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ESSAYS ON EXCHANGE RATES, CRISES AND MONETARY POLICY

A dissertation submitted in partial satisfaction
of the requirements for the degree of

DOCTOR OF PHILOSOPHY

in

ECONOMICS

by

Ryota Nakatani

September 2014

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Abstract

ESSAYS ON EXCHANGE RATES, CRISES AND MONETARY POLICY

by

Ryota Nakatani

Preventing crises caused by a large depreciation of exchange rates is one of the top agenda items for policy makers. This dissertation investigates the occurrence and prevention of crises from several perspectives: Chapter 1 analyzes currency crises from the firms' perspective; Chapter 2 studies a twin banking and currency crisis from the banks' and the monetary authority's perspectives; and Chapter 3 empirically researches the effects of different shocks and the mechanism through which shocks can be propagated.

Chapter 1 analyzes the role of firms during currency crises. The literature assumes that currency depreciation has only negative effects on the economy. I also incorporate positive effects by introducing exports into the third generation model developed by Aghion, Bacchetta and Banerjee (2001) (the ABB model). I derive an intuitive formula that describes each country's structural vulnerability and graphically explain how this vulnerability plays an important role.

The ABB model has assumed that only firms take the exchange rate risk. However, a currency crisis tends to occur concurrent with a banking crisis. In Chapter 2, I develop the first theoretical model in which banks take the exchange rate risk in the framework of the ABB model, and I show how a twin banking and currency crisis occurs. I also analyze several monetary policy instruments to prevent a twin crisis and find that not only the interest rate defense, which has been argued as a primary policy response in the literature, but also the reserve requirement policy can be effective for avoiding the crisis.

Based on the theoretical model developed in this dissertation, Chapter 3 empirically analyzes the effects of interest rate policy, real and financial shocks and structural vulnerability, which propagates the effects of shocks on the economy, on exchange rates. Using panel data on 51 emerging countries from 1980 to 2011, I employ instrumental variable methods with the generalized method of moments and the two-stage least squares estimators to control the endogeneity of monetary policy response. I provide the first empirical evidence that a productivity shock is quantitatively important for currency crises and the effects of this shock depend on structural vulnerability.

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supported me committedly at all times. Professor Walsh taught me how to write an academic paper that includes a theoretical model, and spent considerable time and thought reviewing my thesis to clarify issues and improve its quality. Professor Kletzer graciously gave me supportive advice and assistance, as well as commenting on my dissertation.

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Chapter 1

Structural Vulnerability in Relation to a Currency Crisis – The Role of Exports

1.1 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 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 first chapter of my dissertation, I discuss and show that exports are a potentially important factor for the prevention of a currency crisis. I introduce exports into the third generation models and derive an intuitive and important formula that captures the structural vulnerability of the economy. I also conduct graphical analysis to explore the roles of exports in currency crises.

The organizational structure of this first chapter includes a literature review section, in which I summarize the literature on currency crises models and the

specific model that I use for my analysis. I then discuss the importance of exports as addressed in the empirical literature. Furthermore, I develop the model and also analyze the role of exports graphically. Finally, I conclude.

1.2 Literature Review

1.2.1 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.¹ There have been three ‘generations’ of models of currency crises (Flood and Marion 1999; Dooley and Walsh 1999; Pesenti and Tille 2000; Aschinger 2001; Fourçans and Franck 2003; Breuer 2004; Burnside, Eichenbaum and Rebelo 2008; Glick and Hutchison 2013; Goldstein and Razin 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). These models describe a government that tries to maintain a pegged exchange rate system,

¹ Milesi-Ferretti and Razin (2000) analyzed various definitions of currency crisis.

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, the first generation models predict that the fixed exchange rate regime must collapse. The models are important since they can explain the repetition of currency crises in South America at the beginning of 1980.² Flood and Garber (1984) extended the first generation model and showed how to calculate the timing of a speculative attack by introducing the concept of a shadow floating exchange rate.³ Using the first generation model, Calvo (1987) showed how the balance of payments crisis occurs in an economy in which the government relies on inflation tax and does not conduct fiscal reform.

From 1992 to 1993, European Exchange Rate Mechanism (ERM) countries suffered fatal currency crises although they had compact and stable fundamental conditions. Thus, as Obstfeld (1994) argued, the first generation model fails to explain the ERM crises. Second generation models were developed to explain these

² Connolly (1986) extended the first generation model to a crawling peg regime and applied it to the experience of Argentina.

³ Buch and Heinrich (1999) applied this method of calculating the timing of collapse to build the first generation type of banking and currency crisis model.

crises that happened in European countries.

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. For example, 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. The government chooses whether or not to keep the exchange rate fixed. In this way, the maximization problem dictates if and when the government will abandon the fixed exchange rate regime. In these models, an interaction between investors' expectations and actual policy outcomes can lead to self-fulfilling crises (Jeanne 2000).

One feature of the second generation model is that the crises need not be driven by macroeconomic fundamentals as in the first generation model. Another feature of the second generation model is the occurrence of multiple equilibria. In this model, speculators may incite the government to abandon a fixed exchange rate regime by causing an attack on its reserves and cause the maintenance of the regime to become too costly. If a large number of speculators do attack, the government will lose a great

amount of reserves, and will be more prone to abandon the regime. A self-fulfilling speculative attack is profitable only if a sufficient number of speculators take part in it. In consequence, there is one currency crisis equilibrium with a speculative attack, and there is another equilibrium, where a currency crisis does not happen. Morris and Shin (1998) criticized standard second generation models because they assume that fundamentals are common knowledge and they demonstrated that introducing a small amount of noise into the agent's signals about fundamentals will lead to a unique equilibrium.

In the aftermath of the Asian currency crises that occurred in 1997-98, the third generation models were developed. The first generation models suggest that ongoing fiscal deficits, rising debt levels or falling international reserves are observed before the collapse of a fixed exchange rate regime. However, this suggestion is inconsistent with the Asian currency crises. In addition, instead of strategic interactions between government and investors, which are analyzed in the second generation models, financial factors in the private sector such as foreign currency denominated debt played key rolls during the Asian currency crises (Krugman 1999). The third generation models emphasize this financial sector in the economy.

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 debt. They explored how problems in the financial markets interact with currency crises, and how crises can have real effects on the economy. Since the model focuses on the private sector, conflicting government fundamentals, such as fiscal imbalances and monetization, are not key factors for currency crises. In addition, unlike the previous two generations of models, Purchasing Power Parity (PPP) does not hold in this model because short run price rigidity is introduced.

Another type of third generation model was developed by Chang and Velasco (2001). They focused on how distortions in the banking system can lead to currency crises, applying the Diamond-Dybvig model (Diamond and Dybvig 1983; Diamond 2007). The model concluded that market-oriented policies improve welfare in the absence of bank runs, but also make the financial system more fragile and vulnerable

to quick capital flow reversals and increase the likelihood of runs. Caballero and Krishnamurthy (2001) developed a model in which there are domestic and international collateral constraints, and described how these two types of constraints interact with each other in the face of a production shock and eventually lead to crises that are observed in emerging countries. Their model is also an application of the Diamond-Dybvig model in the sense that 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.

Another type of third generation model is based on the idea that government guarantees to the banking system can generate moral hazard problems (McKinnon and Pill 1996, 1997, 1999; Corsetti, Pesenti and Roubini 1999a; Dooley 2000; Burnside, Eichenbaum and Rebelo 2001; Dekle and Kletzer 2002). McKinnon and Pill (1996, 1997, 1999) showed that when banks have an information advantage about the returns to domestic investments, banks that enjoy government guarantees have an incentive to increase foreign borrowing and incur foreign-exchange risks that are underwritten by the deposit insurance system. This increases the magnitude of

overborrowing and leaves the economy both more vulnerable to speculative attack and more exposed to the real economic consequences of such an attack. Corsetti, Pesenti and Roubini (1999a) developed a model of currency and banking crises (twin crises).⁴ Twin crises occur because moral hazard arises from government guarantees and foreign creditors are willing to lend for unprofitable projects against the promise of future government bailouts. When the project payoffs turn out to be low there will be a banking crisis. The prospect of the government using seigniorage through money creation to finance the bailouts leads to high inflation expectation and so the currency also collapses. Dooley (2000) showed that the public guarantee of private sector liabilities (especially the protection of the domestic financial system) encourages banks to take on foreign debt and incur foreign-exchange risks, making the banking system more vulnerable to speculative attack. Burnside, Eichenbaum and Rebelo (2001) analyzed the connection between exchange rate devaluations and banks' hedging behavior. They argued that, in the presence of government guarantees, it is optimal for banks and firms to expose themselves to currency risk. Dekle and Kletzer

⁴ Kaminsky and Reinhart (1999) and Glick and Hutchison (2001) empirically analyzed the links between banking and currency crises. See Chapter 2 for a further discussion of twin crisis. Recently, Eijffinger and Karataş (2013) analyzed the linkage between sovereign debt, banking and currency crises.

(2002) analyzed how the government's implicit guarantees of foreign currency liabilities affect the behavior of financial intermediaries and corporate sectors, leading to twin currency and banking crises.

1.2.2 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 financial crisis in 2008-09, central bankers, including me, were concerned with the possibility of currency crises in some countries. Those concerns were strong

especially for emerging European countries such as the Baltic states, Hungary and Romania, that had huge foreign debt in their economies. For instance, Lehmann (2012) argued that exchange rate depreciation is a key risk in countries where the exchange rate exposure of the banking sector or domestic players is high, for instance in Hungary. This ABB model illustrates the situation of those emerging countries accurately.

There have been several research studies that extended the ABB model. Aghion, Bacchetta and Banerjee (2004) added the banking sector into their original model, and analyzed the optimal mix of three monetary policy instruments: (1) interest rate, (2) reserves, and (3) discount window. The optimal policy was a combination of the increase in the interest rate via open market operations and the reduction in the discount window rate (at which banks can borrow from the central bank) to offset the negative effect of the rise in the interest rate on future output. During a crisis period, a reduction in the supply of reserves leads to an increase in the interest rate.

The ABB analysis was based on supply-side shocks such as credit constraints. However, Hale and Arteta (2009) found that only about a quarter of the initial decline in credit could be attributed to the “credit crunch,” while the rest of the decline was

due to contracting demand. García-Fronti, Miller and Zhang (2006) introduced demand-side factors such as consumption and export into the ABB model. They showed that when the output is demand-determined, an increase in the interest rate will strengthen the domestic currency less than when output is supply-determined. They argued that a high interest rate hike might be complemented by fiscal easing to maintain demand.⁵ However, they did not examine the effects of the exchange rate on exports.

Bergman and Jellingsø (2010) 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 implications.

Taking this literature into account, in this chapter, I introduce the demand side factor, export, into the ABB model. This is because empirical research suggests that

⁵ They pointed out temporary investment allowances, accelerated depreciation and interest rate subsidies as fiscal devices.

exports play a key role in preventing and recovering from currency crises as we will see in the next section.

1.2.3 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 chapter analyzes the role of exports during currency crises from the

theoretical point of view.⁶

Although some papers fail to find a positive effect of exports on output, most recent empirical papers present evidence that exports are positively correlated to both output during currency crises and recovery from the crises. Papers that failed to find the effect of exports include Hong and Tornell (2005), who could not find evidence that the share of the export sector was correlated with post-crisis growth. They hypothesized that the reason was that the export share might be positively correlated with the proportion of short-term debt across countries. However, the export share was mostly insignificant even after controlling for this effect. Kaminsky (2006) suggested that countries are unable to attract trade credits to finance exports when their economies are mired in financial problems. In contrast, for crises with no domestic fragilities, booming exports are at the heart of the recovery from currency crises. Recently, the literature has found that the importance of export for currency crises is increasing. Gupta, Mishra and Sahay (2007) analyzed the behavior of output

⁶ 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).

during currency crises and found that growth of exports and trade openness⁷ 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. Desai, Foley and Forbes (2008) used firm-level data to analyze the response of multinational and local firms to currency crises. They found 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 of

⁷ Aşici (2011) found that capital account openness decreased the odds of a crisis. Tong and Wei (2011) found non-foreign direct investment capital inflows (such as bank lending and portfolio flows) were more likely to be reversed than foreign direct investment in the event of crisis.

depreciation.

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.

