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The Effects of Financial and Real Shocks, Structural Vulnerability and Monetary Policy on Exchange Rates from the Perspective of Currency Crises Models*

Ryota Nakatani[1]

Abstract

Is there any factor that is not analyzed in the literature but is important for preventing currency crises? What kind of shock is important as a trigger of a currency crisis? Given the same shock, how does the impact of a currency crisis differ across countries depending on the degree of each country's structural vulnerability? To answer these questions, this paper analyzes currency crises both theoretically and empirically.

In the theoretical part, I argue that exports are an important factor to prevent currency crises that has not been frequently analyzed in the existing theoretical literature. Using the third generation model of currency crises, I derive a simple and intuitive formula that captures an economy's structural vulnerability characterized by the elasticity of exports and repayments for foreign currency denominated debt. I graphically show that the possibility of currency crisis equilibrium depends on this structural vulnerability.

In the empirical part, I use unbalanced panel data comprising 51 emerging countries from 1980 to 2011. The results obtained here are consistent with the prediction of the theoretical models. First, I found that monetary tightening by the central banks can have a significant effect on exchange rates. Second, I found that both productivity shocks in the real sector and shocks to a country's risk premium in the financial markets affect exchange rate dynamics, while productivity shocks appeared more quantitatively important during the Asian currency crisis. Finally, the structural vulnerability of the country plays a statistically significant role for propagating the effects of the shock.

Keywords: Currency Crisis; Foreign Currency Debt; Exports; Productivity Shock; Risk Premium; Monetary Policy; Elasticity

JEL Classification: E22; E4; E5; F1; F3; F4; G15; G2; O43

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1. Introduction

The literature on currency crises has analyzed causes and mechanisms of how the crises occur and what happens when countries experience the crises. Little theoretical literature has focused on factors that prevent currency crises other than policy responses. Is there any factor that is not analyzed in the literature but is important for preventing currency crises?

To answer this question, in this paper, I initially discuss exports and show that they are a potentially important factor for the prevention of a currency crisis. I introduce exports into the third generation models of currency crises that were originally developed by Aghion, Bacchetta and Banerjee (2000, 2001, 2004) (the ABB model), and derive an intuitive and important formula that captures the structural vulnerability of the economy. I also conduct graphical equilibrium analysis to explore the roles of exports in currency crises.

I also conduct an empirical analysis to test the hypothesis obtained in the theoretical part. Theoretical currency crisis models basically predict that central banks should raise the policy interest rate to prevent currency crises (Aghion, Bacchetta and Banerjee 2001; Lahiri and Végh 2007). The empirical literature has examined the effectiveness of this interest rate defense (Kraay 2003; Goderis and Ioannidou 2008; Eijffinger and Goderis 2008; Grier and Lin 2010; Eijffinger and Karataş 2012). The empirical literature on currency crises has also searched for the underlying factors that can lead to the crises (e.g., Edison 2003; Berg, Borensztein and Pattillo 2005; Bussière and Fratzscher 2006; Candelon, Domitrescu and Hurlin 2012; Comelli 2014).

However, the literature has not answered the following questions. What kind of shock is important as a trigger of a currency crisis? Is it a productivity shock or a shock that occurred in the financial market, e.g., a shift in each country's risk premium? My contributions to the existing literature answer these questions empirically. To date, the existing empirical literature has not explicitly included the shocks that trigger currency crises in the explanatory variables, but instead it has included them in the error term. Exclusion of these shocks from independent variables can generate an omitted variable bias on the estimated coefficients, especially when we want to analyze the effects of monetary policy response. For this reason, based on the theoretical models of currency crises, I analyze the effects of different types of shocks that can trigger currency crises. These shocks include productivity shocks in the real sector and shocks that occur in the financial markets, i.e., shocks to each country's risk premium. In addition, I analyze the effects of monetary policy shocks (i.e., changes in the policy interest rate) on exchange rates. In terms of data and methodology, I use unbalanced panel data comprising 51 emerging countries from 1980 to 2011, and apply instrumental variable methods with the generalized method of moments and the two-stage least squares estimators to control the endogeneity of the monetary policy response. In addition, using my results, I discuss the empirical evidence for several currency crises that occurred in emerging countries to evaluate quantitative impacts of each shock. My results suggest that both productivity shocks in the real sector and shocks to a country's risk premium in the financial markets affect exchange rate dynamics, while productivity shocks appeared more quantitatively important during the Asian currency crisis. Furthermore, the results suggest that changes in the central bank's policy interest rate can have a significant effect on exchange rates.

This paper consists of both theoretical and empirical parts, and is organized as follows. The theoretical part of this paper includes a review of the literature, in which I briefly summarize and discuss the relevant literature on currency crises models and compelling reasons for my choice of specific model for my analysis. I then discuss the importance of exports as addressed in the empirical literature. Furthermore, I develop a theoretical model to analyze the role of exports graphically. In the empirical part, I begin with my motivation for the empirical research and a literature review. Then, I explain the methodology and data used in this analysis. Next, I show my empirical results and conduct a robustness check for the results. Moreover, using my results, I discuss the empirical evidence for several currency crises that occurred in developing countries. In the final part, I conclude this paper.

2. Literature and Motivation for Theoretical Analysis

2.1. Three Generations of Currency Crises Models

A currency crisis can be defined as a sudden devaluation of a currency that often ends in a speculative attack in the foreign exchange market. There have been three 'generations' of models of currency crises (Glick and Hutchison 2013). The first generation models focus on inconsistencies between domestic macroeconomic policies, such as a fixed exchange rate regime and a persistent government budget deficit that eventually must be monetized (Krugman 1979; Flood and Garber 1984).

These models describe a government that tries to maintain a pegged exchange rate system, but is subject to a constant loss of international reserves, due to the need to monetize government budget deficits. These two characteristics of the policy are inconsistent with each other, and provoke an eventual speculative attack on the reserves of the central bank. Thus, in the first generation models, the key factor is the government activity and the models predict that the fixed exchange rate regime must collapse. In second generation models, policy makers weigh the cost and benefits of defending the currency and may abandon an exchange rate target. In these models, the government maximizes an explicit objective function; i.e., Obstfeld (1996) developed models in which the central bank minimizes a quadratic loss function that depends on inflation and on the deviation of output from its natural rate. In these models, an interaction between investors' expectations and actual policy outcomes can lead to self-fulfilling crises. The third generation models focus on how distortions in financial markets and banking systems can lead to currency crises. The basic idea is that banks and firms in emerging countries have currency mismatches on their balance sheets since they borrow in foreign currency and lend or invest in local currency. Aghion, Bacchetta and Banerjee (2000, 2001) analyzed the effects of credit constraints on currency crises by focusing on private foreign currency denominated debt. They explored how problems in the financial markets interact with currency crises, and how crises can have real effects on the economy. Another type of third generation models, which was developed as an application of the Diamond-Dybvig (1983) model, include: Chang and Velasco (2001), who focused on how distortions in the banking system can lead to currency crises; and Caballero and Krishnamurthy (2001), who developed a model in which firms finance risky long-term projects with short-term domestic and foreign debts and face a liquidity problem caused by uncertainty about future production and limited amounts of internationally accepted collateral. The other type of third generation models is based on the idea that government guarantees to the banking system can generate moral hazard problems that lead to crises (McKinnon and Pill 1996; Corsetti, Pesenti and Roubini 1999a; Dooley 2000; Burnside, Eichenbaum and Rebelo 2001; Dekle and Kletzer 2002).

2.2. Aghion-Bacchetta-Banerjee Model

In this paper, I extend the third generation model that focuses on credit constraints of firms that was originally developed by Aghion, Bacchetta and Banerjee

(2000, 2001). There are several reasons to use this model. As shown in Aghion, Bacchetta and Banerjee (2001) (the ABB model), their model can include the features of the first and the second generation models. In addition, we can also include the possibility of multiple equilibria. Moreover, by using this model and introducing exports, we can describe the tradeoff between the costs and benefits of large currency depreciation for firms in the open economy. Furthermore, with this type of model, we can have short-run nominal rigidity, which is supported by empirical evidence, and see how financial friction can cause currency crises. Finally, during the recent global financial crisis in 2008-09, central bankers were concerned with the possibility of currency crises in some countries. Those concerns were strong especially for emerging European countries that had huge foreign debt in their economies. This ABB model illustrates the situation of those emerging countries accurately.

Recent extention of the ABB model was developed by Bergman and Jellingsø (2010), who examined the medium term effects of interest rate defense in the ABB model. Their finding was that even though an interest rate hike is successful in preventing a currency crisis in the short-run, it may cause a currency crisis in the medium term. This is because the first period interest rate hike results in lower inflation in the medium term, which in turn raises the real interest rate and thus increases the burden of domestic debt. Therefore, in this paper, I focus on equilibrium in the short term to obtain clear theoretical and policy implications.

Taking this literature into account, in this paper, I introduce the demand side factor, export, into the ABB model. This is because empirical research suggests that exports play a key role in preventing and recovering from currency crises as we will see in the next section.

2.3. Importance of Exports

Theoretical models on currency crises have focused on the vulnerabilities of external exposures in order to identify causes of the crises. The first and second generation models have focused on the government budget deficit that can be supported by the capital inflows of foreign investors. The third generation models have focused on the foreign currency denominated debt of private firms, external funding of commercial banks and moral hazard problems triggered by the government grantees.

However, there are few studies in the literature that examine the opposite side of the story. What is the factor that benefits from a large depreciation of currency and deters currency crises? Empirical studies have found that exports are a potentially important factor in this perspective. The relevance of exports has been considered mainly in empirical analysis characterized by few linkages with theoretical models. Therefore, this paper analyzes the role of exports during currency crises from the theoretical point of view.[2]

Most empirical papers present evidence for the importance of exports in the context of currency crises.[3] Gupta, Mishra and Sahay (2007) analyzed the behavior of output during currency crises and found that growth of exports and trade openness are statistically positively associated with output growth. Deb (2006) found that a faster export growth rate is a key factor for recovery from currency crises. Eijffinger and Goderis (2008) found evidence that higher exports appreciate the exchange rate.

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[2] Although depreciation of currency may induce consumers to move from foreign to domestic goods, I do not analyze the effect of imports. This is because the empirical literature has showed that exports are more important than imports for currency crises (Kaminsky, Lizondo and Reinhart 1998).

[3] Another area of the literature has empirically compared the financial linkages and trade linkages of currency crises and studied the relative importance of those linkages. Eichengreen and Rose (1999), Glick and Rose (1999), Forbes (2002) and Haile and Pozo (2008) have found evidence to support the hypothesis that currency crises spread from one country to another because of trade linkages. On the other hand, Kaminsky and Reinhart (2000), Van Rijckeghem and Weder (2001) and Caramazza, Ricci and Salgado (2004) found that financial linkages play an important role in the propagation of currency crises. However, the purpose of this paper is to analyze theoretically the role of exports in the context of a country's structural vulnerability to currency crises and not the contagion of crises.

Desai, Foley and Forbes (2008) used firm-level data to analyze the response of multinational and local firms to currency crises. They found that U.S. multinational affiliates increased sales, assets and investment significantly more than local firms during and subsequent to currency depreciations. The results suggest that multinational affiliates expanded economic activity during currency crises when most local firms were financially constrained. Using country-level panel data, Cavallo and Frankel (2008) found robust empirical evidence that economies that trade more with other countries are less vulnerable to sudden stops and to currency crises. Bleakley and Cowan (2008) used over 450 firms in Latin American countries and found that the negative balance sheet effects of a depreciation on firms holding dollar debt are more than offset by higher earnings caused by the competitiveness effect (i.e., increased exports) of depreciation.

