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Twin Crises and the Financial Accelerator

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Twin Crises and the Financial Accelerator

By

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Abstract

The incidence of simultaneous banking and currency crises is a recurring theme in emerging economies operating under fixed or quasi-fixed exchange rates. This thesis conducts an empirical analysis of the underlying determinants of so called "twin crises" by applying a probit econometric model to a sample of 48 emerging economies during the 1980-2013 period. Current account deficits are found to be a robust driver of twin crises, with vulnerability increasing in the size of the deficit relative to GDP. There is also evidence that real exchange rate appreciation and higher levels of short-term debt relative to reserves increase crisis probability. Recommendations for prevention policies include a reduction in agency costs through improved regulation and data transparency, the implementation of a managed float exchange rate regime, and the use of price-based controls on capital inflows.

To my parents.

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I: Introduction

A common theme in modern financial history is the occurrence of simultaneous banking and currency crises. From Latin America in the early 1980s to Asia in the late 1990s, so called "twin crises" have routinely decimated the economies of emerging nations, leading to large and painful contractions in real economic activity. In its most basic form, a twin crisis entails a situation in which a country experiences in rapid succession, yet in no particular order, a severe depreciation of its exchange rate along with widespread failures in its financial system. The notion that banking and currency crises are closely linked was popularized by Graciela Kaminsky and Carmen Reinhart (1999), who in an influential paper find that the onset of a banking panic dramatically increases the likelihood that a country falls victim to a currency crisis. Elsewhere in the literature, others have argued that it is the presence of a fixed exchange rate that in fact sets the conditions for capital flight and a banking collapse. Regardless of the causal direction, it is clear that the costs of twin crises are high; Kaminsky and Reinhart (1999) find that losses in terms of GDP and reserve depletion tend to be larger in twin episodes than if either situation were to occur independently, while Hoggarth, Reis, and Saporta (2001) calculate the average fiscal costs borne by governments of twin crisis-affected countries to be 22.9% of GDP.

The twin crisis phenomenon is not confined to emerging economies, yet it remains true that these crises tend to strike emerging nations harder and far more frequently, acting as a substantial impediment to the development process. For emerging market governments hoping to achieve financial stability, an understanding of the anatomy of twin crises is critical for designing appropriate prevention policies. This thesis attempts to clarify the underlying

determinants of twin crises, offering a more general view than previous analyses which have focused intently on the dynamics of the episodes after which they were written. To do so, we conduct a probit econometric analysis of 48 emerging economies during the 1980-2013 period, covering nearly all recorded instances of twin episodes. Current account deficits are shown to be a robust driver of twin crises, with vulnerability increasing in the overall deficit as a percentage of GDP. There is also evidence that real exchange rate appreciation and higher levels of short-term debt relative to reserves increase crisis probability, although these results are less robust to subsample estimations that attempt to control for cross-sectional heterogeneity.

Central to our findings is that twin crises are, above all else, driven by the boom and bust nature of international capital flows. As emerging economies open-up to global capital markets, funds tend to arrive *en masse*, sustaining large current account deficits and, in cases where regulation is weak, imprudent consumption and investment spending. When capital flows eventually reverse course, the demands placed on both the central bank and individual borrowers to produce foreign exchange become insurmountable, and the exchange rate and banking systems crumble under the weight of large-scale withdrawals. Agency costs of borrowing play a key role in this process, with high-cost emerging nations subject to a "flight to quality" as outlined by Bernanke, Gertler, and Gilchrist (1996). The flight to quality occurs as lenders in times of stress funnel capital away from high-agency-cost borrowers and toward more stable nations and firms. Given this general outline, policies to reduce agency costs, ensure stability in the current account, and control the flow of international capital are proposed as a means of preventing twin crises.

The remainder of this thesis is as follows: Section Two discusses the relevant literature, focusing on the split between those who view fundamental factors as the proximate cause of twin

crises and those who favor financial panic explanations. The financial accelerator model

proposed by Bernanke, Gertler, and Gilchrist (1996) is also explored in the context of

international episodes; Section Three develops a conceptual framework following the debt-run

model put forward by Rodrik and Velasco (1999); Section Four outlines the broad features of our

empirical analysis, while Section Five presents the econometric results; Section Six analyzes

policy implications, and Section Seven concludes.