The purpose of this chapter 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. To my knowledge, the export sector is not analyzed frequently in theoretical currency crises models.⁸ 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). A compelling reason to use this model, in addition to the advantages described in detail in the previous section, is as follows.

⁸ One exception is Céspedes, Chang and Velasco (2004). However, they assumed that the value of home exports is an exogenous constant variable.

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.

1.3 Model

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.

1.3.1 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

$$y_t = f(k_t). \quad (1.1)$$

We introduce exports into the firm's profit function. Exports in foreign currency⁹ are assumed to be the function of real exchange rates and foreign demand.

$$x_t \left(\frac{E_t P_t^*}{P_t}, y_t^* \right) \quad (1.2)$$

where E_t is the flexible nominal exchange rate (the price of foreign currency in terms of domestic currency) and y_t^* is a foreign demand. For simplicity, we assume

⁹ Cook and Devereux (2006) presented evidence of foreign currency pricing of exports in Asian countries.

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.

$$x_t \left(\frac{E_t}{P_t}, y_t^* \right) \quad (1.3)$$

Note that exports are the increasing function of real exchange rate depreciation and foreign demand, where higher $\frac{E_t}{P_t}$ means real exchange rate depreciation.

$$\frac{dx_t}{d(E_t/P_t)} > 0, \quad \frac{dx_t}{dy_t^*} > 0 \quad (1.4)$$

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). 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

$$\Pi_t = f(k_t) - (1 + i_{t-1}) \frac{P_{t-1}}{P_t} l_t - (1 + i^*) \frac{E_t}{P_t} l_t^* \quad (1.5)$$

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.¹⁰ Thus, the current retained

¹⁰ The firm will always save a constant fraction of the profits under the assumption of the

earnings available for capital in the next period are¹¹

$$W_{t+1} = (1 - \alpha)\Pi_t. \quad (1.6)$$

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

$$L_t \leq \mu W_t \quad (1.7)$$

where μ is a credit multiplier. The rationale for the constant credit multiplier is derived from moral hazard considerations (Aghion, Banerjee and Piketty 1999).¹² 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:

$$k_{t+1} = (1 + \mu)(1 - \alpha)\Pi_t. \quad (1.8)$$

Then, the output is characterized by the production function

$$y_{t+1} = f(k_{t+1}) = f((1 + \mu)(1 - \alpha)\Pi_t). \quad (1.9)$$

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

logarithmic preference (Aghion, Bacchetta and Banerjee 2004).

¹¹ We assume that the marginal product of capital exceeds domestic and foreign interest rates so that constraint (1.6) is binding.

¹² 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.¹³

$$c_t + x_t \left(\frac{E_t}{P_t}, y_t^* \right) \frac{E_t}{P_t} = f(k_t) \quad (1.10)$$

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

$$y_2 = f \left((1+\mu)(1-\alpha) \left\{ c_1 + \frac{E_1}{P_1} x_t \left(\frac{E_1}{P_1}, y_1^* \right) - (1+i_0) \frac{P_0}{P_1} l_1 - (1+i^*) \frac{E_1}{P_1} l_1^* \right\} \right). \quad (1.11)$$

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).¹⁴ 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.¹⁵ Taking a derivative of the exchange rate with respect to output, we can get the slope of the Wealth curve.

$$\left. \frac{dE_1}{dy_2} \right|_{y_2 > 0} = \frac{P_1}{(1+\mu)(1-\alpha) \left\{ x_1 + \frac{E_1 x_{1E_1/P_1}}{P_1} - (1+i^*) l_1^* \right\}} \frac{1}{f_{k_2}} \gtrless 0 \quad (1.12)$$

¹³ See the second example in Appendix A for the model in which the firm determines consumption and see Chapter 2 for the model in which households determine consumption.

¹⁴ The overall balance of payments account always balances, i.e., $(1+i^*) l_1^* = x_1 + l_2^*$. We assume that the country starts out with large foreign liabilities.

¹⁵ 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

$$\left. \frac{dE_1}{dy_2} \right|_{y_2 > 0} = \frac{P_1}{(1+\mu)(1-\alpha)\{(1+\zeta)x_1 - (1+i^*)_1^*\} f_{k_2}} \frac{1}{f_{k_2}} \gtrless 0. \quad (1.13)$$

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.

$$(1+\zeta)x_1 < (1+i^*)_1^* \Rightarrow \left. \frac{dE_1}{dy_2} \right|_{y_2 > 0} < 0 \quad (1.14)$$

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

$$(1+\zeta)x_1 > (1+i^*)_1^* \Rightarrow \left. \frac{dE_1}{dy_2} \right|_{y_2 > 0} > 0 \quad (1.15)$$

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.

1.3.2 IPLM (Interest-Parity-LM) Curve

In this section we analyze the IPLM curve that is mainly determined by the policy of the central bank. We assume that a real money demand is a standard function of output and the interest rate.

$$m_t^D = m^D(y_t, i_t) \quad (1.16)$$

Underlying assumptions are that a real money demand function is increasing in output and decreasing in interest rates.

$$\frac{\partial m^D}{\partial y_t} > 0 \quad \text{and} \quad \frac{\partial m^D}{\partial i_t} < 0 \quad (1.17)$$

Arbitrage by investors between domestic and foreign currency bonds in a world with perfect capital mobility yields the following interest parity (IP) condition:

$$1 + i_t = (1 + i^*) \frac{E_{t+1}^e}{E_t} \quad (1.18)$$

where E_t^e is the expected nominal exchange rate (the price of foreign currency in terms of domestic currency) at the beginning of period t .

A money market equilibrium can be expressed by an LM equation:

$$M_t^S = P_t m^D(y_t, i_t). \quad (1.19)$$

Using the PPP assumption $P_2 = E_2^e = E_2$, the money market equilibrium in period 2 becomes

$$M_2^S = E_2^e m^D(y_2, i_2). \quad (1.20)$$

Combining the IP condition derived above, we get

$$M_2^S = \frac{(1+i_1)E_1}{1+i^*} m^D(y_2, i_2) \quad (1.21)$$

This equation yields the following the IPLM curve that provides the relationship between E_1 and y_2 .

$$E_1 = \frac{1+i^*}{1+i_1} \frac{M_2^S}{m^D(y_2, i_2)} \quad (1.22)$$

Bergman and Jellingsø (2010) showed that the first-order derivative of the IPLM curve is

$$\frac{dE_1}{dy_2} = -\frac{1+i^*}{1+i_1} \frac{M_2^S}{[m^D(y_2, i_2)]^2} m_{y_2}^D < 0. \quad (1.23)$$

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.

1.3.3 Equilibrium Analysis

The equilibrium of the model is defined by the intersection of the IPLM and the Wealth curves. The first three figures show the relationship between exports and the occurrence of currency crises. Here I use an arctan type of export function (Appendix A) to draw the Wealth curve.

Figure 1.1: Role of Exports in the Context of Currency Crises:

Before the Shock

Figure 1.1.1: Large Export

Figure 1.1.2: Large Foreign Debt

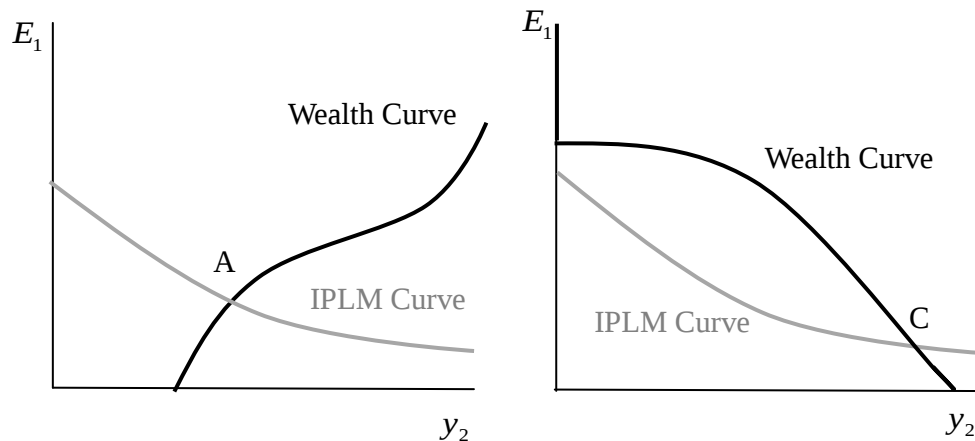


Figure 1.2: Role of Exports in the Context of Currency Crises:

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

Figure 1.2.1: Large Export

Figure 1.2.2: Large Foreign Debt

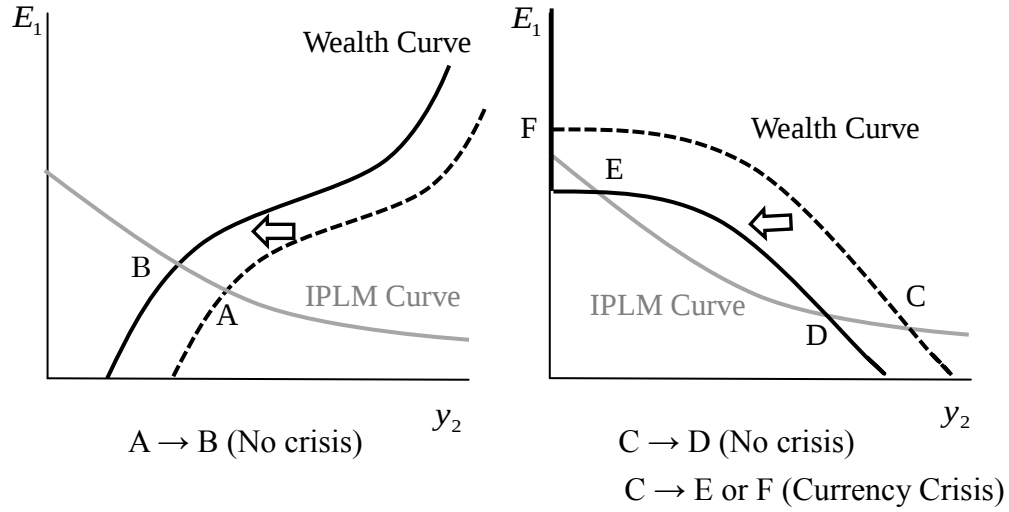


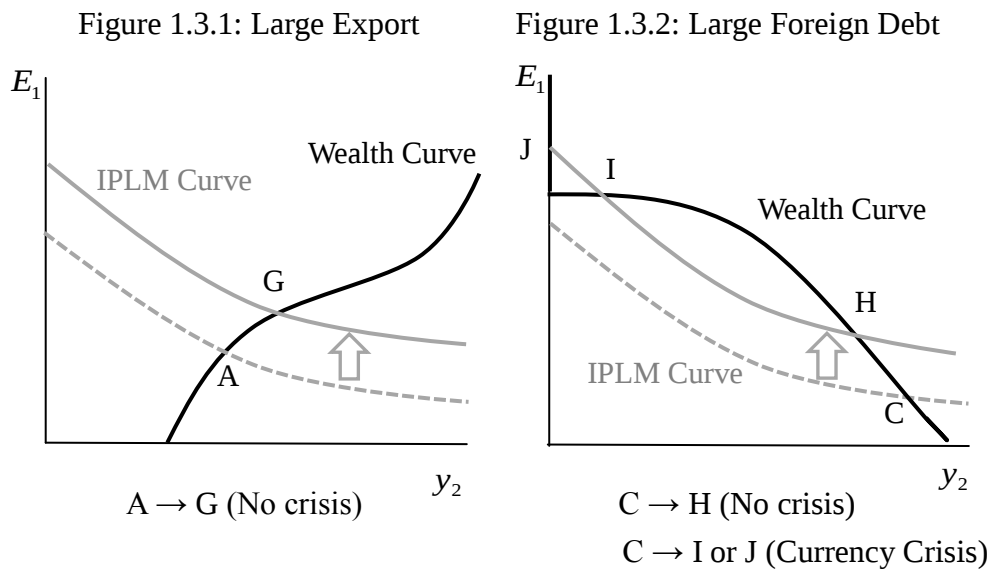
Figure 1.1.1 shows the case where an effect from export is greater than the repayments for foreign debt, $(1+\zeta)x_1 > (1+i^*)_1^*$. When a negative productivity shock (a shift in the $f(\cdot)$ function) or a tightening of the credit market (a shift in μ) occurs, the Wealth curve shifts to the left (Figure 1.2.1). 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 1.1.2 illustrates the economy in which the effects from the

foreign currency denominated debt are greater than those from the export, $(1+\zeta)x_1 < (1+i^*)_1^*$, 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 1.2.2). 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 1.3: Role of Exports in the Context of Currency Crises:

After an Expectational Shock



Next, we analyze the case in which the economy is hit by an unanticipated expectational shock in financial markets (Figure 1.3). In this case, the IPLM curve can be written as

$$E_1 = \frac{1+i^*}{1+i_1} \frac{M_2^S}{m^D(y_2, i_2)} + \eta \quad (1.24)$$

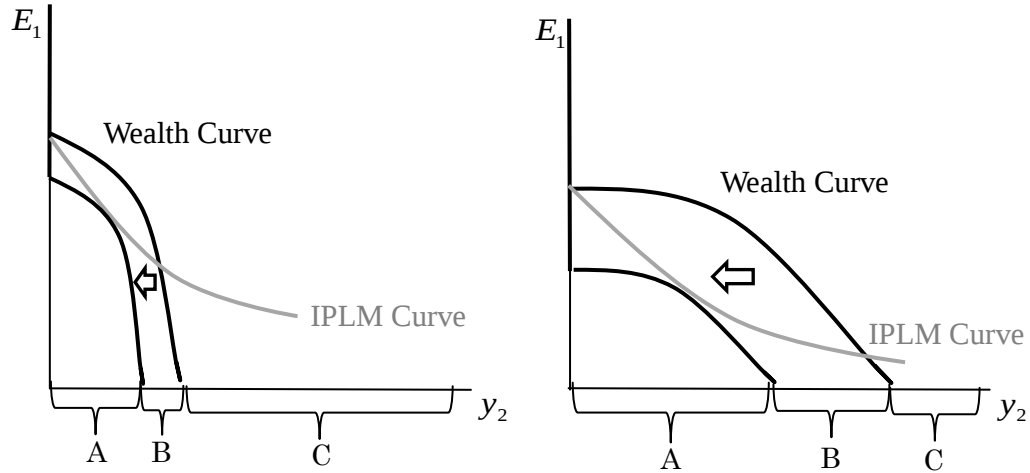
where η is the foreign exchange risk premium after the shock. This increase in risk shifts the IPLM curve upwards. Starting from a good equilibrium “A” in Figure 1.3.1, currency depreciation will increase the output via boosted exports to the new equilibrium “G” when the economy has a large export sector. In contrast, as shown in Figure 1.3.2, 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.

Figure 1.4: Role of Foreign Currency Debt and Monetary Policy

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

Figure 1.4.1: Steep Wealth Curve

Figure 1.4.2: Gradual Wealth Curve



- The Wealth curve meets the horizontal axis in interval A: Only Currency Crisis Equilibrium
- The Wealth curve meets the horizontal axis in interval B: Multiple Equilibria
- The Wealth curve meets the horizontal axis in interval C: Only Good Equilibrium

From here we analyze the effects of foreign currency denominated debt and

monetary policy on currency crises. Figure 1.4.1 is the case when $(1+\zeta)x_1 < (1+i^*)l_1^*$

and $(1+i^*)l_1^* - (1+\zeta)x_1$ is large. Figure 1.4.2 is the case when $(1+\zeta)x_1 < (1+i^*)l_1^*$

and $(1+i^*)l_1^* - (1+\zeta)x_1$ is small. Given the IPLM curve, the probability of facing

currency crises is higher in the case of Figure 1.4.1 than in the case of Figure 1.4.2. In

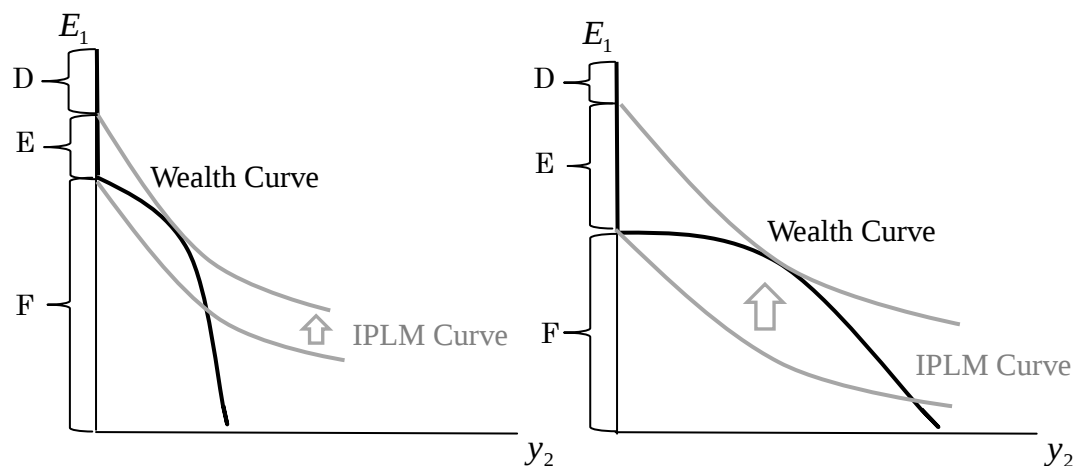
other words, the monetary authority needs to raise the interest rate to a large extent so

as to avoid crisis.

Figure 1.5: Role of Foreign Currency Debt and Monetary Policy
under an Expectational Shock

Figure 1.5.1: Steep Wealth Curve

Figure 1.5.2: Gradual Wealth Curve



- The IPLM curve meets the vertical axis in interval D: Only Currency Crisis Equilibrium
- The IPLM curve meets the vertical axis in interval E: Multiple Equilibria
- The IPLM curve meets the vertical axis in interval F: Only Good Equilibrium

Similar arguments hold for the cases when expectational shock occurs in the financial market (Figure 1.5). Figure 1.5.1 shows that, compared to a gradual Wealth curve depicted in Figure 1.5.2, a small shift in risk perception can increase the possibility of a currency crisis when the economy has huge foreign currency debt and the Wealth curve is steep. Thus, the greater the foreign currency debt, the more aggressively the monetary authority needs to raise the interest rate.

1.4 Conclusion

In this chapter, 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. I also argued the roles of foreign currency debt and monetary policy for the prevention of a currency crisis.

So far we assumed that only firms have foreign currency denominated debt and take the exchange rate risk. However, in practice, it is empirically found that currency crises often occur concurrent with banking crises since commercial banks also have foreign currency debt and bear the exchange rate risk. Moreover, monetary authorities have other policy instruments in addition to the policy interest rate to deal with currency crises. Therefore, by introducing a banking sector and several monetary policy instruments, I construct a banking and currency crisis model, in which banks bear the exchange rate risk, and also derive policy implications for the prevention of the crisis in the next chapter. Furthermore, the implications obtained in my model should be tested by empirical analysis. Thus, I am going to conduct empirical research on this topic in the third chapter of this dissertation.

Chapter 2

Twin Crisis and Implications for Monetary Policy

2.1 Introduction

As reviewed in the previous chapter, the third generation models of currency crises were developed to explain currency crises that occurred in developing countries after the Asian crisis. These models focus on the fragility of the financial system in the economy. The models that were developed by Aghion, Bacchetta and Banerjee (ABB) (2000, 2001, 2004) and extended further in the first chapter of this dissertation investigated the role of foreign currency denominated debt and credit constraint in the economy. Specifically, these ABB models have assumed that firms have foreign currency debt and bear the exchange rate risk. However, it is well known that the banking sector also often takes the exchange rate risk. Thus, in this second chapter, I analyze the case in which commercial banks take the exchange rate risk. This is the first analysis that develops a model in which banks bear the exchange rate risk in the ABB framework and it shows how this risk can affect the banking system and the real

economy. When banks bear the exchange rate risk, not only a currency crisis but also a banking crisis occurs. I show that in this situation not only the interest rate policy but also the reserve requirement policy is effective to prevent a twin (i.e., banking and currency) crisis.

The organization of this second chapter is as follows. In the next section, I review related literature and discuss the importance of the reserve requirement policy that is quite often used by most central banks. Subsequently, I develop a twin crisis model, in which the exchange rate risk is located in the banking sector, and I derive the implications for monetary policy to prevent the crisis. In the final section, I conclude this chapter.

2.2 Related Literature

2.2.1 Banking and Currency Crisis

It is well known that currency crises are found to be strongly associated with banking crises. For example, Kaminsky and Reinhart (1999) conducted empirical research using monthly data from 1970 to mid-1995 for 20 countries and found that a banking crisis tends to precede a currency crisis. Using a sample of 90 countries over

the 1975-1997 period, Glick and Hutchison (2001) found that banking crises tend to cause currency crises especially in emerging economies. Therefore, in this chapter, I introduce a banking sector into the specific currency crisis model that I studied in the first chapter, and analyze the relationship between the banking system and a currency crisis.

The most common way to introduce a banking crisis in the literature is the use of the Diamond-Dybvig model.¹⁶ This type of model assumes two types of depositors (i.e., consumers): an impatient depositor (i.e., an early consumer) and a patient depositor (i.e., a late consumer). It describes how bank runs occur (Goldfajn and Valdés 1997; Chang and Velasco 2001; Bleaney, Bougheas and Skamnelos 2008). Basically, the model relies on the shock caused by heterogeneity among depositors.

However, in practice, problems in the banking sector may be triggered by other factors such as a shift of investors' expectation in financial markets rather than consumers' withdrawal shock. Therefore, one of the two important purposes of this chapter is to develop the model in which we can study how a banking sector is related to or affects the real economy in a currency crisis without relying on the

¹⁶ See Chapter 1 of this dissertation for a comprehensive survey of the literature on currency crisis and twin crisis (banking and currency crisis) models.

heterogeneity of consumers. Instead, I rely on an unanticipated shock such as an expectational shift of international investors in financial markets. In order to do so, I develop the third generation model, which emphasizes the financial sector in the economy, and study the mechanism through which a banking crisis transmits to the real economy during a currency crisis. I use the same ABB model as in the first chapter, which was developed by Aghion, Bacchetta and Banerjee (2000, 2001). As I discuss in the previous chapter, over the past two decades, this has remained the top model in the literature on currency crises. In their model, the presence of foreign currency denominated debts reduces the profits and retained earnings of firms and results in lower investment and lower output in the real sector under a large currency depreciation. In their series of papers (Aghion, Bacchetta and Banerjee 2000, 2001, 2004), only firms are assumed to borrow from abroad and bear the risk of exchange rate. However, it is found that in some countries banks borrow from abroad and have a larger share in foreign currency denominated debt than firms (Buch and Heinrich 1999). Therefore, I added the banking sector into this model and analyzed the case in which commercial banks take the exchange rate risk. In other words, I developed a model that describes the case when the exchange rate risk is located in the banking

sector in the form of the ABB model.

There are some papers that are related to my analysis. Aghion, Bacchetta and Banerjee (2004) used the ABB model to analyze the role of banking as I explained in the first chapter. They incorporated the banking sector into their original model and derived implications for monetary policy during a currency crisis. My research differs from their research in some respects. First, they only studied the case in which firms have foreign currency denominated debts and not the case in which banks have foreign currency debt. However, as the economy develops and is globalized, not only firms but also banks can be exposed to international capital markets. Therefore, as I mentioned above, I analyze the model in which banks have foreign currency debt, and study how this differs from the model in which firms have foreign currency debt. Second, they assumed that there is no transaction cost for banks to receive deposits. By contrast, as I will explain below, I incorporate the cost structure of the banking system into the model. Finally, they also assumed that reserves do not bear interest. But taking into account the increasing attention of the role of interest on reserves as a monetary policy instrument, I analyze the general case where central banks can use that interest rate as one of their monetary policy tools. Another type of model that

investigates how shocks to the banking system affect the real economy uses a costly banking system. Edwards and Végh (1997) used economies of scope between loans and deposits and showed that high rates of devaluation lead to lower credit and lower output. They also analyzed the role of reserve requirements as a countercyclical policy tool. My analysis is consistent in the sense that the cost structure of the bank is a key factor in magnifying macroeconomic disturbances, but differs in some respects. In their model, households played an important role in the foreign exchange rate market because households hold internationally-traded bonds. By contrast, in my model, banks play an important role in taking exchange rate risks. In addition, they assumed zero interest rate on reserves, whereas I analyze a general case in which reserves earn a positive interest rate.