Despite this empirical evidence for the importance of exports, the export sector is not analyzed frequently in theoretical currency crises models.[4] We introduce exports into the third generation model in which firms have foreign currency denominated debt that was developed by the Aghion, Bacchetta and Banerjee (2001).

[4] One exception is Céspedes, Chang and Velasco (2004). However, they assumed that the value of home exports is an exogenous constant variable.

A compelling reason to use this model, in addition to the advantages described in detail in the previous section, is as follows. Since the main cause of currency crises is a foreign currency debt of firms in the ABB model, we can easily see the tradeoff of a large depreciation of currency for the firms by introducing exports into the model. In other words, currency depreciation has both positive and negative effects on the firm's retained earnings because it will increase sales to overseas countries by stimulating exports, whereas it will reduce the cash flow of firms by increasing the burden of foreign currency denominated debt. Thus, the ABB model is the best model for the analysis of exports.

3. Model Analysis

I introduce exports into the ABB model in this section. Exports are among potentially important factors when the economy faces currency crises. In the original ABB paper, foreign currency denominated debt was the sole key factor in currency crises. Therefore in the original model, depreciation of the domestic currency has only negative effects on the economy through deteriorated balance sheets of the private firms. By contrast, in my model, depreciation of the exchange rate has both positive and negative effects on the real economy because it increases exports on one hand but reduces retained earnings via increased debt repayments for the foreign debt on the other hand. In this way, we can see the tradeoff between exports and foreign currency denominated debt under the circumstance of exchange rate depreciation. I derive the simple formula that states the condition for the occurrence of currency crises.

3.1. Wealth Curve

We assume that a representative firm produces one type of goods at the domestic price P_t. Those goods are sold to both domestic and overseas consumers. The output is produced using capital and the production function is written as

$$y_t = f(k_t). \tag{1}$$

We introduce exports into the firm's profit function. Exports in foreign currency[5] are assumed to be the function of real exchange rates and foreign demand.

$$x_t\left(E_t P_t^* / P_t , y_t^*\right) \tag{2}$$

where E_t is the flexible nominal exchange rate (the price of foreign currency in

[5] Cook and Devereux (2006) presented evidence of foreign currency pricing of exports in Asian countries.

terms of domestic currency) and y_t^* is a foreign demand. For simplicity, we assume that the price level of foreign countries (P_t^*) is normalized to 1. Then the export can be written as a function of the real exchange rates in the following way.

$$x_t\left(E_t/P_t\,, y_t^*\right) \tag{3}$$

Note that exports are the increasing function of real exchange rate depreciation and foreign demand, where higher E_t/P_t means real exchange rate depreciation.

$$dx_t/d\left(E_t/P_t\right) > 0\,,\quad dx_t/dy_t^* > 0 \tag{4}$$

In order to concentrate on the role of exports, which is found in the empirical literature, we don't consider the effects of the real exchange rate on domestic consumption here but it is worth mention. In the presence of imported consumption goods, a depreciation of domestic currency will induce domestic consumers to move from foreign to domestic goods because of the import price inflation. Thus, a large currency depreciation will also increase the demand for domestic consumption goods.

The assumption about price rigidity is the same as Aghion, Bacchetta and Banerjee (2001). Purchasing Power Parity (PPP) is assumed to hold at the beginning of period 1. Following an unanticipated shock, there are deviations from PPP ($P_1 \neq E_1$) that are corrected in period 2 ($P_2 = E_2$). This shock may be real – such as a change in productivity – or it may be a shift in expectations.

The timing of events can be summarized as follows. In period 1, the price P_1 is preset and the firm invests. Then, an unanticipated shock occurs; this corresponds to a realization of the nominal exchange rate E_1. The shock is accompanied by an adjustment in the monetary policy set by the central bank. Subsequently, output and profits in period 1 are generated and the firm's debts are repaid. Finally, a fraction of net retained earnings after debt repayment is saved for investment in period 2.

Assuming that the working capital k_t fully depreciates within one period, the firm maximizes its real profit net of loan repayments

$$\Pi_t = f(k_t) - l_t(1+i_{t-1})P_{t-1}/P_t - l_t^*(1+i^*)E_t/P_t \tag{5}$$

where l_t is an amount of domestic currency loan, l_t^* is that of loan denominated in foreign currency, and i_t and i^* are interest rates on domestic and foreign currency loans, respectively. We assume that the interest rate on foreign currency loan is constant over time.

We assume that whenever profit is positive, the firm retains a proportion $(1-\alpha)$ of profit and uses it to finance its future investment.[6] Thus, the current retained

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[6] The firm will always save a constant fraction of the profits under the assumption of the

earnings available for capital in the next period are[7]

$$W_{t+1} = (1-\alpha)\Pi_t \, . \tag{6}$$

Due to the credit constraint, the firm can at most borrow an amount $L_t = l_t + l_t^*$ proportional to its current real wealth W_t

$$L_t \leq \mu W_t \tag{7}$$

where μ is a credit multiplier. The rationale for the constant credit multiplier is derived from moral hazard considerations (Aghion, Banerjee and Piketty 1999).[8] We assume that this credit constraint is binding. Since capital fully depreciates within one period, investment in the current period equals the capital in the next period. Under the credit constraint, this equation of motion for capital can be written as follows:

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

Then, the output is characterized by the production function

$$y_{t+1} = f\left(k_{t+1}\right) = f\left((1+\mu)(1-\alpha)\Pi_t\right). \tag{9}$$

The equilibrium condition in the goods market suggests that the sum of domestic

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logarithmic preference (Aghion, Bacchetta and Banerjee 2004).

[7] We assume that the marginal product of capital exceeds domestic and foreign interest rates so that constraint (6) is binding.

[8] See Aghion, Bacchetta and Banerjee (2001) for the case in which the credit multiplier depends upon real or nominal interest rates.

(c_t) and export sales equals total production in the economy.[9]

$$c_t + x_t\left(E_t/P_t, y_t^*\right)E_t/P_t = f\left(k_t\right) \tag{10}$$

Using this condition, the output in period 2 can be written as

$$y_2 = f\left((1+\mu)(1-\alpha)\left\{c_1 + \frac{E_1}{P_1}x_t\left(\frac{E_1}{P_1}, y_1^*\right) - (1+i_0)\frac{P_0}{P_1}l_1 - \left(1+i^*\right)\frac{E_1}{P_1}l_1^*\right\}\right). \tag{11}$$

This is called the "Wealth curve"; it illustrates the relationship between the exchange rate and future output as originally analyzed by Aghion, Bacchetta and Banerjee (2001).[10] This curve is characterized by the credit multiplier effect times the wealth of the firm (i.e., savings) where the wealth is calculated as saving rate times the firm's profit. The profit is defined as the sum of domestic and export sales minus the sum of domestic and foreign currency denominated debt repayments.[11] Taking a derivative of the exchange rate with respect to output, we can get the slope of the Wealth curve.

$$\left.\frac{dE_1}{dy_2}\right|_{y_2>0} = \frac{P_1}{(1+\mu)(1-\alpha)\left\{x_1 + \frac{E_1 x_{1E_1/P_1}}{P_1} - \left(1+i^*\right)l_1^*\right\}}\frac{1}{f_{k_2}} \gtreqless 0 \tag{12}$$

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9 See the second example in Appendix A for the model in which the firm determines consumption.

10 The overall balance of payments account always balances, i.e., $\left(1+i^*\right)l_1^* = x_1 + l_2^*$. We assume that the country starts out with large foreign liabilities.

11 Although we can think of export credit as another channel that constrains production, this can be eliminated by export credit insurance (Auboin and Engemann 2013).

Using elasticity of export goods with respect to real exchange rate $\zeta = \frac{x_{1E_1/P_1} E_1/P_1}{x_1}$,

the slope of the Wealth curve can be simplified to

$$\left.\frac{dE_1}{dy_2}\right|_{y_2>0} = \frac{P_1}{(1+\mu)(1-\alpha)\left\{(1+\zeta)x_1 - (1+i^*)l_1^*\right\}} \frac{1}{f_{k_2}} \gtreqless 0. \tag{13}$$

This equation suggests that the term in the curly brackets in the denominator determines the slope of the Wealth curve. The condition suggests that if the foreign currency denominated debt (l_1^*) is large, the Wealth curve is downward sloping.

$$(1+\zeta)x_1 < (1+i^*)l_1^* \Rightarrow \left.\frac{dE_1}{dy_2}\right|_{y_2>0} < 0 \tag{14}$$

By contrast, if an export (x_1) is large or an elasticity of export demand (ζ) is large, the Wealth curve is upward sloping.

$$(1+\zeta)x_1 > (1+i^*)l_1^* \Rightarrow \left.\frac{dE_1}{dy_2}\right|_{y_2>0} > 0 \tag{15}$$

The intuition behind this result is straightforward. When the economy has a large foreign currency denominated debt, the real exchange rate depreciation increases the debt burden for the firm and this reduces investment, resulting in lower output in the second period. In contrast, if the economy has a large export industry, a currency depreciation increases the sales and profits of exporting firms and their investments.

Therefore, output in the next period increases. In Appendix A, two examples of export function are analyzed.

3.2. IPLM (Interest-Parity-LM) Curve

The other curve that is analyzed in the ABB model is the IPLM curve, which is mainly determined by the policy of the central bank. The IPLM curve is the same as in the original model, and this is derived by the assumption about PPP, the interest parity condition and money market equilibrium. The IPLM curve provides the relationship between E_1 and y_2:

$$E_1 = \frac{1+i^*}{1+i_1} \frac{M_2^S}{m^D(y_2, i_2)} \tag{16}$$

where M_2^S is the nominal money supply in period 2 and a real money demand $m^D(y_2, i_2)$ is a standard function of output and the interest rate. Bergman and Jellingsø (2010) showed that the first-order derivative of the IPLM curve is

$$\frac{dE_1}{dy_2} = -\frac{1+i^*}{1+i_1} \frac{M_2^S}{\left[m^D(y_2, i_2)\right]^2} m_{y_2}^D < 0 \,. \tag{17}$$

Thus, the slope of the IPLM curve is negative. An increase in future output raises the future demand for domestic real money balances, which results in a future appreciation of the domestic currency. This anticipation of a future appreciation increases the attractiveness of holding the currency today, leading to an appreciation of the exchange rate. We can easily see that the slope of the IPLM curve is steep when the money supply is large and domestic interest rate is low.

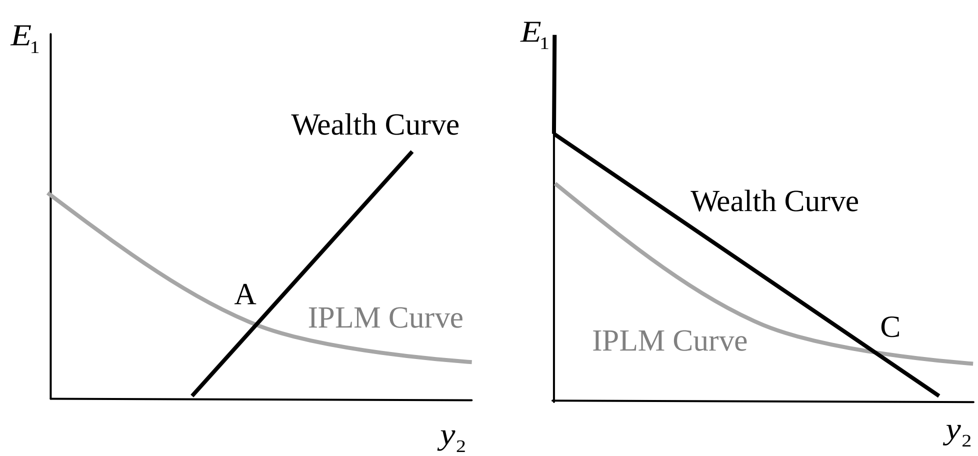
3.3. Graphical Equilibrium Analysis

The equilibrium of the model is defined by the intersection of the IPLM and the Wealth curves.[12] The first three figures show the relationship between exports and the occurrence of currency crises.