II: Literature Review

From an analytical standpoint, twin crises are unique in that they lie beyond the scope of

both first generation balance-of-payments models in the vein of Krugman (1979), and second-

generation models which follow Obstfeld (1994). In the first generation conception offered by

Krugman (1979), governments are able to defend an exchange rate peg by gradually depleting

foreign reserves, a strategy that is effective until market participants launch a speculative attack

on the currency, immediately draining reserves before they would have run out under normal

circumstances. This model necessarily assumes that the maintenance of a fixed-rate regime is

unsustainable in the long-run, as evidenced by steady reserve depletion. Obstfeld (1994) shows

that the collapse of an exchange rate need not be conditioned on underlying instability, but rather

can occur in a self-fulfilling manner, as governments are prompted to abandon pegs when the

welfare costs of maintenance exceed the costs of devaluation. Maintenance costs are in turn

dependent on market expectations, with a relatively flat loss function representing a belief in

"credible commitment" to the peg, and a steeper loss function representing non-credible

commitment. Where these functions are superimposed and the non-credible curve lies above the

abandonment threshold, a shift in expectations toward non-credibility motivates the government

to devalue, and a collapse of the currency therefore becomes an endogenous outcome of investors' beliefs (Arghyrou and Tsoukalas 2011).

A notable shortcoming of both the first and second generation models is that they fail to connect banking and currency crises, despite empirical evidence which suggests the two are intimately linked (Kaminsky and Reinhart 1999). Kaminsky and Reinhart (1999) study a sample of 26 banking and 76 currency crises between 1970 and 1995, identifying 19 instances where the two occurred in the same country within 48 months. The authors show that while the unconditional probability of a currency crisis in their sample is 29 percent, the probability of one occurring within twenty-four months after the start of a banking crisis is 46 percent. This finding suggests that banking crises play a large role in precipitating exchange rate issues.

In addition to Kaminsky and Reinhart's (1999) aforementioned findings on the costs of twin crises, Reinhart and Rogoff (2009) show that losses in terms of GDP following twin episodes in Malaysia, Thailand, Indonesia, and Argentina all exceeded the historical average for banking crises. Hoggarth, Reis, and Saporta (2001) calculate the average fiscal costs borne by governments of twin crisis-affected countries to be 22.9% of GDP, versus only 4.6% when just a banking crisis occurs. Taken in sum, relevant data clearly exhibit the severity with which twin crises can topple emerging economies.

The Fundamental View

Central to Kaminsky and Reinhart's work is a contention that twin crises almost always stem from fundamental weaknesses that develop in the wake of financial liberalization, a view that has found wide support in the literature. Goldfajn and Valdes (1997) argue that, due to deregulation, both capital inflows and domestic credit provision tend to increase markedly in the years immediately preceding crises. These developments are identified as key harbingers of

banking problems by Sachs, Tornell, and Velasco (1998). Kaminsky and Reinhart (1999) add empirical strength to this view, showing that the ratio of both M2/foreign reserves (a measure of international exposure) and domestic credit/GDP dramatically exceed normal levels during the build-up to twin episodes. As a result, both output and exports lag their respective averages in pre-crisis periods. A large body of literature has fallen in-line with the argument that liberalization-induced weaknesses lie at the heart of twin crises, and this point of view will henceforth be referred to as the "fundamental school."

A commonly cited driver of post-liberalization crises is moral hazard, or the failure of economic agents to protect against risks due to the implicit or explicit presence of some form of insurance. Corsetti, Pesenti, and Roubini (1998) develop a formal model in which moral hazard leads to eventual exchange rate and financial collapse by encouraging risky credit provision. Under this framework, implicit or explicit guarantees of private debt by the government create an incentive for foreign lenders to finance unprofitable investments made by domestic firms. This practice is sustainable until publicly-backed debts exceed foreign reserves, at which point expectations of inflationary financing set in and the currency falls under speculative attack. Reserves become insufficient to bail-out domestic firms, resulting in a financial crisis. Corsetti, Pesenti, and Roubini test their model through a linear regression of financial and fundamental variables against a "crisis index", finding that large current account deficits, high levels of non-performing loans, and low foreign reserves relative to the domestic stock of money all contribute significantly to the development and worsening of twin crises.[1]

Additional empirical backing for the moral hazard explanation is provided by Demirgüç-Kunt and Detragiache (1998), who through a multivariate logit model find that the presence of

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[1] The crisis index developed by Corsetti, Pesenti, and Roubini (1998) represents a weighted average of the percentage rate of currency depreciation against the U.S. dollar and percentage rate of foreign reserve depletion.