The other important purpose of this second chapter is to analyze the monetary policy for the prevention of a twin banking and currency crisis when the monetary authority has several policy instruments. This is because when banks take the exchange rate risk, a banking crisis occurs concurrent with a currency crisis and hence a macroprudential policy, such as the reserve requirement policy, is also effective during the crisis. Specifically, I analyze three monetary policy instruments:

the policy interest rate, the reserve requirement ratio and the interest rate on reserves.

This is because the reserve requirement policy is an important policy that is quite often used by central banks especially in emerging economies, but it has not been analyzed frequently in academia. For this reason, I review and discuss the literature on the reserve requirement policy in the next section.

2.2.2 Reserve Requirement Policy

In this chapter, I focus on not only the fragility of the banking sector but also the role of monetary policy in the prevention of a twin crisis. The literature on currency crises suggests that the monetary authority should increase the interest rate to prevent currency crises (Fischer 1998; Aghion, Bacchetta and Banerjee 2001; Flood and Jeanne 2005; Lahiri and Végh 2007).¹⁷ There are some publications that test the policy implications (Baig and Goldfajn 2002; Dekle, Hsiao and Wang 2002; Goldfajn and Gupta 2002, 2003; Kraay 2003). For example, Baig and Goldfajn (2002) found evidence that higher interest rates led to stronger exchange rates during Asian crises.

¹⁷ Braggion, Christiano and Roldos (2009) analyzed an optimal monetary policy in a sudden stop, focusing on the evidence that in the wake of the 1997-98 financial crises, interest rates in Asia were raised immediately, and then reduced sharply. As they noted, a shortcoming of their model was the absence of investment.

Dekle, Hsiao and Wang (2002) also found that raising the interest rate has an impact of appreciating the nominal exchange rate in the short run. Goldfajn and Gupta (2002, 2003) found that tight monetary policy facilitates the reversal of currency undervaluation through nominal appreciation. By contrast, Kraay (2003) found no evidence that increases in interest rates lower the probability that a speculative attack culminates in the devaluation of the currency. However, Kraay's paper 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. Recent empirical research suggests some insights to this policy recommendation.

One important observation that was obtained from the research is that a high interest rate defense is effective when debt is small. Goderis and Ioannidou (2008) found that raising the interest rate lowers the probability of a speculative attack only if a country has low levels of short-term corporate debt. This effect decreases for higher levels of debt. Eijffinger and Goderis (2008) also found that raising the interest rate is more effective in countries with lower corporate short-term debt, higher levels of institutional quality or higher external debt. Eijffinger and Karataş (2012) found that the advanced economies have lower country riskiness and the main cause of

currency crises is the second generation model weaknesses that cause the increased interest rates to be successful in stabilizing the exchange rates. By contrast, since the emerging economies have the first and third generation model weaknesses, higher indebtedness decreases the effectiveness of tight monetary policy by increasing the fragility of the firms and consequently depreciating the domestic currency.¹⁸

The other important observation is that the effectiveness of an interest rate hike depends on the exchange rate regime. Grier and Lin (2010) found evidence that raising interest rates significantly reduces the probability of attacks in hard-pegging countries but increases it in soft-pegging countries.¹⁹ They argued that signaling effects of raising interest rates are stronger for hard peggers than soft peggers.

But the interest rate is not the only monetary policy tool for central banks. A lot of central banks are using more than one policy instrument to control their economies. Most central banks – over 90 % – oblige banks to hold required reserves against their liabilities (Gray 2011). The main policy instruments for central banks in emerging

¹⁸ Coulibaly (2012) suggested that recent strong macroeconomic fundamentals allowed emerging economies to conduct countercyclical monetary policy during the financial crisis of 2008-2009.

¹⁹ Esaka (2010, 2013) explained the importance of exchange rate regimes. For example, floating regimes significantly increase the probability of currency crises because a higher domestic credit growth and a larger real exchange rate overvaluation tend to increase the likelihood of crises. In contrast, pegged regimes with no capital controls significantly decrease the likelihood of crises because they have no monetary policy autonomy and have the strictest discipline for macroeconomic policy.

countries are the reserve requirement ratio and the policy interest rate. After the Lehman shock, the reserve requirement policy was actively used by emerging economies (Tovar, Garcia-Escribano and Martin 2012). For example, Moreno (2010) estimated that reduced reserve requirements released a liquidity that amounted to 4% of GDP in Brazil during the Lehman crisis (Quispe and Rossini [2010] estimated 0.6% for Peru). Recently, Federico, Végh and Vuletin (2012a,b) found that more than half of developing countries have used the reserve requirement policy as a macroeconomic tool and 74 % of them used it countercyclically.²⁰

Nowadays, central banks in emerging countries change the reserve requirement ratio more often than the policy interest rate. For example, the central bank of the world's second largest economy, the People's Bank of China (PBOC), altered the reserve requirement ratio 35 times between July 2006 and June 2011, whereas PBOC altered the one year nominal lending interest rate 16 times in the same period. In addition, a central bank can use the interest rate and the reserve requirement ratio in an opposite way. For example, the Central Bank of the Republic of Turkey (CBRT)

²⁰ Elliott, Feldberg and Lehnert (2013) argued that reserve requirements were used as countercyclical macroprudential tools in the United States. Simulating Turkish data, Mimir, Sunel and Taşkın (2013) recently found that a countercyclical reserve requirement policy countervails the negative effects of the financial accelerator mechanism.

raised the reserve requirement ratio aggressively and lowered the interest rate at the same time in the period from November 2010 to August 2011 (Aktas and Cortuk 2012).

Why is the reserve requirement so important for monetary policy these days? This is because central banks usually have two policy objectives: price stability and financial stability. When there are multiple policy objectives, we cannot attain the goals with one monetary policy instrument, interest rate. In other words, multiple policy goals usually call for multiple instruments (Reinhart and Rogoff 2013). For this reason, many central banks use the reserve requirement ratio for financial stability and the interest rate for price stability. As we will see in the next section, central banks sometimes use interest rates for exchange rate stability especially in a currency crisis. Montoro and Moreno (2011) suggested reserve requirements may serve to complement monetary policy when it would be too costly to rely solely on open market operations to achieve an interest rate target or when a change in the interest rate would not be sufficient to maintain price or financial stability. In addition, when policy rates are close to zero, lowering reserve requirements may then provide

an alternative policy instrument.²¹ Glocker and Towbin (2012) found that reserve requirements become more effective when there is foreign currency debt because interest rate policy is less effective in attaining both financial stability and price stability. Vargas and Cardozo (2012) introduced reserve requirements in a central bank's objective function and showed that the use of reserve requirements is justified when monetary policy has several transmission channels (such as interest rate and exchange rate channels) and the central bank objective function includes financial stability.

What is the theoretical background for the use of the reserve requirement policy?

One conclusion we can obtain from the literature is that raising reserve requirements can prevent financial imbalances by restraining credit growth in the upswing of the business cycle (Calvo, Leiderman and Reinhart 1993).²² In contrast, lowering reserve requirements during a downturn can provide liquidity to the banking system.²³

An increase in reserve requirements raises lending interest rates, reduces deposit

²¹ Keister and McAndrews (2009) analyzed the reason why banks are holding so many reserves in advanced economies.

²² Hoffmann and Löffler (2014) find that central banks in emerging countries raise reserve requirements when interest rates in international funding markets decline or financial inflows accelerate to preserve financial stability, whereas they lower reserve requirements when funding from the advanced economies dries up to provide liquidity in the banking system.

²³ See Galati and Moessner (2013) for literature on macroprudential policy and Lim, Columba, Costa, Kongsamut, Otani, Saiyid, Wezel and Wu (2011) for a discussion of country experiences.

interest rates, and lowers bank stock prices because reserve requirements can be considered as taxes on bank profits (Reinhart and Reinhart 1999; Hein and Stewart 2002; Montoro and Moreno 2011; Walsh 2012). In general, the reserve requirement functions as a tax on deposits (Black 1975; Fama 1980; Freeman 1987).²⁴ Thus, the interest rate on deposits decreases when the reserve requirement ratio is raised. Fama (1985) provided evidence that borrowers pay the reserve tax. Vernon (1990) found that a higher interest rate is associated with a lower reserve ratio and interest payments on bank reserve deposits would raise the absolute interest elasticity of bank reserve ratios. Haslag (1998) showed that the economy's growth rate is inversely related to the reserve requirement ratio because a decline in the return to the agent's portfolio relative to the time rate of preference increases current consumption, depressing capital accumulation. Di Giorgio (1999) showed that the optimal level of reserve requirements is inversely linked to the degree of financial development of an economy. Reinhart and Reinhart (1999) developed the Dornbusch overshooting model to analyze the effects of the reserve requirement policy on capital flows. If a reserve tax is borne by depositors, an increase in reserve requirements lowers a

²⁴ Goodfriend (2002) and Walter and Courtois (2009) argue that the interest on reserves would eliminate distortions in financial markets due to the tax on reserves.

deposit interest rate, which in turn lowers the real interest rate and results in depreciation of the real exchange rate. On the contrary, when a tax is paid by borrowers, higher reserve requirements increase the lending rate.²⁵ In the context of currency crises, Sawada and Yotopoulos (2005) used the first generation model to show that increasing the required reserve ratio could postpone the crises. Mizen (1999) introduced foreign currency deposits by domestic residents into the first generation model and analyzed the role of required reserves on deposits.

Does the empirical literature find the effectiveness of the reserve requirement policy? Some papers suggest that the reserve requirement policy has significant effects on economies (Loungani and Rush 1995; Reinhart and Reinhart 1999; Gelos 2009; Wang 2010; Ostry, Ghosh, Chamon and Qureshi 2012; Vithessonthi and Tongurai 2013; Mora 2014), while others show no or small effect (Valdés-Prieto and Soto 1998; De Gregorio, Edwards and Valdés 2000; Concha, Galindo and Vasquez 2011).

Loungani and Rush (1995) analyzed U.S. data during 1950 to 1987 and found that a reduction in reserve requirements raises investment and output. Reinhart and

²⁵ However, there is no simple explanation for the real exchange rate due to the superneutrality of money.

Reinhart (1999) found some evidence that raising the reserve requirement ratio reduces the deposit rate and raises the lending rate. Lown and Wood (2003) found some evidence that higher interest rates are associated with lower reserve ratios. Gelos (2009) found that one of the key factors for higher interest rates in Latin America is higher reserve requirements. The effects of the reserve requirement policy in Chile have been actively investigated by policy makers since the 1990s. Valdés-Prieto and Soto (1998) analyzed Chilean data for 1987-1996 and found that the reserve requirement policy as capital controls was irrelevant because the private sector found ways to avoid it. De Gregorio, Edwards and Valdés (2000) detected very small effects of the reserve requirement policy on the real exchange rate.

Recent literature on the effectiveness of the reserve requirement policy includes mixed results. Wang (2010) found evidence that a rise in the reserve requirement ratio significantly decreased the aggregate money supply in China and concluded that raising reserve requirements played the most important role in reducing the money multiplier. Concha, Galindo and Vasquez (2011) found some evidence that the reserve requirement policy in Colombia reduced exchange rate volatility, though the impacts were not significant. Pham and Riedel (2012) analyzed monetary policy in Vietnam

and showed that the State Bank of Vietnam used the reserve requirement ratio and its lending facilities to manage base money and the money multiplier. Ostry, Ghosh, Chamon and Qureshi (2012) analyzed 51 emerging economies over the period 1995-2008 and found that reserve requirements were effective in restraining lending by the domestic financial system and seemed to complement the effects of capital account restrictions. Claessens, Ghosh and Mihet (2013) examined the effectiveness of several macroprudential tools and found that reserve requirements helped mitigate increases in bank leverage and assets. Esaka and Takagi (2013) used Japanese data from 1971 to 1980 and found that an increase in reserve requirements only modestly reduced the volume of short-term capital inflows. Mora (2014) used Lebanese data and found that a reserve requirement increase led to a drop in lending. Armas, Castillo and Vega (2014) analyzed Peruvian data and found that a reserve requirement tightening increased lending interest rates and reduced deposit interest rates and short-term external debt.

In the next section, I explain the twin crisis model in which commercial banks bear the exchange rate risk, and I derive policy implications for the prevention of the crisis.