Figure 1: Role of Exports in the Context of Currency Crises:

Before the Shock

Figure 1.1: Large Export Figure 1.2: Large Foreign Debt



[12] Here I use an example of the linear Wealth curve (see Example 1 in Appendix A for the nonlinear case).

Figure 2: Role of Exports in the Context of Currency Crises:

After a Negative Productivity Shock or a Tightening of the Credit Market

Figure 2.1: Large Export   Figure 2.2: Large Foreign Debt

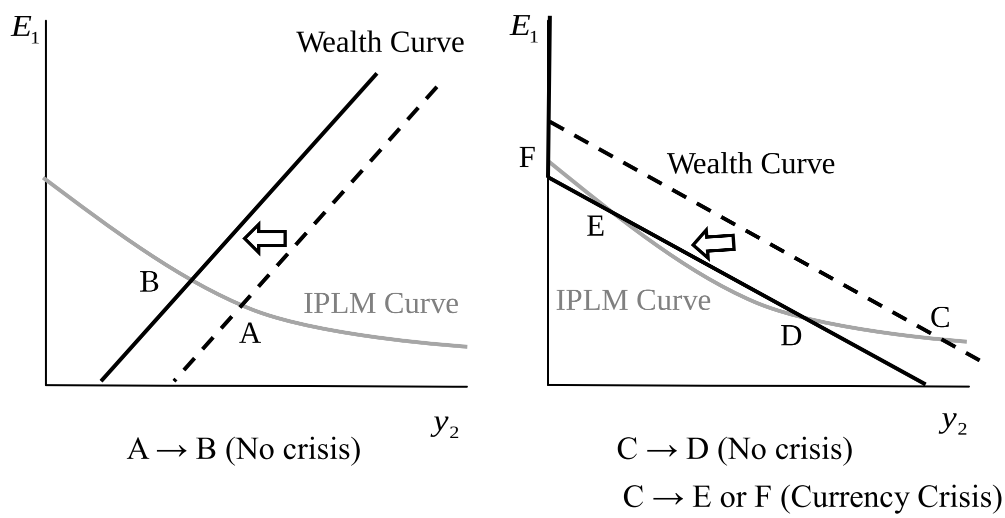


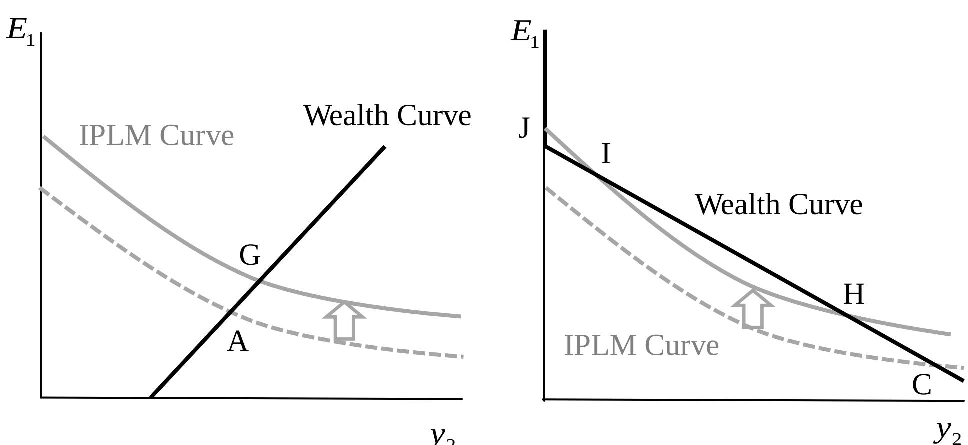
Figure 1.1 shows the case where an effect from export is greater than the repayments for foreign debt, $(1+\zeta)x_1 > (1+i^*)l_1^*$. When a negative productivity shock (a shift in the $f(\cdot)$ function) or a tightening of the credit market (a shift in μ) occurs, the Wealth curve shifts to the left (Figure 2.1). In this case, the exchange rate depreciates but the country can avoid crises equilibria because earnings from the export sector are so large that they can offset the negative effect that comes from the credit constraint of the foreign currency denominated debt.

By contrast, Figure 1.2 illustrates the economy in which the effects from the foreign currency denominated debt are greater than those from the export, $(1+\zeta)x_1 < (1+i^*)l_1^*$, which means that the slope of the Wealth curve is negative. Note that the Wealth curve includes an upward segment of the vertical axis because the firm produces nothing when profit is negative due to a huge foreign debt repayment caused by the large currency depreciation. In this case, multiple equilibria are possible under the shock (Figure 2.2). Thus, we can see the tradeoff between the benefits of currency depreciation and detriments from foreign debt using a simple formula characterized by the elasticity of exports and repayments for foreign debt.

Figure 3: Role of Exports in the Context of Currency Crises:

After an Expectational Shock

Figure 3.1: Large Export | Figure 3.2: Large Foreign Debt



A → G (No crisis)

C → H (No crisis)

C → I or J (Currency Crisis)

Next, we analyze the case in which the economy is hit by an unanticipated expectational shock in financial markets (Figure 3). In this case, the IPLM curve can be written as

$$E_1 = \frac{1+i^*}{1+i_1} \frac{M_2^S}{m^D(y_2, i_2)} + \eta \tag{18}$$

where η is the foreign exchange risk premium after the shock. This increase in risk shifts the IPLM curve upwards. Starting from a good equilibrium "A" in Figure 3.1, currency depreciation will increase the output via boosted exports to the new equilibrium "G" when the economy has a large export sector. In contrast, as shown in Figure 3.2, if the effects from foreign currency debt dominate, starting from a good equilibrium "C", this upward shift in the IPLM curve again leads to a multiple equilibria situation that contains currency crisis equilibrium "J". Note that this possibility of a currency crisis is reinforced by the fact that an increase in the foreign exchange premium raises the interest rate on foreign borrowing, which in turn will move the Wealth curve downward.

4. Literature and Motivation for Empirical Analysis

Theoretical currency crisis models basically predict that central banks should raise the policy interest rate to prevent currency crises. The empirical literature has analyzed the effectiveness of the monetary policy response in defending the domestic currency following a currency crisis. The first analysis was conducted by Kraay (2003) and he failed to find any statistically significant effect of monetary policy on the exchange rate. However, he used central bank discount rates to measure the tightness of monetary policies and it is known that discount rates tend to remain flat and do not reflect monetary policies well in some countries. Improving the measure of monetary policy variable, Goderis and Ioannidou (2008) found that raising interest rates lowers the probability of a speculative attack especially for the economies with low levels of short-term corporate debt. Furthermore, Eijffinger and Goderis (2008) indicated that raising the interest rate is more effective in countries with higher external debt. Their hypothesis was that monetary authorities in countries with high external debts have stronger incentives to support their currencies since those debts increase the costs of depreciation of currencies due to its effects on corporate balance sheets, and these incentives contribute to the credibility of higher interest rates.

Taking account of the stances of exchange rate policy, Grier and Lin (2010) pointed out that raising interest rates significantly reduces the probability of speculative attacks in hard-pegging countries, but increases it in soft-pegging countries. Recently, Eijffinger and Karataş (2012) investigated the different effects of monetary policy between advanced and emerging economies. They found that in advanced economies indicators of the second generation models, such as overvalued real exchange rates, can be important factors and tight monetary policy is effective. In contrast, they documented the fact that emerging economies suffer from high levels of short-term external debt and hence the third generation model weaknesses play a major role, suggesting that the higher indebtedness of the private sector decreases the effectiveness of the monetary policy in these economies since it may increase the fragility of the firms.[13]

However, the literature has not answered the following questions. What kind of shock is important as a trigger of a currency crisis? Is it a productivity shock or a shock that occurred in the financial market, e.g., a shift in each country's risk premium? Given the same shock, how does the impact of a currency crisis differ

[13] In relation to the ABB model, this evidence corresponds to the case in which a high nominal interest rate lowers the credit multiplier (Aghion, Bacchetta, and Banerjee 2000).

across countries depending on the degree of each country's structural vulnerability? In other words, can the shock be propagated by the country's vulnerability that is characterized by its economy's structure? My contributions to the existing literature are to answer these questions empirically. Based on the theoretical model that I developed in this paper, my main contribution is to analyze the effects of different types of shocks that lead to currency crises. In particular, I construct a new variable that captures each country's structural vulnerability in relation to a currency crisis; this new variable essentially determines the slope of the Wealth curve analyzed in the ABB model that is developed further in the theoretical part of this paper. The slope of the Wealth curve is determined by two important factors: exports and foreign debt. The empirical literature on currency crises has treated these two variables in various different ways. For exports, the literature used export growth rates (Berg and Pattillo 1999ab; Osband and Van Rijckeghem 2000; Glick and Hutchison 2001; Edison 2003; Collins 2003; Tudela 2004; Berg, Borensztein, and Pattillo 2005; Beckmann, Menkhoff, and Sawischlewski 2006; Kaminsky 2006; Bussière and Fratzscher 2006; Gupta, Mishra, and Sahay 2007; Eijffinger and Goderis 2008; Goderis and Ioannidou 2008; De Vincente, Álvarez, Pérez, and Caso 2008; van den Berg, Candelon, and

Urbain 2008; Licchetta 2011; Candelon, Domitrescu, and Hurlin 2012; Arduini, De Arcangelis and Del Bello), the level of exports (Kaminsky, Lizondo, and Reinhart 1998; Kaminsky and Reinhart 1999; Inoue and Rossi 2008) or the ratio of exports to GDP (Hong and Tornell 2005; Frankel and Saravelos 2012). For foreign debt, the literature used the ratio of foreign debt to GDP (Frankel and Rose 1996; Milesi-Ferretti and Razin 2000; Frankel 2005; Eijffinger and Goderis 2008; Cavallo and Frankel 2008; Hale and Arteta 2009; Catão and Milesi-Ferretti 2014), the ratio of foreign debt to reserves (Radelet and Sachs 1998; Osband and Van Rijckeghem 2000; Ghosh and Ghosh 2003; Eijffinger and Karataş 2012; Ari 2012; Comelli 2014), or the ratio of foreign debt to exports (Frankel and Saravelos 2012; Agosin and Huaita 2012; Furceri, Guichard, and Rusticelli 2012). However, these publications were not necessarily based on a specific theoretical model and they often included many explanatory variables, which were related to various types of currency crises models, to predict the probability of currency crises.

My analysis here is different from prior publications in several ways. First, most of my explanatory variables are derived from a specific type of theoretical model, i.e., the ABB model, and hence the specification of the model that I estimate is based on strong theoretical underpinnings. To my knowledge, the literature on currency crises has assumed that given the same size of shock, the effects on currency crises are the same across countries. However, the theoretical model that I developed in this paper shows that the effects of the shock on currency crisis differ across countries even if the country is hit by the same size of shock. Specifically, the effect of a shock on the currency depends on the degree of each country's structural vulnerability, which is captured by the relative size of exports and foreign debt.