deposit insurance increases the likelihood that a country falls victim to a banking crisis. This interesting result suggests that the guarantees provided by deposit insurance contribute to excessive lending under conditions of moral hazard. Although not captured explicitly in their model, Demirgüç-Kunt and Detragiache (1998) note that the relationship between deposit insurance and moral hazard is likely present only in situations where financial liberalization reduces prudential regulation of the banking system. Supporting the notion that fundamental weaknesses can also contribute to a slowdown in the real economy, Demirgüç-Kunt and Detragiache (1998) show low GDP growth, high inflation, and high real rates of interest to be closely associated with banking crises. Furthermore, high levels of M2/reserves are revealed to increase crisis probability, consistent with Kaminsky and Reinhart (1999) and Corsetti, Pesenti, and Roubini (1998). While Demirgüç-Kunt and Detragiache (1998) focus their analysis solely on banking crises, their results are significant given the connection between banking and currency panics demonstrated in Kaminsky and Reinhart (1999).

Sachs, Tornell, and Velasco (1998) make an important extension to the preceding literature by demonstrating how weak fundamentals can create the conditions necessary for self-fulfilling runs on central and commercial banks. The authors argue that foreign investors gauge returns in terms of their own currency, and therefore consider the possibility of devaluation when investing abroad. Rational investors assume that so long as the recipient country's central bank maintains reserves in excess of the domestic money supply (guaranteeing its ability to meet all redemptions), then a devaluation is unnecessary even in the event of a large capital outflow. If reserves fall below the money supply, a country must address outflows and the ensuing balance-of-payments shortfall in two ways: reducing domestic consumption and investment, or electing for a real exchange rate devaluation. Nations with frail banking systems will have little appetite

for the former option due to its recessionary consequences, and are thus believed to prefer devaluation. Given this belief, the rational equilibrium entails runs on the banking system and exchange rate regime, actions which in and of themselves bring about the originally feared devaluation.

Sachs, Tornell, and Velasco (1998) test this model empirically using panel data for a sample of twenty countries between 1994 and 1995, a period coinciding with crises in Mexico and Argentina, among others. As expected, they find that significant real exchange rate appreciation, large increases in bank loans/GDP, and high levels of M2/reserves all help to predict the incidence of a crisis. Most notably, if fundamentals (measured by exchange rate appreciation and credit expansion) are weak but M2/reserves is low, crises are unlikely, supporting the authors' conjecture that insufficient reserves are necessary for a crisis to become self-fulfilling.

The Financial Panic View

At its core, the fundamental view of twin crises can be thought of as focusing on the asset side of a country's balance sheet; while crises are ultimately manifested as a run on liabilities, it is deteriorating asset quality which serves as the impetus for the necessary shift in expectations. In contrast, a second, competing school argues that such episodes in fact stem from the liability side, taking the form of self-fulfilling crises which require little or no fundamental weakness. Following Chang (1999), this line of reasoning is known as the "financial panic view." Models in the financial panic tradition overwhelmingly rely on the seminal bank run model presented by Diamond and Dybvig (1983), and any discussion of their predictions therefore requires an explanation this cornerstone theory.

Diamond (2007) provides a clear, simplified description of the Diamond and Dybivg (1983) model. Diamond and Dybvig begin with the assumption that there are two types of investors in the world: Type 1, who prefer to consume in time $T = 1$, and Type 2, who prefer to consume in time $T = 2$. At $T = 0$, all agents are given 1 unit to invest, but do not know whether they will end up being Type 1 or Type 2 consumers. The probability of any agent being Type 1 is given by t, and the probability of being Type 2 is therefore $(1 - t)$. Because agents are unsure of their consumption preferences, but cannot directly insure against this uncertainty, all favor investment in a liquid asset over an illiquid one.[2] Diamond and Dybvig (1983) further assume that, despite this preference, all investors must hold the illiquid asset if they are to do so directly. Banks, however, can transform agents' illiquid holdings into liquid demand deposits, and thus serve an important intermediary function.