2.3 Model

This is a two period model. There are four agents in the economy: households, firms, commercial banks and the authority (the government and the central bank). Households, which own the firms and the banks, consume the goods, and deposit their money to the banks. Firms produce the only goods by borrowing under a credit constraint. Banks finance their lending operations with deposits and foreign currency debts. On the asset side, banks lend to both firms and the government, and hold cash as required reserves. The government collects tax from households and issues bonds to finance its spending. The central bank sets three policy variables: the policy interest rate, the reserve requirement ratio and the interest rate on reserves.

The timing of events can be summarized as follows. The economy is initially in equilibrium before period 1 starts; all initial variables satisfy the equilibrium conditions and the Purchasing Power Parity (PPP) holds (see section 2.3.6). At the beginning of the first period, the price is preset before the actual exchange rate is known. Given this price, households, firms, commercial banks and the central bank choose their actions.²⁶ Then, an unanticipated shock, which corresponds to a

²⁶ In the original ABB model, the central bank is assumed to act after the shock. I changed this

realization of the nominal exchange rate, occurs. This shock makes the price deviate from the PPP by the end of the first period. Subsequently, period 1's output and profits are generated and the firms' and banks' debts are repaid. At this point, since the real exchange rate is different from the level that banks assumed at the beginning of the first period, banks may default depending on the sign of the unanticipated shock. Namely, if there is a positive unanticipated shock that leads to an appreciation of the currency, competitive banks can earn positive profits because the amount of repayments for foreign currency loans is lower than expected. Finally, a fraction of the net retained earnings of the firms after debt repayment is saved for investment in period 2 and this determines the level of output in period 2. By contrast, if there is a negative shock that induces a depreciation of the currency, banks would earn negative profits that make it difficult to repay the foreign currency debt and deposits. This negative unanticipated shock forces banks to default. This is what we call a banking crisis. If the default happens, firms cannot borrow money from banks and thus invest only with their retained earnings. In the absence of financial intermediation, the country's output will shrink in the next period and the banking crisis transmits to the

assumption to understand how the monetary policy affects each economic agent's behavior in general equilibrium.

real economy through the credit channel. This is what we call a twin crisis.

2.3.1 Households

The representative household's utility function is defined as

$$\ln c_1 + \beta \ln c_2 \quad (2.1)$$

where c_1 is consumption in period 1, c_2 is consumption in period 2, and β is the discount factor.

The assumption about price setting is the same as in the ABB model. PPP is assumed to hold at the beginning of period 1, then following an unanticipated shock (that may be a shift of investors' expectations), there are deviations from PPP that are corrected in period 2:

$$P_1 \neq E_1 \text{ and } P_2 = E_2 \quad (2.2)$$

where P_1 is the price level in period 1, E_1 is the nominal exchange rate (the price of foreign currency in terms of domestic currency) in period 1, P_2 is the price level in period 2 and E_2 is the nominal exchange rate in period 2. The price level of foreign countries is normalized to 1.

At the beginning of the period 1, the household anticipates the firm's and the

bank's real profits under the assumption that PPP holds. The expected real profit of the bank, Π_1^{Be} , is different from the actual real profit, Π_1^B , which is determined at the end of period 1, because the shock makes the nominal exchange rate deviate from the level that PPP holds. By contrast, the expected profit of the firm equals the realized profit, Π_1^F , since the unanticipated shock does not affect the firm's profit in period 1. Thus, the household can anticipate the true price level but not the exchange rate.

The household begins the first period with initial savings, s_0 , the initial dividend from the firm, Π_0^F , and the initial profit of the bank, Π_0^B . The household's real budget constraint in period 1 is

$$c_1 + s_1 = \left(1 + i_0^S\right) \frac{P_0}{P_1} s_0 + (1 - \tau) \Pi_0^F + \Pi_0^B \quad (2.3)$$

where s_1 is savings in period 1, i_0^S is the real interest rate on savings that is paid to the household at the end of the period 0 so that the household can use this interest income in period 1, P_0 is the price level in period 0 and τ is the tax rate on the dividend. The budget constraint thus says that, in the first period, the household's income consists of the real return on savings and profits from firms and banks. The household's expenditures consist of consumption, savings, and the tax. Note that the

competitive banking model leads to zero profit of commercial banks.

The household's optimization problem consists in choosing $\{c_t, s_t\}$ for $t = 1, 2$ in order to maximize utility, subject to the budget constraint, given tax rate, τ , initial variables, s_0, i_0^S, P_0, Π_0^F and Π_0^B , price variables P_1 and P_2 , the saving interest rate i_1^S , and the expected profits of the firm and the bank Π_1^F and Π_1^{Be} . Then we get the first order conditions of the household's optimization problem that lead to the following condition that characterizes the household's behavior:

$$\beta \left(\frac{1 + i_1^S}{1 + \pi_2} \frac{1}{c_2} \right) = \frac{1}{c_1} \quad (2.4)$$

where $\pi_2 = (P_2 - P_1)/P_1$ is the inflation rate in period 2. This is an Euler equation that determines the household's intertemporal consumption pattern. This Euler equation suggests that consumption is a decreasing function of the interest rate on savings and an increasing function of the future inflation rate. The household also needs to satisfy the budget constraint. Using these conditions, we can derive the equation that determines the intertemporal relationship of household savings. The saving function in period 1 can be written as

$$s_1(s_0, i_0^S, \Pi_0^F, \Pi_0^B, \pi_1, i_1^S, \Pi_1^F, \Pi_1^{Be}, \pi_2)$$

$$= \frac{1}{1+\beta} \left[\frac{1+i_0^S}{1+\pi_1} s_0 + (1-\tau)\Pi_0^F + \Pi_0^B - \frac{\beta(1+\pi_2)((1-\tau)\Pi_1^F + \Pi_1^{Be})}{1+i_1^S} \right]. \quad (2.5)$$

2.3.2 Government and the Central Bank

The government and the central bank are treated as one agent called “the authority.” The policy objective of the authority is to prevent a currency crisis and a banking crisis. To avoid a twin banking and currency crisis, the central bank can use three monetary policy instruments: the policy interest rate (i_1), the reserve requirement ratio (ϕ_1) and the interest rate on reserves (i_1^R) during the crisis period (i.e., period 1). The authority conducts open market operations using government bonds (b_1^S) to control the policy interest rate in period 1. Commercial banks are the sole market participants in the bond market. The consolidated budget identity of the authority during the crisis period can be written as

$$i_1^R \phi_1 d_1 + i_1 b_1^S + g_1 = \pi \Pi_0^F \quad (2.6)$$

where g_1 denotes the government expenditure in period 1. The authority is imposing an implicit tax on the interest rate on household savings by applying the positive reserve requirement ratio. This means that the household savings are taxed and

distorted by the reserve tax. To avoid double taxation on savings, the government collects tax from the other source of household income, i.e., the dividend from the firm. Note that the amount of this tax base is determined in the previous period. The government collects this tax revenue from the household to finance interest payments on reserves and government bonds and the government expenditure. The government does not conduct any tax reform over the entire period; the tax rate is exogenously determined by the government before households choose their actions and the tax rate is constant over time. This is because we want to focus on and analyze the role of the monetary policy response for a banking and currency crisis rather than a tax policy response. In addition, it is not practical to assume that the government conducts tax reform when the country is combating a crisis. Thus, changes in monetary policy variables should be accompanied by an adjustment in the government expenditure. The government expenditure is treated this way to satisfy the authority's budget identity since the change of g_1 (or the government budget deficit) is not a main focus in this third generation model.²⁷ The central bank announces various interest rates when other agents choose their actions in period 1. Note that both reserves and

²⁷ See Chapter 1 for discussion of the first generation models of currency crises in which the government budget deficit plays a crucial role in a currency crisis.

government bonds are redeemed within the period. Therefore, there is no intertemporal budget constraint for the fiscal policy and hence the Ricardian equivalence does not hold in this model. After the crisis period (i.e., in period 2), as we will see below, the ABB model describes the monetary policy using the money supply variable (M_2^S) to apply the Interest-Parity-LM (IPLM) relationship. This is because the main focus of this chapter is the monetary policy during the currency crisis, not the policy after the crisis.

2.3.3 Banks

The role of banks is to take deposits from domestic households, borrow from foreign investors and lend to both firms and the government. The banking industry is assumed to be perfectly competitive. The representative bank raises its funds from the deposits of domestic households and external debt denominated in foreign currency. The bank gives loans to domestic firms and also purchases government bonds each period. The bank must put a certain fraction of the deposits in a central bank's reserve account to satisfy the reserve requirement obligation. In this setting, the profit of the bank in period 1 is given by

$$\Pi_1^B = i_1^L l_1^S + i_1 b_1^D + i_1^R \varphi_1 d_1 - i_1^D d_1 - i_1^F F_1 \frac{E_1}{P_1} - \Psi(d_1, l_1^S, F_1) \quad (2.7)$$

where i_1^L is the real interest rate on domestic lending in period 1, l_1^S is an amount of domestic lending in period 1, i_1 is the policy interest rate in real terms that is applied to the interbank market in period 1,

$$b_1^D = (1 - \varphi_1) d_1 - l_1^S + F_1 \frac{E_1}{P_1}. \quad (2.8)$$

is the net position of the bank on the interbank market where the bank trades the government bonds with the central bank through open market operations in period 1, φ_1 is the reserve requirement ratio in period 1, d_1 is an amount of deposits in period 1, F_1 is an amount of loan denominated in foreign currency in period 1, i_1^R is the real interest rate on reserves in period 1, i_1^D is the real interest rate on deposits in period 1, i_1^F is the nominal interest rate on foreign currency loans in period 1, and $\Psi(d_1, l_1^S, F_1)$ is a cost function that represents banking technology. Loans and bonds are within period loans and within period bonds. We assume that the bank incurs costs for maintaining and administrating its deposits, loans and foreign debts²⁸ whereas holding the reserve account balance at the central bank is charge-free. The

²⁸ Such a formulation captures the idea that, in practice, banks must carry out a variety of costly activities such as evaluating creditors, managing deposits, maintaining ATM's, and so on.

bank's cost function is assumed to be twice differentiable and satisfies the following standard assumption of convexity (Freixas and Rochet 2008; Dutkowsky and VanHoose 2011):

$$\Psi_d > 0, \Psi_{dd} > 0, \Psi_l > 0, \Psi_{ll} > 0, \Psi_F > 0 \text{ and } \Psi_{FF} > 0 \quad (2.9)$$

where $\Psi_d = \partial\Psi/\partial d_1$, $\Psi_{dd} = \partial^2\Psi/\partial d_1^2$, $\Psi_l = \partial\Psi/\partial l_1^S$, $\Psi_{ll} = \partial^2\Psi/\partial l_1^{S^2}$, $\Psi_F = \partial\Psi/\partial F_1$ and $\Psi_{FF} = \partial^2\Psi/\partial F_1^2$. We assume that the commercial bank holds reserves only to satisfy the reserve requirement obligation for the following reason. In practice, central banks set the interest rate on excess reserves at the level that is equal to or lower than the interest rate on required reserves such as zero. Thus, the interest rate on excess reserves is the lower bound on various interest rates and there is no incentive for commercial banks to hold excess reserves at an optimum.

The banks choose $\{l_1^S, d_1, F_1\}$ to maximize their profits, given $i_1^L, i_1, \varphi_1, i_1^R, i_1^D, i_1^F, \frac{E_1}{P_1}$, and $\Psi(d_1, l_1^S, F_1)$. Since the banks do not anticipate the shock, substituting the net position of the bank in the interbank market, they maximize the following expected profits under the assumption that PPP holds:

$$\Pi_1^{Be} = (i_1^L - i_1)l_1^S + \{i_1(1 - \varphi_1) + i_1^R\varphi_1 - i_1^D\}d_1 + (i_1 - i_1^F)F_1 - \Psi(d_1, l_1^S, F_1) \quad (2.10)$$

The first order conditions of the banks' profit maximization problem are thus:

$$i_1^L - i_1 = \Psi_l, \quad (2.11)$$

$$i_1 - i_1^F = \Psi_F, \quad (2.12)$$

$$i_1(1 - \varphi_1) + i_1^R \varphi_1 - i_1^D = \Psi_d. \quad (2.13)$$

The bank will adjust its volume of loans, foreign borrowing and deposits in such a way that the corresponding intermediation margins, $i_1^L - i_1$, $i_1 - i_1^F$ and $i_1(1 - \varphi_1) + i_1^R \varphi_1 - i_1^D$, equal its marginal management costs. Note that a perfect competition in the banking sector leads to zero profit. To analyze the effect of monetary policy further, we need to specify the cost function. Hereinafter, we analyze the case of constant marginal costs of intermediation ($\Psi_l \equiv \gamma_L, \Psi_F \equiv \gamma_F, \Psi_d \equiv \gamma_D$) since a simple tractable characterization of equilibrium is obtained. The first order conditions of the bank's profit maximization problem yield the following equations that characterize the relationship between interest rates.

$$i_1^L = i_1 + \gamma_L, \quad (2.14)$$

$$i_1^F = i_1 - \gamma_F, \quad (2.15)$$

$$i_1^S = i_1^D = i_1(1 - \varphi_1) + i_1^R \varphi_1 - \gamma_D. \quad (2.16)$$

Before we analyze how a banking crisis occurs and transmits to the real economy in the next section, we need to define a banking crisis as follows.