Second, although the existing literature has included various factors that can lead to a currency crisis, it did not explicitly include the shock, such as a productivity shock or a shock to the country's risk premium, that triggers the crisis. In other words, shocks are included in the error term in the literature. Exclusion of shocks from independent variables can cause an omitted variable bias on the estimated coefficients. By including the shocks explicitly in explanatory variables, we can analyze the effect of each shock on a currency crisis and identify what kind of shock can trigger the crisis. In this paper I analyze two types of shocks that trigger currency crises in the ABB model: one is the productivity shock in the real sector and the other is the shock to the country's risk premium in the financial markets. As far as I know, this is the first paper that analyzes the effects of these shocks on currency crises using panel data. Although large declines in productivity had been observed during currency crises by researchers (e.g., Brandt, Dressler and Quintin 2004; Meza and Quintin 2007), the literature has not analyzed the direct link between productivity shock and currency crises since it focused on the effects of productivity shock on output (see a further discussion of the literature and my results in section 8, where I investigate several major currency crises episodes). As for the shock to the risk premium, the literature has used an interest rate differential between the rates for domestic and foreign countries (Kaminsky, Lizondo and Reinhart 1998; Kaminsky and Reinhart 1999; Berg and Pattillo 1999ab; Edison 2003; Licchetta 2011), but this is not a shock and it only compared the relationship between the spread and exchange rates. Since various factors, e.g., monetary policy, development of banking system, etc., can affect this premium, I identify the shock to the premium by controlling these factors.

Thus, key innovations of this paper are two-fold: (1) the construction of the variable that captures the vulnerability of each country's economic structure, which is an important factor for the propagation mechanism of the shock during the currency crisis, and (2) the provision of empirical evidence that evaluates the size of contribution of each shock and each factor that triggers, leads to and propagates the currency crises.

In the next section, I begin by explaining how the measure of the slope of the Wealth curve used in this study represents the tradeoff between benefits of exports and costs of foreign debt under a currency depreciation and how we can construct this variable from data. Next, I explain the estimation techniques and show baseline empirical results.

5. Methodology and Data

5.1. Empirical Methodology

As I derived in section 3, the ABB model shows that the nominal exchange rate is determined by the intersection of two curves: the IPLM curve and the Wealth curve. The derivation and the slope of the IPLM curve are shown in Aghion, Bacchetta and Banerjee (2001) and the curvature of the IPLM curve is proved in Bergman and Jellingsø (2010). In the model part, I argued the importance of the slope of the Wealth curve that can be both positive and negative. The slope of the Wealth curve for country i in period t can be calculated as:

$$\text{Slope of the Wealth curve} \equiv \frac{\Lambda}{(1+\zeta_i)x_{i,t} - (1+i_t^*)l_{i,t}^*} \gtreqless 0. \qquad (19)$$

where ζ_i is the elasticity of exports of country i with respect to its real exchange rate, $x_{i,t}$ is the exports of country i in period t expressed in U.S. dollars, i_t^* is the international interest rate in period t, $l_{i,t}^*$ is an amount of country i's foreign debt in period t, and Λ is the remaining term. Since Λ is always positive and neither affects the sign of the slope of the Wealth curve nor can be a main focus here, we assume that this term is the same across countries. Thus, the sign of the slope depends on the denominator of equation (19), $(1+\zeta_i)x_{i,t} - (1+i_t^*)l_{i,t}^*$, which is a crucial factor for the analysis of currency crises. Scaling this term by dividing by each country's size (i.e., $GDP_{i,t}$: Gross domestic product of country i in period t), I will designate this "a determinant of the sign of the slope of the Wealth curve." The effects of the productivity shock (W-shock) depend upon both the slope of the Wealth curve and the size of the shock (Figure 4). A two-dimensional graphical explanation of the effect of the slope of the Wealth curve on the exchange rate ($E_{i,t}$) is displayed in Figure 5.

Figure 4: The Effects of W-Shock on Exchange Rates

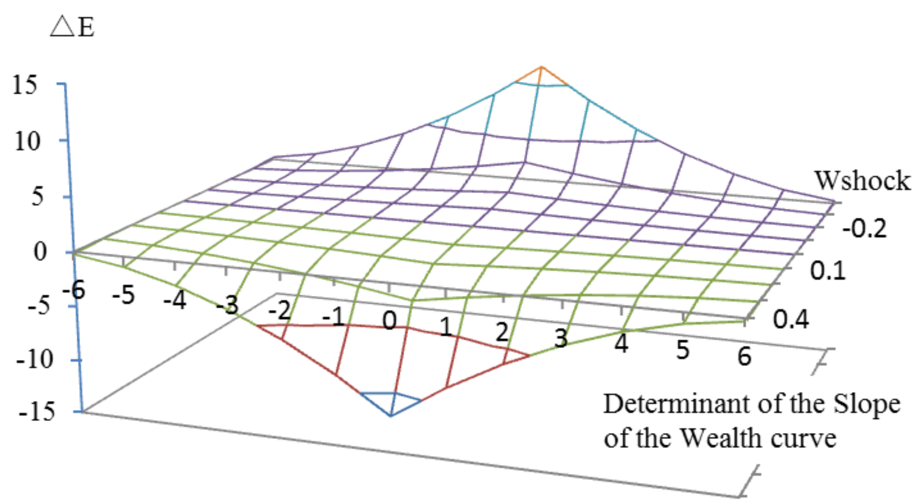
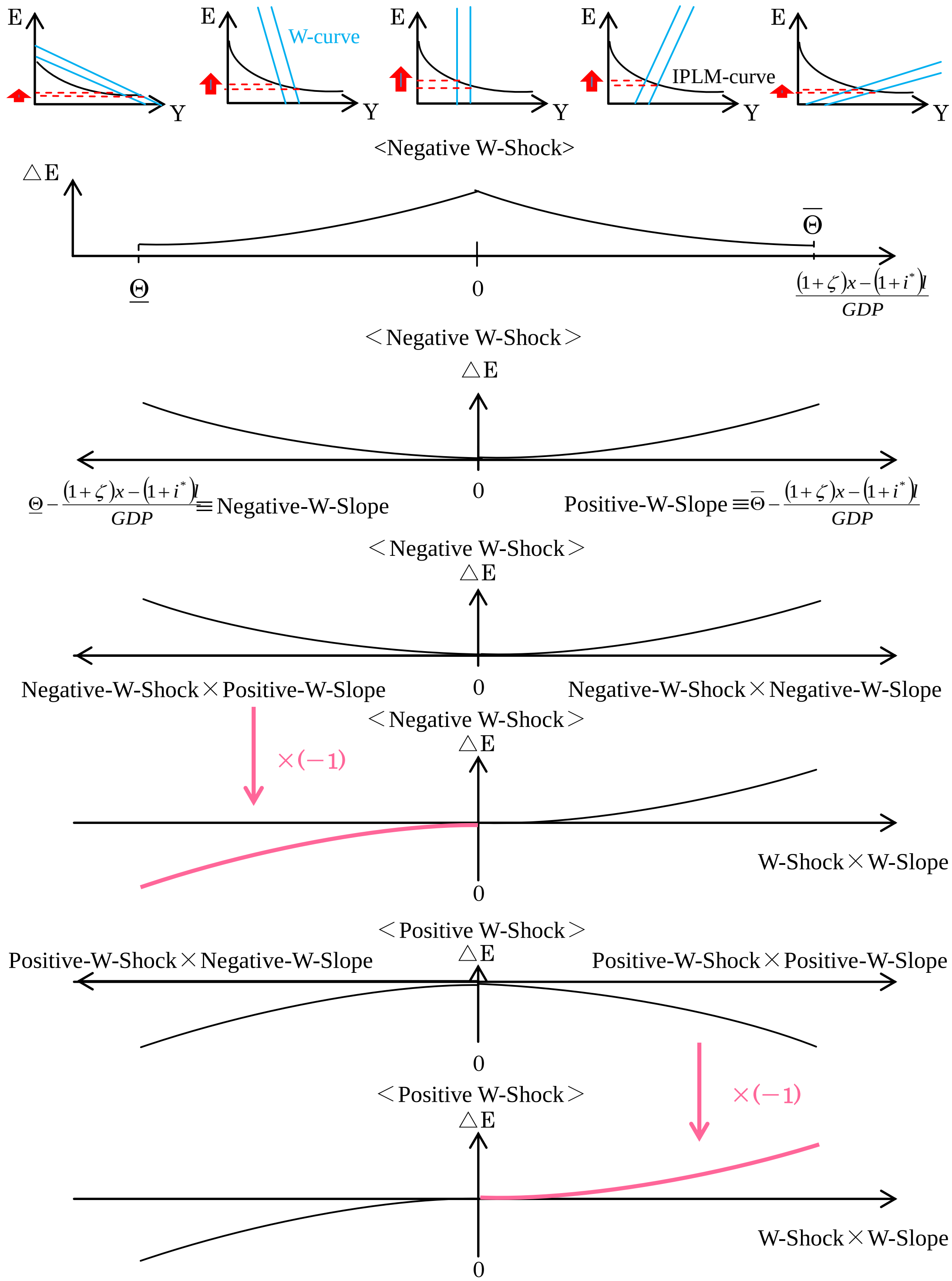


Figure 5: Graphical Explanation for the Construction of W-Slope Variable



Then I construct the following variable:

$$\text{W-}Slope_{i,t} \equiv -\overline{\Theta} + \frac{(1+\zeta_i)x_{i,t} - (1+i_t^*)l_{i,t}^*}{GDP_{i,t}} \quad \text{if} \quad \frac{(1+\zeta_i)x_{i,t} - (1+i_t^*)l_{i,t}^*}{GDP_{i,t}} \geq 0 \tag{20a}$$

$$\text{W-}Slope_{i,t} \equiv \underline{\Theta} - \frac{(1+\zeta_i)x_{i,t} - (1+i_t^*)l_{i,t}^*}{GDP_{i,t}} \quad \text{if} \quad \frac{(1+\zeta_i)x_{i,t} - (1+i_t^*)l_{i,t}^*}{GDP_{i,t}} < 0 \tag{20b}$$

where $\overline{\Theta}$ is an upper limit of the distribution of a determinant of the sign of slope and $\underline{\Theta}$ is a lower limit of the distribution. As we can see from Figure 5, by using the cross-term of this new variable (W-$Slope_{i,t}$) and the productivity shock (W-$Shock_{i,t}$), we can estimate the effect of the slope of the Wealth curve on movements of exchange rates in the face of a productivity shock.

For an empirical procedure, each country's elasticity of exports with respect to the real exchange rate can be obtained by estimating the following equation for each country (Bayoumi, Harmsen, and Turumen 2011; Thorbecke and Kato 2012; Chen, Milesi-Ferretti, and Tressel 2013):

$$\ln X_t^i = \alpha_1^i + \alpha_2^i \ln REER_t^i + \alpha_3^i \ln Demand_t^i + \upsilon_t^i \tag{21}$$

where X_t^i is the volume of exports from country i in period t, $REER_t^i$ is the real exchange rate index for country i in period t, $Demand_t^i$ is a real foreign demand variable for country i in period t, and υ_t^i is an error term. I construct the real foreign demand variable for each country by weighting the real GDPs of trading partners using the export weights. All variables are converted to constant 2005 dollars. Since both exports and real exchange rates are determined in the markets simultaneously, I employ the two-stage least squares method. Equation (21) is estimated by using X_{t-1}^{i}, $REER_{t-1}^{i}$ and $Demand_{t}^{i}$ as instruments. From this specification, I get the elasticity of exports, $\zeta_i = \alpha_2^i$.