Diamond (2007) shows that banks' ability to transform liquidity is made possible by investing their depositors' money in an illiquid asset that provides a return, R, in $T = 2$ that is greater than the return achievable in $T = 1$. Given this, they can offer all depositors a liquid asset that returns r_1 in period 1, and $r_2 = \frac{[1-tr_1]R}{1-t}$ in period 2 (Diamond 2007). Importantly, the period 1 return of this liquid asset is greater than the period 1 return offered by selling the original illiquid asset early (Diamond 2007). Note also that the payout promised to investors in period 2 is simply the rate of return provided by the illiquid asset, times the number of assets remaining in the bank in period 2 (after Type 1 investors have withdrawn), split among all remaining depositors. The bank has therefore created liquidity, giving investors the option to withdraw in either period 1 or 2 and still realize an appropriate return. Witness, though, that if enough

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[2] Diamond (2007) demonstrates this numerically. The investor's utility function is represented by $tU(r_1) + (1 - t)U(r_2)$. If $t = 0.25$, and the return profile of the illiquid asset is $(r_1 = 1, r_2 = 2)$, then the utility from the illiquid asset is $0.25(1) + 0.75(2) = 0.375$. If a more liquid asset has a return profile of $(r_1 = 1.28, r_2 = 1.813)$, then utility from this more liquid asset is $0.25(1.28) + 0.75(1.813) = 0.391 > 0.375$. Investors therefore prefer the more liquid asset.

depositors (denoted by f) seek to withdraw in period 1, so that $f\,r_1$ is greater than the bank's total

portfolio value, then the bank is suddenly unable to give investors their promised returns in either

period (Diamond 2007). If investors expect that withdrawals will be substantial enough to meet

this condition, the rational choice is for all of them to withdraw immediately, leading to a

collapse of the institution. Critical to this analysis is the role of expectations; so long as agents

believe that withdrawals will not exceed a level that causes the bank to fail, equilibrium dictates

that the bank will in fact not fail. Banking crises in the Diamond-Dybvig framework are

therefore entirely self-fulfilling phenomena, with both the run and remain equilibria representing

perfectly rational outcomes given investors' expectations of how others will behave.[3]

Goldfajn and Valdes (1997) extend Diamond-Dybvig (1983) to explain large capital

outflows consistent with twin episodes. For any investment in a foreign country, there is a

threshold level of profitability that makes it preferable to hold assets in this country as opposed

to more liquid international alternatives. Below this level, the rational choice is to invest

elsewhere. Because such investments are made through banks and other financial intermediaries,

the profitability threshold can be thought of as the return R of an illiquid asset, as in Diamond-

Dybvig. In Goldfajn and Valdes's case, R is dependent on the returns given by domestic

technology, so that an adverse development such as a productivity shock can push expectations

toward the run equilibrium. Because the banking system's liabilities are ultimately denominated

in foreign currency (due to free convertibility), this equilibrium also takes the form of a run on

the central bank, which must either draw down reserves to meet redemptions or devalue.

Another interesting possibility in this model is that the shock which sets off a run is the fear of

devaluation itself, as a devaluation would push the return to investors (denominated in their own

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[3] The summary of Diamond-Dybvig (1983) provided here draws heavily on Diamond (2007).

currency) below the run-threshold level. Goldfajn and Valdes's analysis is very similar to that of

Sachs, Tornell, and Velasco (1998), yet doesn't require weak fundamentals pre-shock.

While many analysts examine financial panic in the context of self-fulfilling runs,

Marshall (1998) stresses the risks of large-scale coordination failure. To explain how

coordination failure can facilitate systemic crises, he first assumes that all economies require a

specific level of external credit in order to finance working capital. Above this level,

investments in the country produce returns in excess of safe international alternatives, but below

the threshold, returns are 0 as the country collectively fails to meet its working capital needs.

Critically, Marshall makes the realistic assumption that a nation's financing requirements are

beyond what any one lender can provide on its own. As a result, there exists a clear coordination

problem: if all lenders provide enough capital, then all achieve a return in excess of available

alternatives. If lenders believe that a sufficient number of others will opt-out, then they too will

opt out (Marshall 1998). Rather than cause a run on banks, the opt-out equilibrium in this case

entails a severe deficiency in capital used to finance business investment, leading to sharp

contraction in economic output and a collapse of the exchange rate. Marshall (1998) notes that

the recessionary dynamics at work here are similar to those in Keynes's (1936) "beauty contest"

metaphor, wherein aggregate investment is largely dependent on market participants'

assessments of others' willingness to invest. As bankruptcies begin to pile up, financial

institutions accumulate non-performing loans, and they too experience crises. The systemic

panic engendered by coordination failure is entirely avoidable so long as enough capital is

forthcoming from investors, demonstrating that countries need not have poor fundamentals to

experience a twin crisis.