Definition of Banking Crisis

A banking crisis occurs when commercial banks earn negative profits and cannot meet debt obligations to international investors and/or domestic depositors. When this happens, commercial banks have no choice but to default.

2.3.4 Firms and the Wealth curve

In period 1, the price P_1 is preset and firms borrow to produce goods by investment under the credit constraint. The firms get domestic currency loans from domestic commercial banks. Then, an unanticipated shock, which corresponds to a realization of the nominal exchange rate E_1 (the price of foreign currency in terms of domestic currency), occurs. Subsequently, period 1's output and profits are generated and the firms' debts are repaid. Finally, a fraction of the net retained earnings after debt repayment is saved for investment in period 2.

The representative firm uses capital input k_1 to produce one type of goods y_1 that can be sold to domestic households in period 1. We assume the following production function:

$$y_1 = f(A_1, k_1) = A_1 k_1 \quad (2.17)$$

where A_1 is the total factor productivity in period 1. Assuming that the working capital k_1 fully depreciates within one period, the firm maximizes its real profit net of loan repayments

$$\Pi_1 = y_1 - (1 + i_1^L) l_1^D. \quad (2.18)$$

where, l_1^D is an amount of domestic currency loans in period 1 and i_1^L is the real interest rate on domestic currency loans in period 1. Apart from the original ABB model, all loans are within period loans; the firm borrows at the beginning of each period and repays loans at the end of the period.

As in the ABB model, firms are facing the credit constraint and an amount of capital can be determined as follows. We assume that whenever profit is positive, the firm retains a proportion $(1 - \alpha)$ of profit and uses it to finance its future investment.²⁹ Thus, the retained earnings in period 1 can be defined as $(1 - \alpha)\Pi_1$. The remaining proportion α of profit is distributed to domestic households; the households receive a fraction of the firm's profit that equals

$$\Pi_1^F = \alpha \Pi_1 \quad (2.19)$$

²⁹ The firm will always save a constant fraction of the profits under the assumption of the logarithmic preference (Aghion, Bacchetta and Banerjee 2004).

where Π_1^F is a realized profit. In the presence of the credit constraint, the firm can at most borrow an amount proportional to its assets for capital (i.e., retained earnings) from the commercial bank:

$$l_1^D \leq \mu(1-\alpha)\Pi_1. \quad (2.20)$$

We assume that this constraint is binding when we analyze the implications for twin crises. We focus on the case in which the credit multiplier is constant over time and firms do not have a choice to default.³⁰ As in the case of households, the firm assumes that PPP holds. Since capital fully depreciates within one period, investment in the current period equals the capital in the next period. Therefore, under the credit constraint, the equation of motion for capital, which equals investments, can be written as follows:

$$k_2 = (1+\mu)(1-\alpha)\Pi_1 \text{ for } E_1 \leq E_1^* \quad (2.21a)$$

where E_1^* is the level of the nominal exchange rate that satisfies PPP in period 1 ($E_1^* = P_1$). As long as an unanticipated shock leads to an appreciation of the currency, competitive banks can earn positive profits and engage in financial intermediation

³⁰ The derivation of the constant credit multiplier based on moral hazard in the credit market is shown by Aghion, Banerjee and Piketty (1999). See Aghion, Bacchetta and Banerjee (2001) for the case in which the credit multiplier depends on interest rates, and Aghion, Bacchetta and Banerjee (2004) for the case in which firms have a choice to default.

because the amount of repayments for foreign currency loans is lower than expected.

Note that an amount of the working capital in period 1 is determined in the same way:

$$k_1 = (1 + \mu)(1 - \alpha)\Pi_0 \quad (2.22)$$

where $(1 - \alpha)\Pi_0$ is the initial retained earnings that the firm holds at the beginning of period 1. In the credit-constrained economy, the output of the supply-side in period 2 is characterized by the following production function:

$$y_2^S = f(A_2, (1 + \mu)(1 - \alpha)\Pi_1) \text{ for } E_1 \leq E_1^* \quad (2.23a)$$

Thus, y_2^S is predetermined at time 2. This equation characterizes the relationship between output in period 2 and the nominal exchange rate in period 1; this is called the Wealth curve. For the same reason, the output in the first period can be written as

$$y_1^S = f\{A_1, (1 + \mu)(1 - \alpha)\Pi_0\}. \quad (2.24)$$

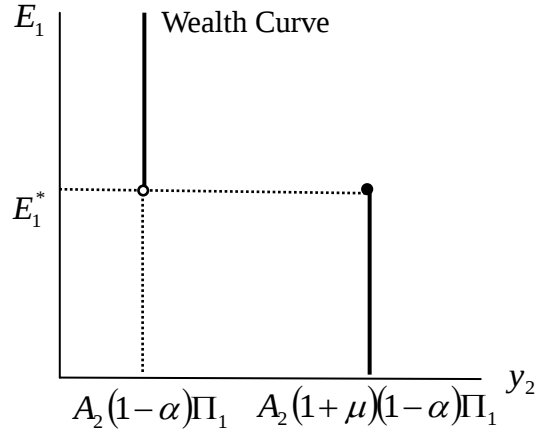
By contrast, when an unanticipated shock that induces a real currency depreciation occurs, commercial banks should default due to the negative profit and firms cannot borrow from banks. This means that there is a jump in the Wealth curve because the credit multiplier suddenly becomes zero.

$$k_2 = (1 - \alpha)\Pi_1 \text{ for } E_1 > E_1^* \quad (2.21b)$$

$$y_2^S = f(A_2, (1 - \alpha)\Pi_1) \text{ for } E_1 > E_1^* \quad (2.23b)$$

Thus, firms can invest only with their retained earnings, and output in period 2 should always shrink. These two situations can be drawn as in Figure 2.1.

Figure 2.1: Wealth Curve of Banking and Currency Crisis Model



Using the equation for the profit of the firm, the credit constraint, and the output function, we can write the loan demand function of the firm in period 1 as follows:

$$l_1^D(i_1^L, A_1, \Pi_0) = \frac{\mu(1-\alpha)f\{A_1, (1+\mu)(1-\alpha)\Pi_0\}}{1 + \mu(1-\alpha)(1+i_1^L)}. \quad (2.25)$$

In contrast, the output of the demand-side in period $t=1,2$ is determined as

$$y_1^D = c_1 + I_1 = c_1 + (1+\mu)(1-\alpha)\Pi_1, \quad (2.26)$$

$$y_2^D = c_2 + I_2 = c_2 + (1+\mu)(1-\alpha)\Pi_2 \quad \text{for } E_1 \leq E_1^*, \quad (2.27a)$$

$$y_2^D = c_2 + I_2 = c_2 + (1-\alpha)\Pi_2 \quad \text{for } E_1 > E_1^*. \quad (2.27b)$$

Note that the government does not purchase any goods from the firm. Under the

assumption that the credit constraint affects investments, we can obtain the following equation for the demand-side of output by using the equation for the profit of the firm:

$$y_1^D = c_1 + (1 + \mu)(1 - \alpha)(y_1^D - R_1) \quad (2.28)$$

$$y_2^D = c_2 + (1 + \mu)(1 - \alpha)(y_2^D - R_2) \quad \text{for } E_1 \leq E_1^* \quad (2.29a)$$

$$y_2^D = c_2 + (1 - \alpha)(y_2^D - R_2) \quad \text{for } E_1 > E_1^* \quad (2.29b)$$

where $R_t = (1 + i_t^L)l_t$ denotes a loan repayment in period t . Solving the equations above, we finally obtain the output of the demand-side:

$$y_1^D = \frac{c_1 - (1 + \mu)(1 - \alpha)R_1}{1 - (1 + \mu)(1 - \alpha)}, \quad (2.30)$$

$$y_2^D = \frac{c_2 - (1 + \mu)(1 - \alpha)R_2}{1 - (1 + \mu)(1 - \alpha)} \quad \text{for } E_1 \leq E_1^*, \quad (2.31a)$$

$$y_2^D = \frac{c_2 - (1 - \alpha)R_2}{1 - (1 - \alpha)} \quad \text{for } E_1 > E_1^*. \quad (2.31b)$$

2.3.5 IPLM Curve

The interest rate on foreign currency debt and the deposit interest rate satisfy the following uncovered interest parity condition since banks are indifferent between borrowing from abroad and taking deposits from domestic households.

$$1 + i_1^D = (1 + i_1^F) \frac{E_2^e}{E_1} \quad (2.32)$$

where E_2^e is the expected nominal exchange rate at the beginning of period 2.

Evidently, if i_1^D is increased, but E_2^e and i_1^F are unchanged, then E_1 must fall (appreciate): the orthodox relationship.

A money market equilibrium can be expressed by an LM equation:

$$M_2^S = P_2 m^D(y_2, i_2, \varphi_2, i_2^R) \quad (2.33)$$

where a real money demand (m^D) is a standard function of output and the monetary policy instruments. Using the PPP assumption $P_2 = E_2^e = E_2$, the money market equilibrium in period 2 becomes

$$M_2^S = E_2^e m^D(y_2, i_2, \varphi_2, i_2^R). \quad (2.34)$$

Combining the IP condition (2.32) with the LM equation (2.34), the IPLM curve in this twin crisis model can be written as

$$E_1 = \frac{1 + i_1^F}{1 + i_1^D} \frac{M_2^S}{m^D(y_2, i_2, \varphi_2, i_2^R)}. \quad (2.35)$$

We can see the negative relationship between E_1 and y_2 , suggesting a negative slope of the IPLM curve.

2.3.6 Defining the Equilibrium

From here I define the equilibrium when i^F is exogenous, which is a standard assumption in a small open economy model, because I will derive the policy implication in this setting later. Recalling that the economy is initially in equilibrium where PPP holds; initial variables $\{\Pi_0, \Pi_0^F, \Pi_0^B, y_0, i_0^L, i_0^S, i_0, \varphi_0, i_0^R, s_0, l_0, b_0, F_0, g_0, A_0\}$ satisfy the following equilibrium conditions:

$$\Pi_0 = y_0 - (1 + i_0^L)l_0, \quad (2.36)$$

$$\Pi_0^F = \alpha \Pi_0, \quad (2.37)$$

$$\Pi_0^B = i_0^L l_0 + i_0 b_0 + i_0^R \varphi_0 d_0 - i_0^S s_0 - i^F F_0 - \Psi(s_0, l_0, F_0) = 0, \quad (2.38)$$

$$y_0 = f\{A_0, (1 + \mu)(1 - \alpha)\Pi_0\} \quad (2.39)$$

$$b_0 = (1 - \varphi_0)s_0 - l_0 + F_0, \quad (2.40)$$

$$i_0^L - i_0 = \Psi_1, \quad (2.41)$$

$$i_0 - i^F = \Psi_F, \quad (2.42)$$

$$i_0(1 - \varphi_0) + i_0^R \varphi_0 - i_0^S = \Psi_d, \quad (2.43)$$

$$s_0 = (1 - \tau)\Pi_0^F \frac{1 + i_0^S - \beta}{1 + i_0^S} \frac{1 + \beta}{\beta - i_0^S}, \quad (2.44)$$

$$l_0 = \frac{\mu(1 - \alpha)f\{A_0, (1 + \mu)(1 - \alpha)\Pi_0\}}{1 + \mu(1 - \alpha)(1 + i_0^L)}, \quad (2.45)$$

$$i_0^R \varphi_0 d_0 + i_0 b_0 + g_0 = d\Pi_0^F, \quad (2.46)$$

where the subscript 0 denotes that the variable is in the initial equilibrium. Note that four initial variables $\{i_0, \varphi_0, i_0^R, A_0\}$ are exogenous variables in the initial equilibrium.

