta)} < \frac{(1+i^*)(1+\eta)}{(1+i_1)} \cdot \frac{M_2^s}{M_2^d(0,i_2)} = E_1\big|_{IPLM,y_2=0} \qquad (11)$$

The equation above shows that the expectational shock measured by η will shift the wealth curve downwards while pushing the IPLM curve upwards, which will increase the likelihood of a currency crisis. The present setup implies an additional effect of the exchange rate fluctuations on the wealth curve that is omitted in the literature. Indeed, an increase in the exchange rate will reduce the imports in volume which in turn will lower the burden of foreign currency debt. This implies according to (11), a lower probability of currency crisis. However, if the cut in imports is relatively low, it is possible that the imports increase in value following the depreciation, which will push the wealth curve further to the left. In addition to its impact on output through the cost side (lower investment capacity), a reduction of the imported working capital implies a negative effect on the revenue side which reduces output in t=2. According to (11), *ceteris paribus*, a fall in imports measured in volume will move the wealth curve further left and increase the probability of a currency crisis, reinforcing the mechanism described in ABB (2001).

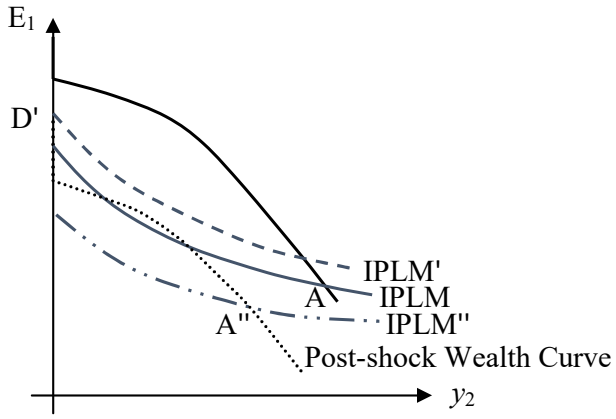
Following the increase in the exchange rate and the fall in future output, the economy moves along the wealth curve to the right of the initial equilibrium given by A. It also implies moving along the IPLM curve since the fall in output implies a lower money demand according to (1). If the condition given in (11) is validated, the shock leads to a currency crisis situation represented by point C and D starting from the good equilibrium A. However, the economy could also move to B and remain there if, as shown by ABB (2001), no one expects the bad equilibrium. At point B, output is still relatively high despite the depreciation.

3.2 The Effect of Monetary Policy

In order to avoid an eventual currency crisis that can be triggered by the exchange rate depreciation due to the expectational shock in t=1 a monetary reaction is necessary. As can be seen from (11), by raising the interest rate in t=1 the monetary authority can reduce the probability of the shock. Indeed, higher interest rate will bring about an appreciation of the exchange rate all other things being equal. This is the standard policy prescription analyzed in

ABB (2001). Note, however, that pushing the IPLM curve downwards to its pre-shock level is not sufficient to restore the pre-shock level of output since monetary policy has no effect on the wealth curve. Monetary policy must shift the IPLM curve further towards the origin in order to restore the initial equilibrium. This mechanism defined in ABB (2001) is either reinforced or mitigated in the present setup for two reasons. First, the exchange rate depreciation following the shock will reduce imports in volume, which will reduce the foreign currency debt burden if the price elasticity of imports is high enough. In this case (11) implies that the probability of a crisis is low since the leftward shift of the wealth curve following the shock is also low. In contrast, if the price elasticity of imports is low (which is more realistic) then the shock will lead to a big shift in the wealth curve. Second, the fall in the imported inputs will reduce the current output. As (11) shows, this will increase the probability of a crisis since the wealth curve will shift further to the left. Figure 2 below, illustrates the case of low price elasticity of imports.

Figure 2. Required Monetary Reaction to the Exchange Rate



In the case of a low price elasticity of imports and high productivity of imported capital, the downwards shift of the Wealth curve will be larger. Assuming that the expectational shock shifts the IPLM curve upwards to IPLM', a monetary reaction that simply shifts the IPLM curve to its initial position is not enough to avoid the currency crisis contrary to what is indicated in ABB (2001). Indeed, the increase in the interest rate must be sufficiently high to be able to push the IPLM curve down to IPLM" in order to ensure that the equilibrium passes from point A to A" instead of D'. This fact can explain why the exchange rate does not decrease despite the recent monetary tightening in Turkey. The central bank may have to increase the rate drastically in order to achieve the desired effect.

In contrast to the present setup, Nakatani (2017) reports that lowering the interest rate may be preferable if the export sector is large and the price elasticity of exports is high. However, since imports are absent in that setup, the negative aspects of an exchange rate depreciation is limited to the standard balance sheet effect. ABB (2001) also shows that monetary tightening may not be optimal when the credit multiplier depends on the nominal interest rate. However, the authors conclude that this case is unlikely since the credit multiplier is expected to depend on the real interest rate. Therefore, monetary tightening seems to be the appropriate policy as a general case. The present setup shows that countries with a large share of imported intermediate/capital goods need to increase the interest rate more than those that rely less on imports for the production process. Of course, it is possible to imagine alternative policy reactions based on other monetary policy instruments which

could enhance the effect of the interest rate similarly to Nakatani (2016) who considers the effect of the reserve requirement ratio in addition to the interest rate.

4.Conclusion

The present paper extends the currency crisis analysis of ABB (2000, 2001) and the resulting literature by studying the role of imports in the occurrence of a currency crisis. For this, the present setup incorporates imports as foreign capital and intermediate goods used in the production process by domestic firms. This assumption is especially plausible for emerging market countries such as Turkey and Malaysia. The results show that the reliance on foreign inputs can increase the probability of a currency crisis following a financial shock. Indeed, a currency depreciation increases the cost of production in the presence of foreign inputs, which is similar to the standard balance sheet effect. In addition, the present setup provides a second channel through which a currency depreciation affects the output: a fall in imports (due to the exchange rate increase) lowers the capital available for production and implies thereby a direct negative effect on output.

By increasing the interest rate, the central bank can avoid the crisis. However, the effect of the exchange rate on the imports requires a more aggressive monetary reaction compared to the case without imports as inputs. This may explain why Turkey and Argentina continue to experience currency depreciations despite the monetary reaction. The limited effectiveness of the interest rate response may also result from an increase in the risk premium due to a lack of the monetary policy credibility. Introducing this idea into the present setup requires an endogenous risk premium. Another interesting extension would be to assume that imports depend not only on the exchange rate but also on income. Indeed, it seems that the income elasticity of imports is high in emerging market countries.

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