Analyzing the East Asian crises of the late 1990s, Radelet and Sachs (1998) also point to coordination failure as a potential source of crisis development. Radelet and Sachs note that an important distinction exists between an insolvent borrower, which lacks the net worth to honor its obligations, and an *illiquid* borrower, which simply lacks the cash to do so immediately. In their view, countries can have perfectly strong fundamentals (indicating solvency) and still be prone to liquidity crises should short-term obligations exceed the ability to repay all at once. Crucially, even an illiquid borrower can survive if creditors agree to roll over debt, and coordination among lenders, or lack thereof, is thus central to the determination of whether or not a country enters crisis. Radelet and Sachs show that Thailand, Argentina, Mexico, Indonesia, and Korea all maintained short-term debt/reserve ratios greater than one in the years immediately before suffering twin crises, suggesting that illiquidity was indeed a factor in generating vulnerability. Yet at the same time, the Philippines, which experienced a twin crisis in 1997, held sufficient reserves to meet its obligations, indicating that although illiquidity increases the risk of a crisis, it is not required for one to occur. Indeed, Hong Kong fell victim to speculative attacks against both its currency and stock market in 1998 despite maintaining complete U.S. dollar backing of the monetary base (due to a currency board regime). While Hong Kong was able to repel the attacks, maintenance of its peg came at the expense of a more than 5% decline in real GDP (Harake and Meade 2014). Hong Kong's experience further illustrates the fact that illiquidity is a sufficient but not necessary condition for economic crises to occur in the event of mass capital outflows.

As many analysts, including Radelet and Sachs (1998), stress, a high ratio of M2 to foreign reserves appears to expose a country to twin crises by making it vulnerable to currency-crushing capital outflows. Within the literature, this condition has been dubbed "international

illiquidity", and is explored formally by Chang and Velasco (2000). Chang and Velasco (2000) contend that under a fixed-rate regime, "the liabilities of banks are, implicitly, obligations in international currency." Runs are therefore possible when foreign liabilities exceed liquid reserves, as complete repayment would be impossible at the existing rate. Chang and Velasco (2000) note that in the event of a crisis, the central bank can defend the peg, eliminating its lender of last resort function, or abandon the peg and extend credit to the banking system, which would serve to deplete already scant reserves. Whether a crisis takes the form of a banking or currency panic is therefore dependent on central bank policy, but in either case the emergence of a run is conditioned on international illiquidity.

Rodrik and Velasco (1999) examine the issues posed by illiquidity empirically, sampling 32 emerging economies in the 1988-1998 period. They find that countries which experienced financial crises ran short-term debt/reserve levels roughly twice those of non-crisis countries. Furthermore, the authors provide statistically robust probit regressions showing that a ratio of short-term foreign obligations/reserves in excess of one nearly triples the probability of a crisis in their sample. It is important to recognize that Rodrik and Velasco define a crisis as a sudden outflow of foreign capital greater than 5% of GDP. While in theory it is possible for such outflows to occur in the absence of a twin episode, the authors point out that their criteria leads to the inclusion of nearly all crises identified by studies which considered broader measures such as currency depreciation and reserve depletion.

The Financial Accelerator

Both the fundamental and financial panic schools present clear views on the factors which make developing economies vulnerable to crises, as well as on the catalysts which finally set the crises off, but where the extant literature is lacking is in explaining the "small shock, large

cycle"[4] phenomenon which often characterizes twin episodes. As many twin crisis observers

recognize, events such as those in Southeast Asia during the 1990s defy conventional models in

that the severity of the incident tends to drastically exceed prediction. The question of why

seemingly insignificant stimuli can (in the spirit of the fundamental school) lead to widespread

deterioration in the real economy, or (in the spirit of the panic view) push an economy toward the

run equilibrium is thus critical in understanding the nature and development of twin crises.

Bernanke, Gertler, and Gilchrist (1996) demonstrate how adverse shocks are multiplied

by credit markets, through an effect they term "the financial accelerator." The authors begin

under the assumption that, as previous literature shows, financing is more costly for firms to

obtain externally rather than internally due to the agency costs of lending. Interest rates on

external finance are taken to be inversely proportional to a firm's net worth, which Bernanke,

Gertler, and Gilchrist (1996) define as the "sum of its gross cash flows and net discounted

assets." Furthermore, it is assumed that all lending must be collateralized, making net worth the

upper bound on potential indebtedness. From these assumptions, Bernanke, Gertler, and

Gilchrist (1996) make clear that a decline in either cash flows or asset value reduces net worth,

restricting available credit and raising premiums on any credit that is forthcoming. As a result,

investment falls, cash flows are reduced further, and a vicious cycle of continually tightened

credit conditions sets in. Bernanke and Gertler (1989) argue that the preceding dynamics are

possible on a macro level as well, with even a small economy-wide shock bringing about a

similar cycle of declining cash flow and investment.