Departing from the initial equilibrium, a new equilibrium at the end of period 1 is a set of allocations $\{c_1, c_2, k_1, k_2, y_1, y_2, \tilde{s}_1, l_1, b_1, F_1, g_1, \Pi_1, \Pi_1^F, \Pi_1^{Be}, \Pi_1^B\}$ and a set of interest and exchange rates $\{i_1^L, i_1^S, E_1\}$, given $\{\Pi_0, \Pi_0^F, \Pi_0^B, i_0^S, s_0, P_0, P_1, P_2, A_1, A_2, i_1, \varphi_1, i_1^R, i_1^F, M_2^S, E_2^e, \tau, \alpha, \beta, \mu, \Psi\}$ such that:

1. $\{c_1, c_2, s_1\}$ solve the household's problem and satisfy equations (2.3), (2.4), and (2.5).
2. $\{l_1^D\}$ solves the firm's problem of maximizing its profit Π_1 , which is determined by equation (2.18) and a proportion of which is distributed to the household as a dividend Π_1^F by equation (2.19), subject to the credit constraint and its production technology (2.24), which determines y_1 with k_1 defined by (2.22), and satisfies the equation (2.25). Since the firm's problem determines the amount of capital in the next period k_2 by condition (2.21ab), it also determines the level of the output in the next period y_2 by condition (2.23ab).

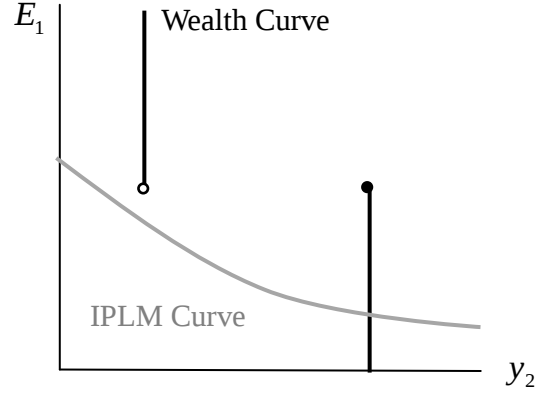
3. $\{d_1, l_1^S, F_1\}$ solve the commercial bank's problem of maximizing the expected profit Π_1^{Be} , which is determined by equation (2.10) (and results in Π_1^B ex post from equation [2.7]), and satisfy the balance sheet condition (2.8), which determines the commercial bank's demand of bonds b_1^D , and the first order conditions (2.11), (2.12) and (2.13).
4. $\{b_1^S, g_1\}$ solve the authority's problem and satisfy equation (2.6).
5. $\{E_1\}$ satisfies the IPLM condition (2.35).
6. Markets clear: $s_1 = d_1 = \tilde{s}_1$ (2.47), $b_1^D = b_1^S = b_1$ (2.48), and $l_1^D = l_1^S = l_1 > 0$ $\forall E_1 \leq E_1^*$ and $l_1 = 0$ $\forall E_1 > E_1^*$ (2.49).

We can solve this model because we have 21 endogenous variables (if we count s_1 and d_1 as different variables and count l_1 and b_1 in the same manner) and 21 equilibrium conditions (if we count [2.21ab] as one condition and count [2.23ab] in the same manner).

2.3.7 Implications for a Twin Crisis

The initial equilibrium, which is defined by the intersection of the IPLM and Wealth curves, is graphically shown in Figure 2.2.

Figure 2.2: Equilibrium before the Shock



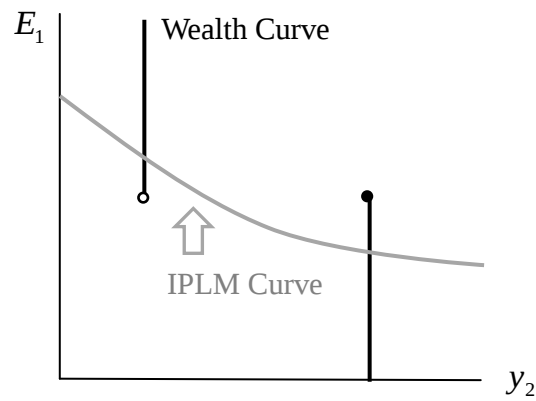
Similar to the original ABB model, we consider the case in which the perceived exchange rate risk premium increases in period 1. Taking into account the fact that the deposit interest rate is a function of three monetary policy variables, the new IPLM curve can be written as

$$E_1 = \frac{1 + i^F}{1 + i_1^D(i_1, \varphi_1, i_1^R)} \frac{M_2^S}{m^D(y_2, i_2, \varphi_2, i_2^R)} + \eta \quad (2.50)$$

where η is the foreign exchange risk premium after the shock. This increase in risk premium shifts the IPLM curve upwards as depicted in Figure 2.3. Now we have a multiple equilibria situation that contains a twin (i.e., banking and currency) crisis equilibrium with low y_2 and high E_1 . Note that the output level of a twin crisis is

small but still positive because firms can invest with their retained earnings when banks bear the exchange rate risk. Recalling that firms produce nothing when their profits are negative in the original ABB model, in which firms have foreign currency denominated debts and bear the exchange rate risk, the output loss in a twin crisis is smaller than in the previous model since the firms' retained earnings can be a buffer.

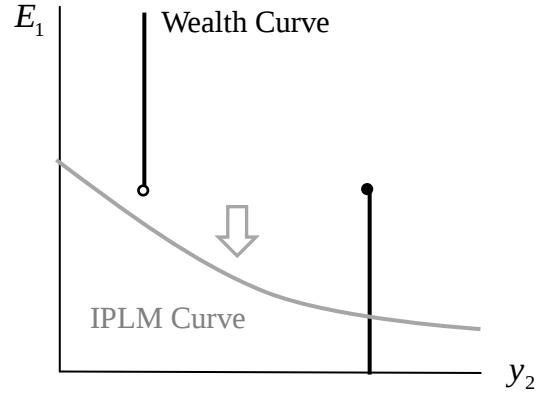
Figure 2.3: Equilibria after the Shock without Policy Response



What kind of monetary policy should the central bank choose in a twin crisis?

The IPLM curve implies that the monetary policy response to prevent a banking and currency crisis is to raise the deposit interest rate during the crisis period (Figure 2.4).

Figure 2.4: Equilibrium after the Shock with Monetary Policy Response



How does the central bank increase the deposit interest rate? Equation (2.16) shows that the central bank should raise the policy interest rate and/or the interest rate on reserves, whereas it should lower the reserve requirement ratio in order to increase the deposit interest rate.

$$i_1^D = i_1 (1 - \varphi_1) + i_1^R \varphi_1 - \gamma_D = i_1 - \underbrace{(i_1 - i_1^R)}_{\substack{+ \\ \downarrow}} \varphi_1 - \gamma_D \quad (2.51)$$

$\uparrow \quad \uparrow \quad \uparrow$

Policy Implications for a Twin Crisis

The monetary policy that prevents a twin banking and currency crisis is to (1) raise the policy interest rate, (2) lower the reserve requirement ratio, and/or (3) raise the interest rate on reserves.

The economic intuition is as follows. A decrease in the reserve requirement ratio (or an increase in the interest rate on reserves) leads to a decrease in the reserve tax imposed on deposits. This reduction in the distortion caused by the required reserves makes deposits more attractive to the commercial bank and hence it increases the deposit interest rate. This increase in the deposit interest rate induces a currency appreciation from the IPLM condition (2.50).

2.4 Conclusion

Prevention of currency and banking crises is an important goal for policy makers, especially for the monetary authority. In this chapter, I developed a twin banking and currency crisis model by extending the third generation model of currency crises developed by Aghion, Bacchetta and Banerjee (2000, 2001, 2004). The key innovation of my model is that commercial banks take foreign currency loans and bear the exchange rate risk in the framework of the ABB model, and I show how a banking crisis occurs and how it transmits to the real economy.

In this twin banking and currency crisis model, I also showed that the monetary authority can use several policy instruments for the prevention of the crisis. The

literature on currency crises has been mainly focused on interest rate defense by the central bank. However, in practice most central banks are using not only the policy interest rate but also other policy instruments to stabilize financial markets. As argued in the literature review (section 2.2.2), one of the most widely and often used policy tools is the reserve requirement policy, which can be an effective tool to stabilize the banking system. Therefore, introducing the banking sector and the reserve system and analyzing the behavior of commercial banks, I examined the effectiveness of several monetary policy tools that can prevent a twin banking and currency crisis and found that the reserve requirement policy is an effective instrument to prevent the crisis.

In summary, the main contribution of this chapter is to construct a twin crisis model in which I extended the ABB model in a way that the exchange rate risk is located in the banking sector and the shock caused by the shift of investors' expectation can trigger a banking and currency crisis, and I provided the mechanism through which the crisis affects the real economy. I also provided an analysis of the monetary policy that prevents a twin crisis when the central bank has multiple policy instruments. I hope that the analysis in this chapter will provide helpful insights when policy makers use several monetary policy measures in a banking and currency crisis.

Chapter 3

Empirical Analysis of the Effects of Monetary Policy and Structural Vulnerability on Exchange Rates from the Perspective of Currency Crises Models

3.1 Introduction

In the first two chapters of this dissertation, I developed theoretical models of currency and twin crises based on the third generation model of currency crises that was originally developed by Aghion, Bacchetta and Banerjee (2000, 2001, 2004) (the ABB model). In Chapter 1, I introduced exports into the ABB model and analyzed how the country's structural vulnerability plays an important role during currency crises. In Chapter 2, I constructed the model in which commercial banks bear the exchange rate risk by extending the ABB model, and analyzed how a monetary authority can respond to prevent currency crises. In this chapter, I conduct an empirical analysis to test hypotheses obtained from these models in the previous two chapters.

This third chapter is organized as follows. I begin with my motivation for this empirical research and the 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 chapter and my dissertation.

3.2 Motivation and Literature Review

Theoretical currency crisis models basically predict that central banks should raise the policy interest rate to prevent currency crises (see Chapter 1 and Chapter 2). 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 the 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 their 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.³¹

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 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 models that I developed in the first two chapters, 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 Chapter 1 of this dissertation. The slope of the Wealth curve is determined by two important factors: exports and foreign

³¹ 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).

debt.³² 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 1999a,b; 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 Vicente, 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 2012), 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;

³² See section 1.2.3 in Chapter 1 for a discussion of the importance of exports during currency crises, in which I review the empirical literature on this topic.

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 Chapter 1 shows that the effects of the shock on a 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 3.6, 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 1999a,b; 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.

3.3 Methodology and Data

3.3.1 Empirical Methodology

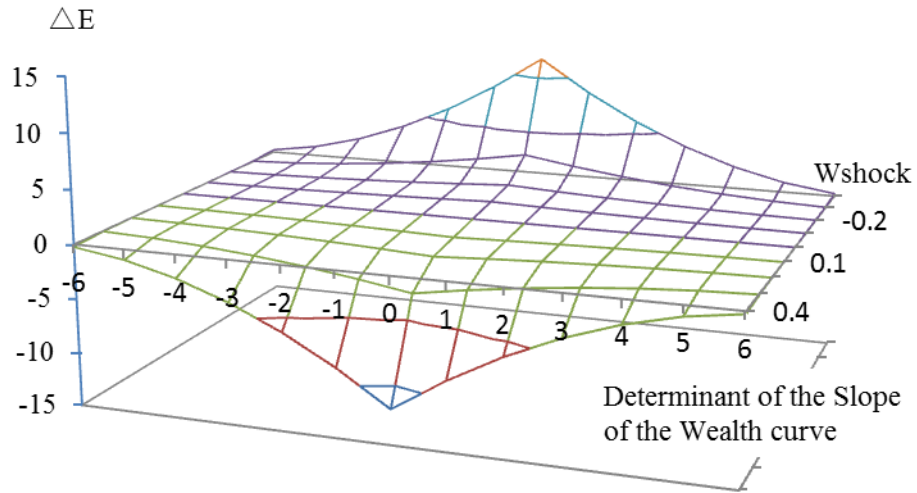
As I derived in Chapter 1, the ABB model shows that the nominal exchange rate is determined by the intersection of two curves: the IPLM curve and the Wealth curve. The derivation and the slope of the IPLM curve are shown in Chapter 1 and the curvature of the IPLM curve is proved in Bergman and Jellingsø (2010). In Chapter 1, 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:

$$\text{Slope of the Wealth curve} \equiv \frac{\Lambda}{(1 + \zeta_i)x_{i,t} - (1 + i_t^*)l_{i,t}^*} \gtrless 0. \quad (3.1)$$

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 (3.1), $(1 + \zeta_i)x_{i,t} - (1 + i_t^*)l_{i,t}^*$, 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 3.1). 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 3.2.