The regression equation to determine the relation between the monetary policy and the exchange rates is defined as:

$$\Delta E_{i,t} = \beta_0 + \beta_1 \Delta E_{i,t-1} + \beta_2 \Delta i_{i,t} + \beta_3 \frac{l_{i,t}^{*}}{GDP_{i,t}} + \beta_4 IPLMshock_{i,t} + \beta_5 Wshock_{i,t}$$

$$+ \beta_6 Wshock_{i,t} Wslope_{i,t} + \beta_7 Z_{i,t} + \nu_i + \varepsilon_{i,t} \qquad (22)$$

where $\Delta E_{i,t}$: Change in the nominal exchange rate; $\Delta i_{i,t}$: Interest rate policy (Change in the policy interest rate); $\frac{l_{i,t}^{*}}{GDP_{i,t}}$: The ratio of short-term external debt to GDP; $IPLMshock_{i,t}$: Change in the country's risk premium that shifts the IPLM curve; $Wshock_{i,t}$: Productivity shock that shifts the Wealth curve; $Wshock_{i,t} Wslope_{i,t}$: Interaction term that searches the influence of the productivity shock for different levels of structural vulnerabilities; $Z_{i,t}$: Control variables; ν_i:

Country fixed effect; $\varepsilon_{i,t}$: An error term. Control variables include deviation of the GDP growth, exchange rate overvaluation and foreign reserves to imports. Note that an increase in the dependent variable means that the national currency depreciates.

From the econometrical perspective, a potential problem in this analysis arises from the possible endogeneity of monetary policy. If central banks determine policy interest rates after they observe some shocks that are neither captured by the W-shock nor the IPLM-shock, i.e., $Cov(\Delta i_{i,t}, \varepsilon_{i,t}) \neq 0$, the OLS estimation of equation (22) results in inconsistent estimators of all the β_i. To solve this problem, I use the instrumental variable (IV) method; I employ the lagged interest rate as an instrument because this variable is apparently strongly correlated with the current interest rate policy and exogenous in the sense that it is predetermined before the shock happens in the current period (see the significance of the first-stage coefficient and the first-stage F statistic in Table 4). I use the Generalized Method of Moments (GMM) in the benchmark estimation and the two-stage least squares (2SLS) estimation for the robustness check.

The IPLM-shock can be identified by the following estimation for each country:

$$\delta_t^i = \gamma_1^i + \gamma_2^i HPtrend_t^i + \gamma_3^i \Gamma_t^i + \eta_t^i \tag{23}$$

where δ_t^i: Country i's risk premium in period t (defined as the interest rate spread over the U.S. rate, i.e., $\delta_t^i \equiv i_{i,t} - i_{US,t}$)[14]; $HPtrend_t^i$: Trend estimated by the Hodrick-Prescott filter; Γ_t^i: Control variables; η_t^i: the IPLM-shock that represents investors' perception on country i's assets in period t and is estimated as an error term. Control variables include variables that capture the effects from monetary policy (i.e., the central bank's policy interest rate differential over the U.S. rate), development of the banking sector (i.e., the banks' assets to GDP), and government activity (i.e., credit to the public sector to GDP). To avoid an endogeneity problem, policy rate differentials are lagged one period.

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[14] A risk premium can be divided into the difference in nominal interest rates across currencies and the expected change in the exchange rate between these currencies. However, as Alvarez, Atkeson and Kehoe (2009) argue, in the data "the expected change in the exchange rate is roughly constant and interest differentials move approximately one-for-one with risk premia." This is because exchange rates are roughly random walks (Meese and Rogoff 1983; Cheung, Chinn and Pascual 2005), so that the expected depreciation of a currency is roughly constant and captured in the term γ_1^i as a drift. Engel and West (2005) provide the theoretical justification for the random walk of exchange rates. Under some empirically plausible circumstances (if at least one of the underlying fundamentals has a unit root and the discount factor is near one) exchange rates are near-random walks. Engel, Mark and West (2007) found that the forecasting ability of a random walk outperforms that of economic predictors when the models are estimated country by country. Rossi (2013) recently surveyed a broad range of literature up to date and concluded that "Messe and Rogoff's finding does not seem to be entirely and convincingly overturned."

5.2. Data

The sample in this study covers 51 countries from 1980 to 2011 (Table B in Appendix B). The detailed construction and sources of the data used in the analyses are presented in the Appendix C. Summary statistics for each variable are shown in Table 1.

Table 1: Summary Statistics

Variable	Mean	Std. Dev.	Min	Max
Change in Exchange Rates	16.33	65.76	-28.23	1253.84
Interest Rate Policy	-0.68	17.17	-269.74	244.35
Short-term External Debt / GDP	7.88	11.43	0.01	135.13
IPLM-Shock	0.63	31.00	-270.49	399.44
W-Shock	0.39	4.71	-27.50	25.19
W-Shock × W-Slope	2.56	31.24	-161.36	188.57
Deviation GDP Growth	0.22	4.07	-21.11	18.03
Exchange Rate Overvaluation	-0.60	10.34	-72.69	116.01
Foreign Reserves / Imports	0.52	0.47	0.001	4.04

The results of panel unit root tests are reported in Table 2 (Im, Pesaran, and Shin 2003; Maddala and Wu 1999; Choi 2001).[15] A number of panel unit root tests indicate that all variables are stationary at the 5 percent level of significance.

Table 2: Panel Unit Root Tests

Types of Tests	Im-Pesaran-Shin	Maddala-Wu	Choi
Change in Exchange Rates	-13.869***	411.363***	1119.98***
	(0.0000)	(0.0000)	(0.0000)
Interest Rate Policy	-18.028***	579.537***	1366.00***
	(0.0000)	(0.0000)	(0.0000)
Short-term External Debt / GDP	-3.532***	152.117***	233.133***
	(0.0002)	(0.0010)	(0.0000)
IPLM-Shock	-15.906***	457.861***	479.536***
	(0.0000)	(0.0000)	(0.0000)
W-Shock	-13.121***	314.268***	456.140***
	(0.0000)	(0.0000)	(0.0000)
W-Shock × W-Slope	-18.165***	427.795***	453.045***
	(0.0000)	(0.0000)	(0.0000)
Deviation GDP Growth	-19.026***	555.307***	762.489***
	(0.0000)	(0.0000)	(0.0000)
Exchange Rate Overvaluation	-35.816***	1081.59***	1498.10***
	(0.0000)	(0.0000)	(0.0000)
Foreign Reserves / Imports	-1.857**	128.325**	169.224***
	(0.0316)	(0.0296)	(0.0000)

Notes: The significance level of the variables is indicated by *(10%), **(5%) and ***(1%). P-values are in parentheses.

[15] Levin and Lin (1992) proposed another panel unit root test under the assumption of i.i.d. disturbances. However, O'Connell (1998) showed that the Levin-Lin test statistic is no longer correct when there is a cross-sectional heterogeneity. The Im-Pesaran-Shin test is generally better than the Levin-Lin test.

6. Empirical Results

In the baseline estimation, I use the Arellano-Bond (1991) GMM estimator that is designed for situations in which a dependent variable is dynamic, independent variables are not strictly exogenous, and there are fixed individual effects and heteroskedasticity and autocorrelation within individuals. Specifically, I employ the two-step GMM estimator with small sample correction as proposed by Windmeijer (2005) since it is asymptotically efficient and robust to initial conditions and the distributions of the error term.[16] The baseline estimation results are presented in Table 3. In the table, I report the test statistics for the Arellano-Bond AR(2) test of serial correlation in the error term. The Arellano-Bond AR(2) test statistics are insignificant in all specifications, suggesting the absence of serial correlation in the error terms. Note that country-specific fixed effects are eliminated by the Arellano and Bond (1991) difference GMM. The lagged dependent variable is included in the control variables to capture the dynamic effects of the exchange rates.[17] In the benchmark regression, the number of lags of each independent variable is set at two.

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[16] Windmeijer (2005) found that the efficient two-step GMM estimator outperforms somewhat the one-step GMM estimator in estimating coefficients with lower bias.

[17] When the coefficient on AR(1) term is close to unity, it is known that the system GMM estimator that is proposed by Arellano and Bovar (1995) and Blundell and Bond (1998) performs well, though this is not the case here since the coefficient is about 0.1 and far from unity.

In Table 3, column (1) is the estimation with the IPLM-shock, whereas column (2) checks the effects of the W-shock. Column (3) is the result of the estimation that includes both types of shocks. Column (4) further analyzes the regression result by including the effects of the W-Slope.

We are interested in the effectiveness of interest rate policy on exchange rates. The coefficient on interest rate policy is negative, as predicted by the theory, and statistically significant at the 1 percent level in the first three columns and at the 5 percent level in the last column. This implies that the monetary authority's interest rate hike against a currency crisis has a significant effect on exchange rates. The results suggest that a 1 percentage point increase in the policy interest rate is associated with approximately between a 0.4 and 0.5 percentage point appreciation of domestic currency in columns (1) through (3) and this magnitude decreases slightly to around a 0.3 percentage point when we incorporate the structural vulnerability term in column (4).

One of the key factors that have been analyzed in the third generation models of currency crises, including the ABB model, is a short-term external debt. The coefficients on short-term external debt to GDP ratio are always positive and statistically significant (at the 1 percent level in the first three columns and at the 5 percent level in the last column). This means that the higher external leverage is associated with a depreciation of domestic currency, which is consistent with the prediction of the third generation models of currency crises.

In the ABB model, there are two types of shocks that can trigger currency crises. One is a shock to the country's risk premium that is displayed as the IPLM-shock in this model and in the table. This shock is found to be statistically significantly associated with currency depreciation. The results show that a 1 percentage point increase in the country's risk premium is associated with around a 0.2 percentage point appreciation of domestic currency. This result is consistent with the prediction of the theoretical model since a positive shock to the country's risk premium induces currency depreciation by shifting up the IPLM curve.

The other type of shock, which is analyzed in the ABB model, is a productivity shock that is referred to as the W-shock in the table. The table shows that the productivity shock is negatively associated with the currency depreciation and this is always statistically significant at the 1 percent level. In other words, the results suggest that a positive productivity shock induces an appreciation of domestic currency, whereas a negative productivity shock induces a depreciation of the currency. This result is consistent with the prediction of the ABB model because the Wealth curve shifts to the left (right) in the presence of the negative (positive) W-shock and leads to a currency depreciation (appreciation). The coefficients obtained here suggest that a 1 percent increase in productivity is associated with approximately a 2.8 percentage point depreciation of domestic currency according to column (3).

As I demonstrated in the theoretical analysis, it is important to note that the W-shock can be propagated by each country's structural vulnerability. The variable, W-shock×W-slope, in the table captures this propagative effect. As predicted in the theory, the coefficient on this structural vulnerability variable is positive and statistically significant at the 1 percent level in column (4). Thus, we can conclude that any estimation ignoring this vulnerability effect will lead to a misspecification of the model.

The estimated results for other control variables can be discussed as follows. The deviation GDP growth, which captures the effect from the business cycles, is negative in column (1). This variable may capture the effect from productivity shock in this column where the W-shock is excluded. In fact, when we introduce the W-shock in the remaining three columns, the sign of this variable becomes positive in those specifications. This indicates that it is more likely for a currency crash to occur when the economy is in the upswing of the business cycle and enjoying the boom. Although we observed predicted signs, this variable is no longer statistically significant in columns (3) and (4). The coefficient on exchange rate overvaluation is negative and statistically significant in each column. This may due to the difficulty in measuring accurate expectations in exchange rate markets. Finally, the sign of the coefficients on the ratio of foreign reserves to imports is negative in all specifications and statistically significant at the 1 percent level in the first three columns and at the 10 percent level in the last column. This result is consistent with the prediction of the first generation models of currency crises.