The aggregate supply-aggregate demand graph below illustrates how the financial

accelerator can magnify shocks to an economy. Suppose that there is a productivity shock that

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[4] Bernanke, Gertler, and Gilchrist (1996).

causes the AS curve to shift upwards to AS_1.[5] The consequent decline in real output causes an overall drop in the net worth of firms (given the national income accounting identity), leading financial intermediaries to both scale-back credit and raise the cost of any they make available. With credit now scarce, investment is curtailed, and the AD curve shifts downwards to AD_1. Output falls to Y_2, at which point the net worth of firms is further reduced, generating even tighter credit conditions which push aggregate demand to AD_2. While the example provided here assumes the vicious cycle ceases once output reaches Y_3, the financial accelerator literature is unclear on when exactly the economy stabilizes. In practice, countercyclical fiscal and monetary policies would be the most obvious mechanisms used to stem a downward credit-output spiral.

FIGURE 1: AS-AD MODEL WITH FINANCIAL ACCELERATOR

P

AS_1

AS_0

AD_0

AD_1

AD_2

Y_3 Y_2 Y_1 Y_0

Y
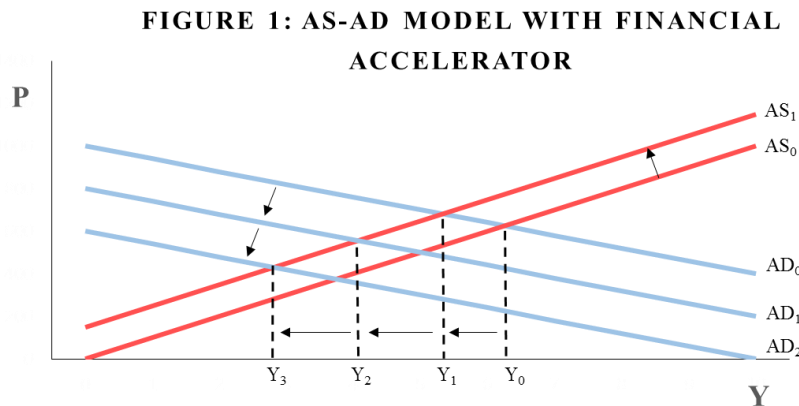
Another important consideration of the financial accelerator model as put forth by Bernanke, Gertler, and Gilchrist (1996) is the "flight to quality", a process whereby lenders restrict credit to at-risk borrowers, channeling it instead to safe alternatives. The shift towards safer borrowers occurs during periods of economic stress, as enhanced bankruptcy risk increases

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[5] The example of a productivity shock is given by Bernanke, Gertler, and Gilchrist (1996) in discussing the macroeconomic features of the financial accelerator.

the agency costs associated with lending to low net worth firms. Agency costs lie at the heart of the financial accelerator, leading in adverse conditions to severe credit restriction for those who require liquidity most. Rationing in the presence of agency costs has also been explored by Stiglitz and Weiss (1981), who demonstrate the potential for interest rates to screen borrowers, and Holmstron and Tirole (1997), who show that the costs of monitoring loans can cause intermediaries to restrict credit to weaker borrowers.

The most notable exposition of financial accelerator phenomena in the twin crisis literature is provided by Krugman (1999), who models a situation whereby high leverage, particularly in foreign currency, creates a "feedback loop" between firms, credit markets, and the exchange rate regime. Under Krugman's formulation, expectations that borrowers lack sufficient net worth generate credit tightening, which in turn promotes a depreciation in the real exchange rate, setting off a chain of bankruptcies and validating the original decision to withhold capital. Gertler, Gilchrist, and Natalucci (2007) also study balance sheet effects of this sort, noting that interest rate hikes in defense of a peg serve to curtail investment and exacerbate financial accelerator dynamics already underway. Furthermore, rising interest rates reduce the present discounted value of firms' assets, dragging down net worth, while at the same time increasing their debt burdens, ultimately raising questions about solvency (Bernanke, Gertler, and Gilchrist 1996; Furman et al. 1998). In both cases, the net effect is once again a flight to quality and reduction in at-risk borrowers' access to credit.