Figure 3.1: The Effects of W-Shock on Exchange Rates



Then I construct the following variable:

$$W-Slope_{i,t} \equiv \bar{\Theta} + \frac{(1+\zeta_i)x_{i,t} - (1+i_t^*)_{i,t}^*}{GDP_{i,t}} \quad \text{if} \quad \frac{(1+\zeta_i)x_{i,t} - (1+i_t^*)_{i,t}^*}{GDP_{i,t}} \geq 0 \quad (3.2a)$$

$$W-Slope_{i,t} \equiv \underline{\Theta} - \frac{(1+\zeta_i)x_{i,t} - (1+i_t^*)_{i,t}^*}{GDP_{i,t}} \quad \text{if} \quad \frac{(1+\zeta_i)x_{i,t} - (1+i_t^*)_{i,t}^*}{GDP_{i,t}} < 0 \quad (3.2b)$$

where $\bar{\Theta}$ is an upper limit of the distribution of a determinant of the sign of the slope and $\underline{\Theta}$ is a lower limit of the distribution. As we can see from Figure 3.2, 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):

$$\ln X_t^i = \alpha_1^i + \alpha_2^i \ln REER_t^i + \alpha_3^i \ln Demand_t^i + \nu_t^i \quad (3.3)$$

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 ν_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 (3.3) 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:

$$\begin{aligned} \Delta E_{i,t} = & \beta_0 + \beta_1 \Delta E_{i,t-1} + \beta_2 \Delta i_{i,t} + \beta_3 \frac{l_{i,t}^*}{GDP_{i,t}} + \beta_4 IPLMshock_{i,t} + \beta_5 Wshock_{i,t} \\ & + \beta_6 Wshock_{i,t} Wslope_{i,t} + \beta_7 Z_{i,t} + v_i + \varepsilon_{i,t} \end{aligned} \quad (3.4)$$

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; v_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 Ordinary Least Squares estimation of equation (3.4) 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 3.4). 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:

$$\delta_t^i = \gamma_1^i + \gamma_2^i HPtrend_t^i + \gamma_3^i \Gamma_t^i + \eta_t^i \quad (3.5)$$

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., $\delta_t^i \equiv i_{i,t} - i_{US,t}$)³³; $HPtrend_t^i$: 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.

³³ 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."

3.3.2 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 3.1.

Table 3.1: 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 $\times$ 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 3.2 (Im, Pesaran and Shin 2003; Maddala and Wu 1999; Choi 2001).³⁴ A number of panel unit root tests indicate that all variables are stationary at the 5 % level of significance.

Table 3.2: Panel Unit Root Tests

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

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

³⁴ 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.

3.4 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.³⁵ The baseline estimation results are presented in Table 3.3. 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.³⁶ In the benchmark regression, the number of lags of each independent variable is set at two.

³⁵ Windmeijer (2005) found that the efficient two-step GMM estimator outperforms somewhat the one-step GMM estimator in estimating coefficients with lower bias.

³⁶ 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 Bover (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 3.3, 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 % level in the first three columns and at the 5 % 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 % level in the first three columns and at the 5 % 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 % 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 % 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, $W\text{-shock} \times W\text{-slope}$, 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 % 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 be 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 % level in the first three columns and at the 10 % level in the last column. This result is consistent with the prediction of the first generation models of currency crises.

Table 3.3: Results of Generalized Method of Moments (Arellano-Bond) Estimations

Variable	(1)	(2)	(3)	(4)
Lagged Dependent Variable	0.106*** (0.019)	0.107*** (0.007)	0.130*** (0.021)	0.128*** (0.024)
Interest Rate Policy	-0.409*** (0.013)	-0.483*** (0.053)	-0.414*** (0.031)	-0.272** (0.123)
Short-term External Debt / GDP	0.205*** (0.014)	1.985*** (0.066)	2.316*** (0.378)	1.138** (0.537)
IPLM-Shock	0.292*** (0.010)		0.201*** (0.011)	0.184** (0.078)
W-Shock		-2.872*** (0.234)	-2.783*** (0.454)	-18.717*** (4.937)
W-Shock $\times$ W-Slope				2.491*** (0.724)
Deviation GDP Growth	-1.765*** (0.055)	0.452** (0.184)	0.431 (0.462)	0.018 (0.260)
Exchange Rate Overvaluation	-0.723*** (0.011)	-1.726*** (0.054)	-1.606*** (0.139)	-1.666*** (0.149)
Foreign Reserves / Imports	-11.262*** (1.625)	-24.411*** (4.044)	-18.132*** (5.284)	-7.065* (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 3.3 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 3.4. 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 3.4 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 % 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 % 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 3.4 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 3.4: 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 $\times$ 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.

3.5 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 3.5 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 % 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 % 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 % 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 % 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 % 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 3.5: Results of Fixed-Effects Instrumental Variables Regressions (2SLS)

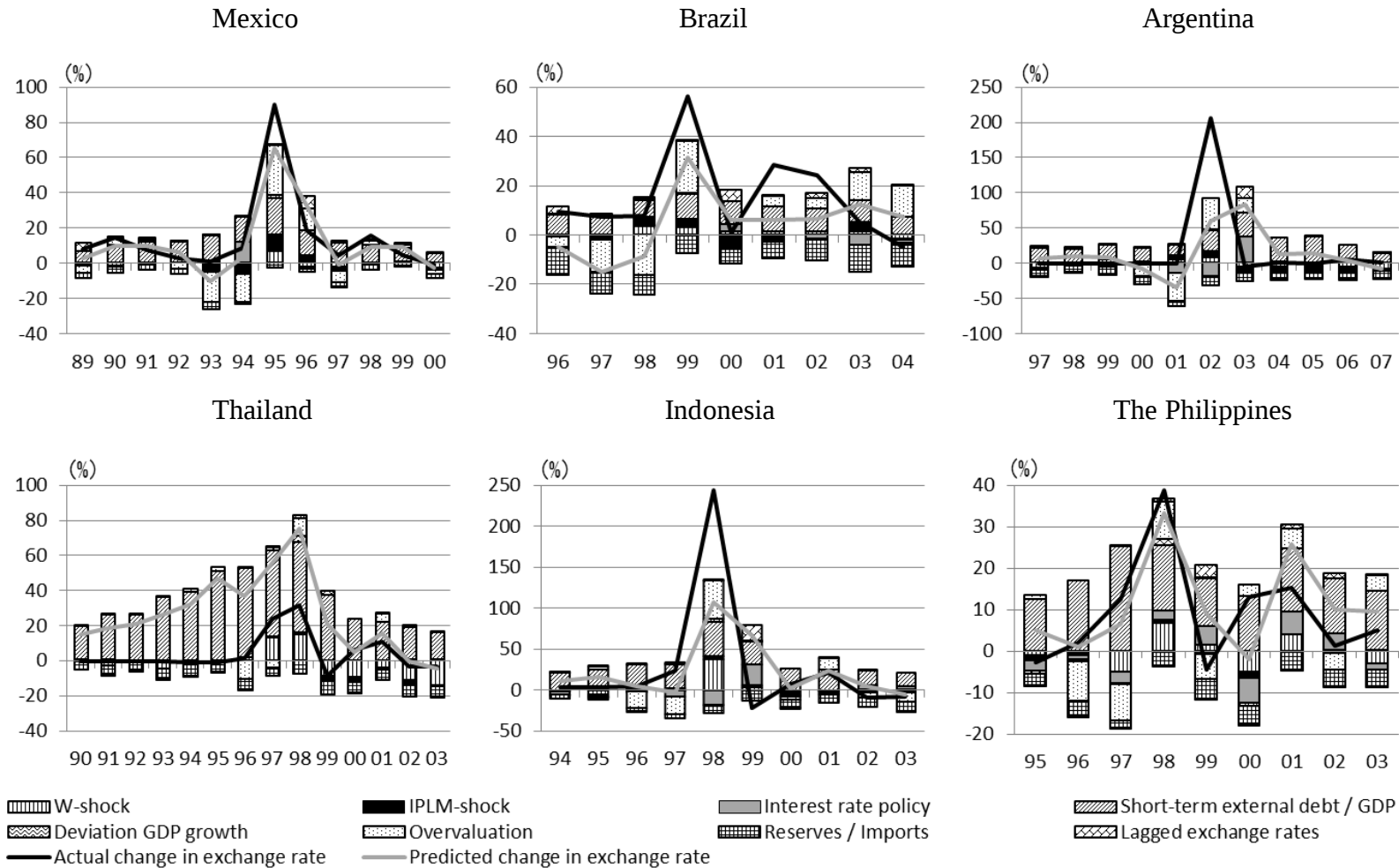
Variable	(9)	(10)	(11)	(12)
Lagged Dependent Variable	0.143** (0.070)	0.141* (0.080)	0.140 (0.088)	0.161* (0.088)
Interest Rate Policy	-2.601*** (0.461)	-2.655*** (0.497)	-2.630*** (0.527)	-2.631*** (0.524)
Short-term External Debt / GDP	0.371 (0.288)	1.516** (0.687)	2.150** (0.962)	1.925** (0.962)
IPLM-Shock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

3.6 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 Republic of the Philippines (referred to as the Philippines); the Brazilian crisis in 1999 and the Argentine crisis in 2001-02. Figure 3.3 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 3.4 to predict the changes in exchange rates since this is the most econometrically sophisticated model in my analysis.

Figure 3.3: 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 1996³⁷). 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 investors' 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

³⁷ 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 Végh 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 debt³⁸ 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

³⁸ More than 80 % 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 3.3 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 dissertation, 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 extraordinary 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 for 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 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's 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 the 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.

3.7 Conclusion

In this third chapter, 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 the previous two chapters of this dissertation 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 models in the first chapter, 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 dissertation. 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 last chapter 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

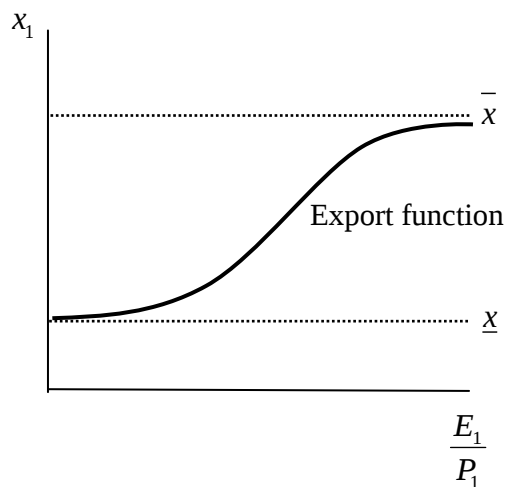
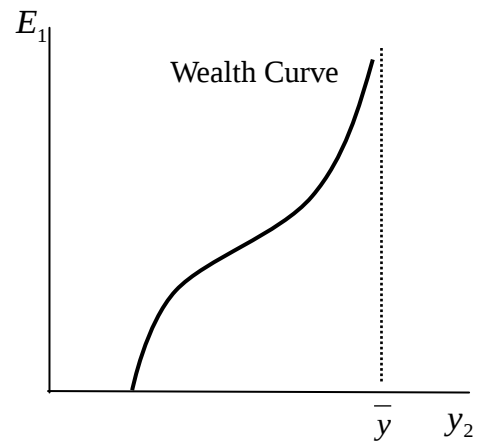


Figure A.2: Wealth Curve



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

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

where $\Phi(c_t + x_t)$ is a cost function that includes various costs such as operating costs and/or fixed set-up costs.³⁹ The firm maximizes its profit subject to an export demand that is a function of real exchange rates and foreign demand

$$x_t = x^d \left(\frac{E_t}{P_t}, y_t^* \right).^{40}$$

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.

³⁹ 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.

⁴⁰ While it has not been analyzed in this dissertation, this model should be analyzed further by incorporating imports into the model.

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

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

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	Republic of the 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 (3.5). 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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