Table 3: Results of Generalized Method of Moments (Arellano-Bond) Estimations

Variable	(1)	(2)	(3)	(4)
Lagged Dependent Variable	0.106***	0.107***	0.130***	0.128***
	(0.019)	(0.007)	(0.021)	(0.024)
Interest Rate Policy	-0.409***	-0.483***	-0.414***	-0.272**
	(0.013)	(0.053)	(0.031)	(0.123)
Short-term External Debt / GDP	0.205***	1.985***	2.316***	1.138**
	(0.014)	(0.066)	(0.378)	(0.537)
IPLM-Shock	0.292***		0.201***	0.184**
	(0.010)		(0.011)	(0.078)
W-Shock		-2.872***	-2.783***	-18.717***
		(0.234)	(0.454)	(4.937)
W-Shock × W-Slope				2.491***
				(0.724)
Deviation GDP Growth	-1.765***	0.452**	0.431	0.018
	(0.055)	(0.184)	(0.462)	(0.260)
Exchange Rate Overvaluation	-0.723***	-1.726***	-1.606***	-1.666***
	(0.011)	(0.054)	(0.139)	(0.149)
Foreign Reserves / Imports	-11.262***	-24.411***	-18.132***	-7.065*
	(1.625)	(4.044)	(5.284)	(3.819)
Number of Countries	48	35	34	34
Number of Observations	735	616	507	507
Arellano-Bond Test for AR(2) (p-value)	0.697	0.207	0.297	0.127
Hansen test (p-value)	1.000	1.000	1.000	1.000

Notes: The significance level of the variables is indicated by *(10%), **(5%) and ***(1%). Cluster-robust standard errors are in parentheses.

One problem that we encounter when we use the GMM estimators for finite samples can be due to too many instruments generated by the moment conditions. As found in Bowsher (2002), the standard GMM tests of overidentifying restrictions associated with Hansen (1982) and Sargan (1958) are undersized and have extremely poor power properties when the number of moment conditions increases rapidly with the time series dimension of the dynamic panel. This problem of too many instruments can weaken the Hansen test of the instruments' joint validity to the point where it produces implausibly good p-values of 1.000 (Roodman 2009a). The results shown in the last row of Table 3 imply this problem.

To avoid this problem, I also examine another GMM estimator to test the robustness of our results. Roodman (2009b) suggested that there are two steps to resolve this problem caused by too many instruments. First, I reduce the number of lags used for instruments to one (I have used two lags so far). Second, I collapse the instruments set. This means that I create one instrument for each variable and lag distance, rather than one for each variable, time period, and lag distance. The results based on a reduced number of lags and collapsing method are shown in Table 4. As we can see from the table, now we have plausible p-values for the Hansen test. The

Arellano-Bond test for AR(2) suggests the absence of serial correlation in the error term as before.

Table 4 shows that the results based on the collapsing method are almost the same as previous ones. From the perspective of statistical significance, the significance level increased in some important independent variables. Specifically, the coefficients on interest rate policy, the IPLM-shock and the ratio of foreign reserves to imports are now all statistically significant at the 1 percent level in all specifications. In addition, the coefficients on these three variables have expected signs consistent with the theory.

From the perspective of the magnitude of each coefficient, some variables have somewhat larger impacts on exchange rates, while others have somewhat smaller impacts compared with previous results. For example, the effect of interest rate policy on exchange rates is larger than before, indicating that a 1 percentage point increase in the policy interest rate is associated with approximately a 1 percentage point appreciation of domestic currency. The effect of the IPLM-shock also becomes larger and the result from column (7) suggests that a 1 percentage point increase in the risk premium is associated with about a 0.5 percentage point appreciation of currency. By contrast, the effect of the W-shock becomes somewhat smaller than before, suggesting that a 1 percent increase in productivity is associated with a 1.7 percentage point depreciation of domestic currency according to column (7). The signs of these variables in Table 4 are consistent with the prediction of the currency crisis models. Therefore, we can conclude that the results obtained by the GMM estimators are robust.

Table 4: Results of GMM Estimations Using a Collapsed Instrument Matrix

Variable	(5)	(6)	(7)	(8)
Lagged Dependent Variable	0.006 (0.051)	0.039* (0.021)	0.085*** (0.020)	0.078*** (0.011)
Interest Rate Policy	-1.083*** (0.212)	-1.144*** (0.107)	-0.998*** (0.090)	-0.984*** (0.091)
Short-term External Debt / GDP	0.293 (0.224)	2.009*** (0.307)	2.249*** (0.277)	1.950*** (0.243)
IPLM-Shock	0.563*** (0.168)		0.514*** (0.096)	0.395*** (0.137)
W-Shock		-1.455*** (0.254)	-1.749*** (0.361)	-19.705*** (3.619)
W-Shock × W-Slope				2.680*** (0.516)
Deviation GDP Growth	-0.850*** (0.283)	-0.071 (0.309)	0.073 (0.340)	-0.245 (0.296)
Exchange Rate Overvaluation	-1.168*** (0.279)	-1.476*** (0.149)	-1.233*** (0.135)	-1.238*** (0.123)
Foreign Reserves / Imports	-14.288* (7.209)	-22.435*** (3.697)	-12.049*** (3.930)	-11.587*** (3.097)
Number of Countries	48	35	34	34
Number of Observations	735	616	507	507
Arellano-Bond Test for AR(2) (p-value)	0.477	0.169	0.366	0.338
Hansen test (p-value)	0.144	0.181	0.209	0.132

Notes: The significance level of the variables is indicated by *(10%), **(5%) and ***(1%). Cluster-robust standard errors are in parentheses. To limit the number of instruments, the instruments are collapsed.

7. Robustness Check

In this section, to check the robustness of our results obtained in the previous section, I also examine a different estimation technique, the IV method using the 2SLS, to control the endogeneity problem. Table 5 provides the 2SLS estimation results. Before we interpret the results, we need to check the validity of the instrument. First, the coefficient on the instrument in the first stage regression is statistically significant at the 1 percent level in each specification. Thus, we can confirm that the instrument is strongly correlated with the endogenous variable. Second, the F statistic on the significance of the instrument in the first stage of 2SLS exceeds 10 in each specification (Staiger and Stock 1997). These two diagnoses mean that we can proceed with the IV estimation.

The findings are similar to the previous results and are robust. The table supports the hypothesis that a tight interest rate policy by the monetary authority during a currency crisis can avoid currency depreciation. The coefficient on the interest rate policy is statistically significant at the 1 percent level and negative in all specifications, suggesting that the central bank's interest rate defense leads to a currency appreciation and hence can prevent a currency crisis. The results suggest that a 1 percentage point increase in the policy interest rate is associated with approximately a 2.6 percentage point appreciation of domestic currency. This effect is larger than the one obtained in the GMM estimation results.

The short-term external debt to GDP ratio has a significant coefficient at the 5 percent level except in column (9) indicating that an increase in this variable contributes to currency crises. As in the previous section, this result is consistent with the theory of the third generation currency crises models.

The coefficient on the IPLM-shock is positive and statistically significant at the 1 percent level in each specification. This is consistent with the prediction of the ABB model and means that an increase in the country's risk premium induces currency depreciation by shifting up the IPLM curve.

In contrast, the coefficient on the W-shock is negative and statistically significant at the 1 percent level in all columns that include this variable. This is also consistent with the prediction of the ABB model by showing that an increase in productivity leads to higher output and currency appreciation, whereas the opposite outcome occurs in the presence of a negative productivity shock.

The interaction of W-shock with W-slope is significantly positive in the last column (12) and this is consistent with the predicted sign derived by the theoretical model. This result indicates that the slope of the Wealth curve in the ABB model can explain a country's vulnerability leading to a currency crisis induced by the productivity shock.

The estimated results of the other control variables are as follows. The result for coefficients on the GDP growth, which attain significance only in column (9) as in the previous table, can be explained by the same reason as in the previous section. The regression results here present the same negative coefficient for real exchange rate overvaluation as the baseline estimation. The significant negative coefficients on foreign reserves to imports show that countries that have more reserves are less likely to experience currency depreciation. This finding is the same as the baseline results and consistent with the prediction of the first generation models of currency crises.

In summary, the results obtained by using the 2SLS here is the same as those obtained by GMM, and we can conclude that our empirical results are robust. In the next section, using our estimation results, I discuss the implications for currency crises.

Table 5: Results of Fixed-Effects Instrumental Variables Regressions

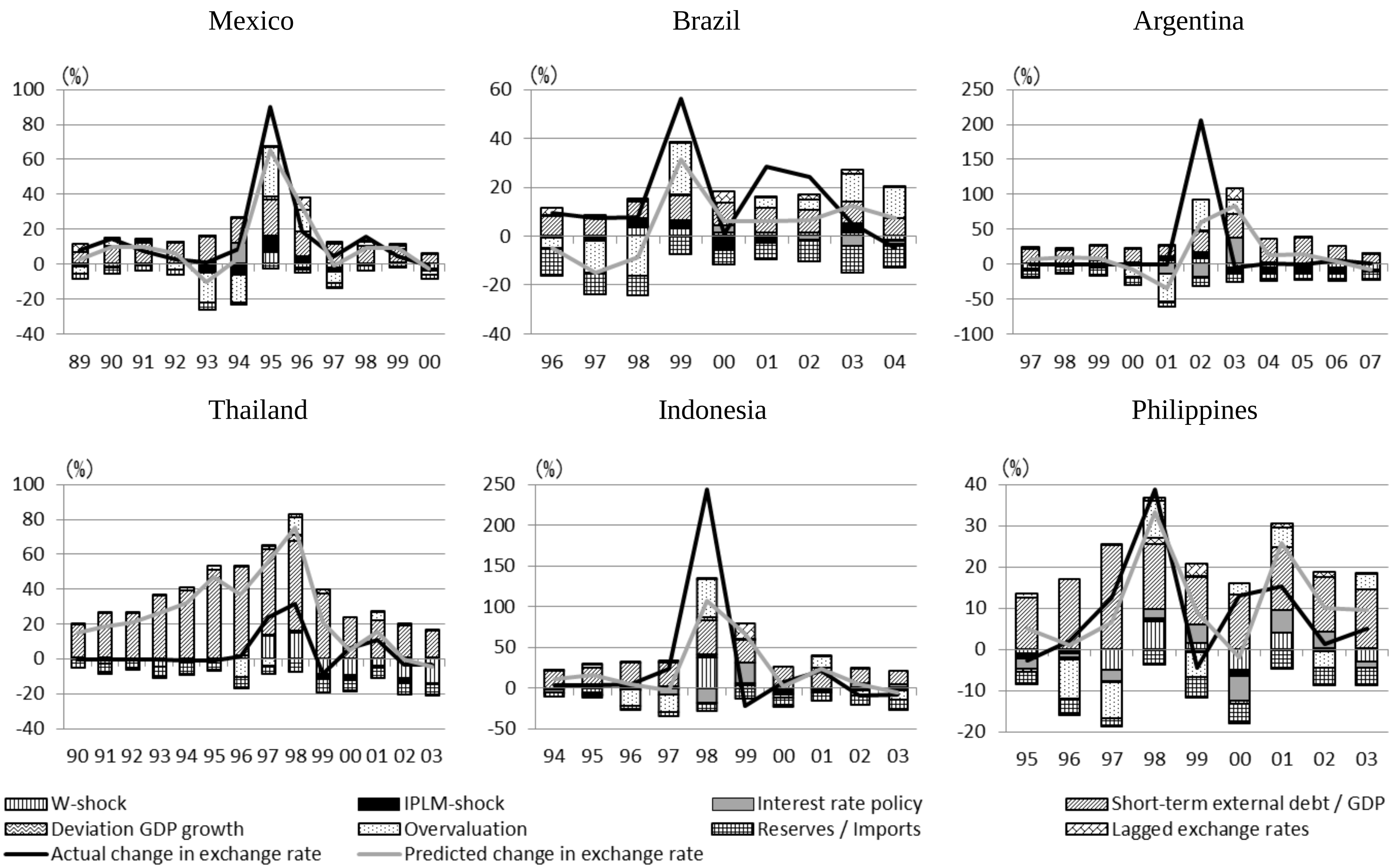
Variable	(9)	(10)	(11)	(12)
Lagged Dependent Variable	0.143**	0.141*	0.140	0.161*
	(0.070)	(0.080)	(0.088)	(0.088)
Interest Rate Policy	-2.601***	-2.655***	-2.630***	-2.631***
	(0.461)	(0.497)	(0.527)	(0.524)
Short-term External Debt / GDP	0.371	1.516**	2.150**	1.925**
	(0.288)	(0.687)	(0.962)	(0.962)
IPLM-Shock	0.360***		0.333***	0.295***
	(0.096)		(0.110)	(0.110)
W-Shock		-3.457***	-3.919***	-31.966***
		(1.247)	(1.417)	(12.191)
W-Shock × W-Slope				4.277**
				(1.847)
Deviation GDP Growth	-2.189***	0.132	0.299	0.077
	(0.715)	(1.348)	(1.553)	(1.551)
Exchange Rate Overvaluation	-1.011***	-1.873***	-1.732***	-1.625***
	(0.285)	(0.503)	(0.583)	(0.582)
Foreign Reserves / Imports	-22.106***	-27.923**	-33.372**	-32.199**
	(8.508)	(11.800)	(14.183)	(14.121)
Constant	19.358***	14.762	14.499	15.358
	(6.256)	(9.350)	(11.735)	(11.696)
First-stage Regression				
Lagged Interest Rate	-0.329***	-0.333***	-0.341***	-0.341***
	(0.034)	(0.039)	(0.042)	(0.042)
F Statistic	23.57***	17.02***	15.10***	13.51***
Number of Countries	48	35	34	34
Number of Observations	785	653	542	542

Notes: The significance level of the variables is indicated by *(10%), **(5%) and ***(1%). Cluster-robust standard errors are in parentheses.