As a real world example of financial accelerator dynamics, one can look to the policies enacted in response to the Asian crises of 1997-1998. Beginning with the devaluation of the Thai baht in July 1997, a wave of panic spread over Southeast Asia, leading to successive attacks against the Malaysian ringgit, Indonesian rupiah, Korean won, Philippine peso, and Hong Kong

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dollar. To counter the severe pressure mounting against these currencies, central banks rapidly pushed up short-term interest rates. Interest rates were raised again following each country's eventual devaluation, a policy suggested, and later required, by the International Monetary Fund as a means to stem inflation and any additional depreciation. Furman et al. (1998) argue that these contractionary monetary policies not only constrained output, but acted to raise bankruptcy risk among weak firms, reducing expected returns in the affected economies and prompting additional capital flight. Radelet and Sachs (1998) further contend that the true effect of tight monetary policy was not stabilization of exchange rates, which continued to fall, but rather a substantial drop in output due to enhanced financial fragility. The authors point to a statement from the IMF itself, which conceded that "the tightening of monetary conditions [in Indonesia] transferred market pressures to the domestic economy, putting heavy strains on the already-weak financial sector" (Radelet and Sachs 1998, p.65).

In the context of the Asian crisis, it is important to note that the initial tightening of credit came not from the private sector, as occurs in Bernanke, Gertler, and Gilchrist's (1996) model, but from direct monetary policy actions taken by the region's respective central banks (at the insistence of the IMF). Nonetheless, anecdotal evidence suggests that the consequent effects on output and bankruptcy risk sparked the very processes predicted by financial accelerator models. Stiglitz (2010) makes a similar contention, arguing that the pro-cyclical monetary and fiscal policies which often accompany "Washington consensus" packages serve to magnify the size of economic fluctuations. In this view, government programs and the financial accelerator exist in a type of positive feedback loop, with successive drops in output prompting further monetary and fiscal tightening and thus further credit scarcity. Additionally, to the extent that tight credit

conditions not only reduce output, but also induce capital flight by signaling distress, the financial accelerator is consistent in part with both the fundamental and financial panic schools.

While the analyses presented by Krugman (1999), Bernanke, Gertler, and Gilchrist (1996) and others view financial accelerator effects at the firm level, it is not difficult to extend their ideas to international markets. If one takes the aggregate worth of a country (measured in gross domestic product) to be analogous to firm net worth, then it becomes plausible to analyze credit rationing and the flight to quality as a possible explanation for the rapid capital outflows observed during twin crises. Agency costs are also likely to play a role in driving the flow of international capital, as high-cost borrowers, primarily in emerging markets, are more susceptible to the flight to quality. The financial accelerator theory can therefore prove useful in explaining the exacerbation of shocks both within and between affected nations.

III: Conceptual Model

As both theory and historical experience show, rapid and severe capital outflows constitute a central feature of twin crises. Such outflows typically take the form of runs, whether on short-term debt, commercial banks, or foreign reserves held at the central bank, and in almost all cases lead to a collapse of the financial system. Given the critical role of runs in causing twin crises, this thesis proceeds with a conceptual framework that builds upon the short-term debt model developed by Rodrik and Velasco (1999).

In the Rodrik and Velasco model, an investor is given k units in period 0 to invest in an illiquid asset which returns $R > 1$ in period 2 and $\rho < 1$ if liquidated in period 1. It is assumed that k is funded with some combination of short-term borrowing d and long-term borrowing $(k - d)$. Short-term debt matures in period 1, at which point holders of d, who operate under

rational expectations, can either demand repayment or roll over into period 2. If all short-term

creditors seek repayment, the investor is forced to liquidate some amount of assets γ such that

$d = \rho\gamma$. The total amount liquidated in the "run" scenario is therefore $\gamma = \left(\frac{d}{\rho}\right)$. Following

liquidation, the investor's period 2 wealth is $R\left(k - \frac{d}{\rho}\right)$, while his period 2 debts are $(k - d)$.

Notice that if $(k - d) > R\left(k - \frac{d}{\rho}\right)$, the investor lacks the funds in period 2 needed to meet his

outstanding obligations, making the run by short-term creditors entirely rational *ex post*.

Rearranging the preceding inequality, Rodrik and Velasco (1999) show that in order for a run on

short-term debt to be the rational choice of creditors, debt must meet the condition:

$$d > \left(\frac{R - 1}{R - \rho}\right)\rho k \tag{3.1}$$

In this form, the model can be easily adapted to encompass a holistic view of twin crises.