8. Implications for Currency Crises

In this section, using the coefficients obtained in the baseline regression results, I analyze how much of the change in exchange rates can be explained by each variable in the case of major currency crises that occurred in Latin American and Asian countries: the Mexican peso crisis in 1994-95; the Asian crisis in 1997-98 that originated in Thailand and spread to other Asian countries such as Indonesia and the Philippines; the Brazilian crisis in 1999 and the Argentine crisis in 2001-02. Figure 6 compares the prediction of change in exchange rates by the estimated model and the actual exchange rates observed in the markets, and shows the size of contribution of each variable to the dynamics of exchange rates. I used coefficients obtained in column (8) of Table 4 to predict the changes in exchange rates since this is the most econometrically sophisticated model in my analysis.

Figure 6: Currency Crises in Latin American and Asian Countries



Let me provide an overview of the results first. Overall, the short-term external debt has a sizable effect on currency depreciation in each country. This result is consistent with the study by Eijffinger and Karataş (2012) that found that an increase in the short-term external debt contributes to the currency crises in developing countries. This indicates that developing countries tend to have the third generation model weakness of currency crises. We also find that overvalued exchange rates contributed to a currency depreciation during the crisis period. Furthermore, the results show that, compared to the IPLM-shock, the W-shock was more important to trigger currency crises, especially in the Asian countries. This means that there were large negative productivity shocks in these countries during the Asian crisis. From here, I discuss each country's currency crisis episode and compare my results to the findings in the empirical literature on currency crises.

Currency Crises in Latin American Countries

Mexican Crisis in 1994-95

The Mexican peso crisis occurred at the end of the year 1994 and appeared severe in 1995. The figure shows that the prediction of our model traces the actual dynamics of exchange rates accurately for the Mexican crisis. It is said that this Mexican crisis has a feature of the second generation models of currency crises in which the expectation of investors plays a crucial role as a self-fulfilling prophecy (Cole and Kehoe 1996; Sachs, Tornell, Velasco, Giavazzi and Székely 1996; Calvo and Mendoza 1996[18]). Significant magnitudes of both overvalued exchange rates and the IPLM-shock in the figure support this view. The overvalued exchange rate is supposed to capture the degree of expectation of exchange rates in the financial market. The result suggests that the IPLM-shock, which is a shock to the country risk premium and can be interpreted as a shift of investor's expectation of the country's risk, contributed to a currency depreciation during the Mexican crisis. The W-shock also contributed to the crisis, but the result shows that its size was relatively modest compared to the IPLM-shock. The short-term external debt also had a significant impact on changes in exchange rates. This reflects the fact that the increase in the short-term dollar-indexed government bonds called Tesobonos was an important factor for the Mexican crisis. This is supported by the evidence that the central bank

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[18] Note that the model presented in Calvo and Mendoza (1996) is not a pure second generation model of currency crises and includes the features of the first generation models since the level of international reserves plays a critical role for the collapse of the exchange rate regime.

of Mexico found it difficult to roll over this government debt during December 1994 and January 1995. To sum up, the main causes of the Mexican crisis include a feature of second generation model, i.e., investors' expectations, as well as some features of the first generation model, e.g., unsustainable government debt policy.

Brazilian Crisis in 1999

The Brazilian currency crisis started in January 1999 and Brazil eventually devalued its national currency, the Brazilian Real, in February 1999. It is noteworthy to see the evidence that there was a rise in Brazilian spreads before the crisis occurred (Kaminsky, Reinhart and Vegh 2003), which we can see as a positive IPLM-shock in 1998 in the figure. This increase in the risk premium could have been affected by the Russian currency crisis in 1998. Both the Russian and Brazilian economies were affected by commodity prices such as oil price, and there was a financial linkage between these two countries; Brazilian banks invested in Russian short-term treasury securities (Griffin 2010). The figure also documents the fact that the central bank of Brazil used international reserves to stabilize the value of the currency during the crisis period. The overvalued exchange rate was also a large factor in the Brazilian crisis. In contrast to other developing countries, changes in the short-term external debt were relatively stable in Brazil during this period. Although there were negative productivity shocks, i.e., the negative W-shocks, in Brazil before the crisis, the size of shocks was limited compared with experiences of other countries' crises. The difference between the predicted change of exchange rates and actual change is due to Brazil's relatively large country fixed effects. Another factor that is important for the Brazilian crisis and not analyzed in the ABB model is the large budget deficits over this period. Taking into account this fiscal factor and the large contribution of reserves, we may conclude that the Brazilian crisis has the features of the first generation type of currency crisis models, and also the feature of the second generation models, i.e., expectation of investors.

Argentine Crisis in 2001-02

The Argentine crisis took place from December 2001 until January 2002. The literature on the Argentine crisis suggested that this crisis had properties of both the first and the second generation models of currency crises. Feldstein (2002) asserted that an overvalued Argentine Peso and the government debt[19] held by foreign lenders were the major causes of the Argentine crisis. Boinet, Napolitano and Spagnolo (2005) found that the Argentine crisis was partly driven by economic fundamentals and then shifts in devaluation expectation forced the self-fulfilling currency crisis, indicating that this crisis had features of both the first and the second generation models.

Our figure shows that exchange rate overvaluation contributed to the Argentine crisis and this is consistent with the literature above. Similar to the Brazilian crisis, the IPLM-shock contributed to currency depreciation during the crisis period. This rise in the country's risk premium can be explained by the perceived political instability during this period. Although the W-shock also contributed to the currency crisis, its effect was much smaller than the IPLM-shock. The gap between the predicted and actual changes in currency depreciation during the crisis period should reflect another factor that is not included in the ABB model, which may be a fiscal factor such as the default of sovereign debt. It is important to see that the contribution of short-term external debt more than doubled from 2001 to 2002 and this caused a

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19 More than 80 percent of Argentina's government debt was denominated in dollars by late 2001 (Edwards 2002).

severe economic stagnation afterwards.

Currency Crises in Asian Countries

Overview of the Asian Crisis in 1997-98

The Asian crisis occurred from 1997 to 1998. The Asian crisis is characterized by the fragility of the financial system such as growing short-term external debt, rapidly expanding bank credit and inadequate regulation of financial institutions, and these weaknesses left the Asian countries vulnerable to a rapid reversal of capital flows (Radelet and Sachs 1998). A rising share of foreign borrowing in Asian countries was in the form of short-term external debt, which is the main cause of the crisis as the literature found. As shown in Corsetti, Pesenti and Roubini (1999b), there was a serious mismatch between foreign liabilities and foreign assets of Asian banks and non-bank firms. Domestic banks borrowed heavily from foreign investors but lent mostly to domestic ones. As exchange rates depreciated and the domestic currency costs of servicing foreign currency debts rose, international investors became more reluctant to extend new loans and roll over existing loans. Thus, an important aspect of this crisis is the credit constraint of the economy and this is the reason why the Asian crisis has a feature of the third generation models of currency crises (Aghion, Bacchetta and Banerjee 2001). The results in Figure 6 support this view. The short-term external debt was the most important driver of currency crisis in Asian countries. I analyze the situation of currency crisis for each country below.

Thailand

Thailand was the epicenter of the Asian crisis. The pressure on the Thai Baht had emerged from 1996 and was fostered by the concern about its rapidly increasing reliance on short-term foreign capital. Our results show that the short-term foreign debt had been rapidly accumulated since the late 1980s and reached an unsustainable level in the early 1990s before the speculative attacks occurred. Since Thailand had used a pegged exchange rate regime before the crisis happened, it didn’t have a chance to use exchange rates as an adjustment tool for the external imbalance caused by this high level of short-term foreign capital. If a crisis occurs, international reserves must be large enough to cover a country's external debt service obligations, including the roll-over of short-term external debt. However, the amount of foreign debt was beyond this sustainable level in Thailand. After the collapse of the regime and following the introduction of the flexible exchange rate system and supports from the IMF and other institutions, this high level of short-term external debt was reduced, and as can be seen from the figure, the prediction of our model fits better to the movement of actual exchange rates. Thus, as is consistent with the literature, we found that short-term foreign borrowing played the largest role during the Thai crisis.

More interestingly, our results show that another important contributor to the Thai crisis was the productivity shock, which is displayed as the W-shock in the figure. As shown by the ABB model, the negative productivity shock triggers a currency crisis. The figure shows that there was a huge negative productivity shock in 1997 and 1998 in Thailand that led to the crisis. This effect from the W-shock is more than that of overvaluation of exchange rates. Although seeking the reasons for the full explanation of this decline in productivity in Thailand is beyond the scope of this paper, it can be related to the decline of new investment in manufacturing in the early 1990s and the explosion of investment in real estate that began in 1994 and continued through 1996 (Glassman 2001). This is because this real estate investment was not matched by comparable investment in construction and might have involved speculative land deals. From our analysis here, we can conclude that the short-term external debt and negative productivity shock were the main drivers of the Thai crisis.

Indonesia

The Indonesian currency crisis occurred as a contagion from the Thai currency crisis and resulted in a large depreciation of the Indonesian currency, Rupiah. As can be seen from the figure, the degree of currency depreciation was extraordninary and Indonesia is the country that was hardest hit by the crisis in the East Asian region. The result shows the evidence that the policy interest rate was used as a central element of the monetary policy response and raised to defend the currency in 1997 and 1998 (Grenville 2000). Similar to the results of Thailand, short-term external debt and the negative productivity shock contributed to the crisis to a large degree, accompanied by the overvaluation of exchange rates. The figure shows that the actual depreciation rate of currency is much bigger than the predicted change. This gap between prediction and actual outcome is explained by the other factors that are important in the Indonesian crisis but not analyzed in this model, including political risks caused by extensive crony capitalism and corruption, and sharp decline in the world petroleum price since Indonesia has been an oil-producing country (Radelet and Sachs 2000).

The Philippines

The Asian crisis that originally occurred in Thailand also influenced the Philippines' currency, Pesos. The figure shows that our model's prediction for the Philippine crisis is relatively good. As in the cases of other East Asian countries that suffered from the currency crisis, the short-term foreign borrowing was high in this country. Overvalued exchange rates and negative productivity shocks also contributed to the currency crisis in the Philippines. As in the Indonesian case, the policy interest rate was hiked by the central bank of the Philippines in 1997 to defend the currency.

Before I conclude, let me discuss the new findings obtained in this research, which is the importance of productivity shocks during currency crises. The ABB model suggests that the negative shocks to total factor productivity (TFP) are the primary cause of economic stagnation and a currency crisis. The literature has found that the TFP falls largely during a currency crisis (Brandt, Dressler and Quintin 2004; Meza and Quintin 2007; Pratap and Urrutia 2012; Poczter, Gertler and Rothenberg

2014). In the literature, it is argued that factor utilization plays an important role in productivity movements during currency crises. For example, Brandt, Dressler and Quintin (2004) found that capital utilization could account for the drop in TFP in Mexico during the 1994-95 Peso crisis. Meza and Quintin (2007) also found evidence that factor utilization can account for a significant part of the fall of TFP during currency crises. Capital utilization can account for the fall of TFP in currency crises in Latin American and Asian economies, including the Mexican crisis in 1995, the Thai crisis in 1997-98, the Indonesian crisis in 1998 and the Argentine crisis in 2001-02. The authors also found that labor hoarding also played a role in the drop in TFP in the Mexican crisis, and stated that they expected similar results to arise in the case of Thailand and Indonesia's crises. Calibrating the model to the Mexican economy prior to the 1994-95 crisis, Pratap and Urrutia (2012) showed that financial frictions, which is modeled as a working capital constraint on the purchase of intermediate goods, can endogenously generate a large fall in TFP after an unexpected interest rate shock by exacerbating a static misallocation of inputs in a way that generates a sharp decline in TFP. Using Indonesian data, Poczter, Gertler and Rothenberg (2014) recently found that the decrease in productivity during the

Indonesian crisis can be explained by the inefficient reallocation of resources across industries and exit of more productive firms. However, most of the literature focused on the effects of the TFP shock on output during the crisis, and none of the literature has analyzed the magnitude of the effects of the productivity shock on currency crisis quantitatively. Thus, the results obtained here by using the panel data estimation techniques can be considered as a new finding and my contribution to the empirical literature on currency crises.

9. Conclusion

In this paper, I surveyed the three generations of currency crises models and argued that exports are important factors during currency crises that have not been analyzed frequently in the literature. Thus, I introduced exports into the third generation model which was developed by Aghion, Bacchetta and Banerjee (2001).

In the original ABB paper, foreign currency denominated debt was the sole key factor for the occurrence of currency crises. Namely, in the original model, depreciation of the domestic currency induced by an unanticipated shock has only negative effects on the economy through deteriorated balance sheets of private firms.

The introduction of exports into the model suggests that depreciation of the exchange rate has both positive and negative effects on the real economy because it increases exports on one hand but reduces retained earnings via increased debt repayments for the foreign debt on the other hand. In this way, we could analyze the tradeoff between exports and foreign currency denominated debt under the circumstance of exchange rate depreciation in my model. I showed that graphical explanations with the Wealth curve and the IPLM curve are helpful to see this tradeoff. I derived a simple and intuitive formula that determines the slope of the Wealth curve when firms are exporting to foreign countries. In that formula, I found that the elasticity of exports plays a crucial role in the context of currency crises. I also showed that the structural vulnerability is important for the prevention of currency crises and the effectiveness of monetary policy response.

Furtheremore, I empirically analyzed the dynamics of exchange rates using unbalanced panel data of developing countries to test the propagation mechanism of the structural vulnerability of an economy and policy implications obtained in my theoretical model from the perspective of currency crises models. The results obtained here are consistent with the prediction of the theoretical models. First, I found that monetary tightening by the central banks can have a significant effect on exchange rates. Second, I also found that both productivity shocks in the real sector and shocks to the country risk premium in the financial markets affect exchange rate dynamics. Third, the structural vulnerability of the country, which is derived from the theoretical part of this paper, can play an important role in the currency market. Fourth, applying the results of my estimated model to major currency crises that occurred in Latin American and Asian countries, I found that the crises in Latin American countries tend to have features of the first and the second generation models of currency crises, whereas Asian countries have those of the third generation models of currency crises. This result is consistent with the existing literature. Furthermore, my results suggest that the productivity shocks were important factors that triggered currency crises especially during the currency crises in Asian countries. Thus, this is the first analysis that examined the effects of shocks on currency crises using the panel data estimation techniques and found that the productivity shocks are relatively important during currency crises. In addition, I also contribute to the literature by providing the empirical evidence that the effects of the shocks can be propagated by each country's structural vulnerability.

Last of all, let me conclude this paper. In the current highly globalized world, the dynamics of exchange rates have a significant effect on the lives of people across the world. The role of monetary policy to prevent a currency crisis is still among the top agenda priorities of central bankers, especially in developing countries. To derive policy implications and understand the mechanism through which both various types of shocks and monetary policy affect exchange rates, I hope that the empirical results documented in this paper will provide some evidence to support the effectiveness of monetary policy during a currency crisis.

Appendix A. Export and Consumption Functions

Example 1: An arctan type of export function

If we assume a constant level of foreign demand and an arctan type of export function (Figure A.1), which has lower and upper limits on the volume of exports, and also assume that domestic consumption is not affected by the real exchange rates and the amount of foreign debt is negligible, then the Wealth curve would be similar to the curve depicted in Figure A.2.

Figure A.1: An Arctan Type of Export Function

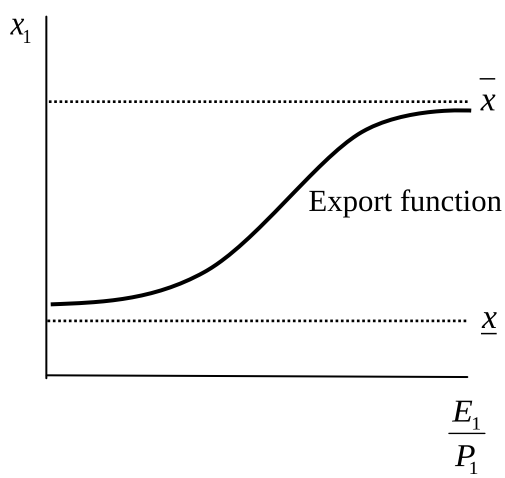
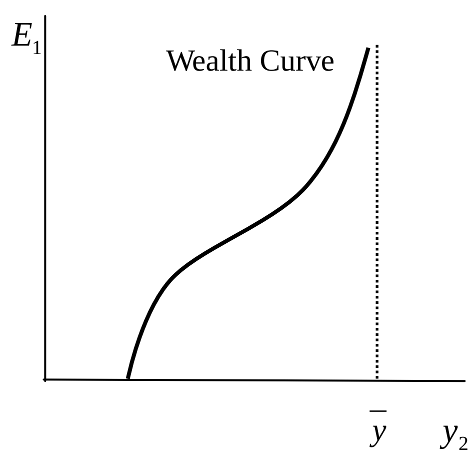


Figure A.2: Wealth Curve



Example 2: Export and consumption functions based on microeconomic foundation

If we want to derive an export function explicitly, we need to model the firm's behavior based on the microeconomic foundation. The firm's profit maximization problem can be set as

$$\Pi_t = c_t + \frac{E_t}{P_t} x_t - (1+i_{t-1})\frac{P_{t-1}}{P_t} l_t - (1+i^*)\frac{E_t}{P_t} l_t^* - \Phi\left(c_t + x_t\left(\frac{E_t}{P_t}, y_t^* \right)\right) \qquad \text{(A.1)}$$

where $\Phi(c_t + x_t)$ is a cost function that includes various costs such as operating costs and/or fixed set-up costs.[20] The firm maximizes its profit subject to an export demand that is a function of real exchange rates and foreign demand $x_t = x^d\left(E_t/P_t, y_t^*\right)$.

The first order conditions for the firm's profit maximization problem yield the following supply conditions for domestic sales and exports, which in turn determine domestic consumption and export volumes.

[20] For example, Nguyen and Schaur (2010) analyzed the case in which the quadratic cost function can be written as $\Phi(c_t + x_t) = H + K + \beta(c_t + x_t) + \frac{1}{2}(c_t + x_t)^2$ where H is the fixed cost of production, K is the sunk entry cost of exporting and β is the firm's idiosyncratic marginal cost of production.

$$1 = \frac{\partial \Phi\left(c_t + x^d\left(\frac{E_t}{P_t}, y_t^* \right) \right)}{\partial c_t} \tag{A.2}$$

$$\frac{E_t}{P_t} = \frac{\partial \Phi\left(c_t + x^d\left(\frac{E_t}{P_t}, y_t^* \right) \right)}{\partial x_t} \tag{A.3}$$

At an optimum, the firm equates the marginal revenue from the domestic consumption, unity, to the marginal cost of producing it. The same optimum condition holds for exports. In general, note that the function Φ captures the complementarity (or substitutability) of production between exports and domestic consumption. If we assume negative cost complementarities between export and domestic sales, $\frac{\partial \Phi}{\partial c_t \partial x_r} < 0$, a depreciation of real exchange rates increases exports, which in turn reduces marginal costs of production for domestic sales and hence also results in an increase in production for domestic consumption.

Appendix B: List of Countries

Table B: List of Countries

Algeria	Macedonia
Argentina	Malawi
Armenia	Malaysia
Belize	Mexico
Bolivia	Moldova
Brazil	Morocco
Bulgaria	Nicaragua
Burundi	Nigeria
Cameroon	Papua New Guinea
Central African Republic	Paraguay
Chile	Peru
China	Philippines
Colombia	Romania
Democratic Republic of the Congo	Russia
Costa Rica	Sierra Leone
Cote d'Ivoire	South Africa
Dominican Republic	Thailand
Gabon	Togo
Gambia	Tunisia
Georgia	Turkey
Ghana	Uganda
Grenada	Ukraine
Guyana	Uruguay
India	Venezuela
Indonesia	Zambia
Iran	

Appendix C: Data Description and Sources

1. Change in the Nominal Exchange Rate: The annual percentage change of the domestic currency price of the U.S. dollar. Source: IMF, International Financial Statistics (IFS).
2. Interest Rate Policy: The annual increase in the central bank policy interest rate expressed in percentage points. Source: Central banks and IFS.
3. Short-term External Debt to GDP: Short-term external debt is defined as debt that has an original maturity of one year or less. The ratio of short-term external debt to GDP is used for the analyses to account for the size of the economy. Source: World Bank, World Development Indicators (WDI) and IMF, World Economic Outlook (WEO).
4. W-Shock: The annual growth rate of total factor productivity. Source: Penn World Table Version 8.0 provided by Feenstra, Inklaar, and Timmer (2013).
5. IPLM-Shock: Identification method is explained in equation (23). Source: IFS, WEO, central banks, and Global Financial Development Database (GFDD).
6. Exports (level): Yearly total value of exports from a country. Source: IMF, Direction of Trade Statistics (DOTS).
7. Exports (volume): Yearly total volume of exports from a country. Source: WEO, DOTS.
8. Foreign Demand: Weighted average of real GDPs of trading partners using the export weights. Source: WEO, DOTS.
9. Imports: Yearly total value of imports to a country. Source: DOTS.
10. International Interest Rate: The U.S. interest rate. Source: IFS.
11. Deviation of GDP Growth: The deviation of real per capita GDP growth in a country from its average in the five preceding years. Source: WEO.
12. Exchange Rate Overvaluation: The percentage deviation of the real effective exchange rate from its five-year moving average. Source: IFS and Bank for International Settlements (BIS), BIS Effective Exchange Rate Indices.
13. Foreign Reserves: International reserves minus gold. Source: IFS.

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