First, we see that higher levels of short-term debt make a country more prone to crisis by

requiring larger liquidations in the event of a run. As a result, it follows that policies which

encourage short-term debt accumulation necessarily increase crisis probability.[6] Deposit

insurance, whether implicit or explicit, serves exactly this function, as it lowers banks' short-

term funding costs by reducing the risk assumed by any individual creditor (Calvo 2000;

Demirgüç-Kunt and Detragiache 1998). So long as banks respond to a backstop by raising short-

term exposure, one would expect deposit insurance to be associated with a higher probability of

panic-driven liquidations. Yet while deposit insurance acts to increase crisis probability through

the short-term debt channel, it also helps to stem bank runs by guaranteeing investors a minimum

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[6] As will be shown below, short-term debt can in some cases reduce the likelihood of default by giving lenders greater monitoring power.

payout in all periods.[7] At the international scale, however, deposit insurance often fails to overcome widespread crises of confidence, possibly because inter-country information asymmetries restore the uncertainty that insurance is designed to prevent. An international lender of last resort may therefore prove necessary to maintain confidence in the global capital markets, particularly if it can create needed foreign exchange rather than simply act as a fiscal backstop (Fischer 1999).

Beyond deposit insurance, three other primary distortions play a role in pushing borrowers toward short maturities. First, agents' choice of maturity composition may be constrained by what lenders are willing to provide. As demonstrated in Diamond and Dybvig (1983), uncertainty surrounding consumption creates a demand among actors for highly liquid deposits, the shortest liability held by the financial sector. Liquidity considerations are also manifest in bank funding channels such as the overnight repurchase and interbank lending markets. To the extent that highly-leveraged financial institutions have access primarily to short-term instruments, liabilities are likely to reflect a short maturity structure. This concern is less relevant to non-financial firms, which operate with significantly lower leverage. For these firms, a more important distortion may come from the incentives faced by equity holders, who in almost all cases control the enterprise as mangers. Diamond and He (2014) show that for investment projects with constant volatility, the value of short-term debt rises less than the value of long-term debt for any increase in firm value. That is, equity holders capture a greater share of a rise in firm value when debt is primarily short-term, creating an incentive for managers to contract shorter liabilities.

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[7] This function is a central implication of the Diamond-Dybvig (1983) model. One can interpret this result to mean that deposit insurance removes some (if not all) uncertainty surrounding potential returns, and therefore helps to achieve a Nash equilibrium where no single investor finds it optimal to run on the bank.

A second phenomenon which may encourage short-term borrowing is moral hazard, which alters the risk-reward calculus faced by both borrowers and creditors. From the perspective of borrowers, the presence of a lender of last resort mitigates the risk of a liquidity crunch in the financial sector, while the presence of a bailout-prone fiscal authority ensures that early asset liquidation does not lead to bankruptcy. Both of these distortions can drive agents toward the nominally cheapest form of debt available, which given an upward-sloping yield curve is always short-term. As shown below, the result is reversed when borrowers internalize maturity risk, in which case they optimally contract only long-term borrowing (Rodrik and Velasco 1999). Creditors also receive security from real or potential bailouts, and as a result become more willing to provide capital to fragile firms, especially financial institutions covered by the lender of last resort (Radelet and Sachs 1998). Additionally, Demirgüç-Kunt and Detragiache (1998) argue that deposit insurance may act as a source of moral hazard by inducing banks to issue inherently riskier loans, as they can generate potentially higher returns without assuming a commensurate amount of risk (because insurance effectively sets a floor on returns to depositors). Demirgüç-Kunt and Detragiache (1998) show behavior of this sort to be a robust empirical indicator of banking crises.

Finally, Rodrik and Velasco (1999) note that the policies of private rating agencies can impact the level of short-term debt held in an economy. As argued by Furman et al. (1998), bond rating agencies often impose a "sovereign ceiling" on emerging markets, meaning no individual borrower can carry a stronger rating than the central government. Such a practice solves the problem of costly information acquisition for creditors by imposing a maximum rating on the nation, but comes at the expense of distorted incentives for borrowers. Because higher levels of short-term debt increase the economy-wide risk of self-fulfilling crises, firms that take

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on short-term liabilities impose an externality on all other agents (Rodrik and Velasco 1999). If the credit ratings of individual firms were assigned independent of the central government, then part of this externality would be internalized, as increased risk of a run would be manifest in a weaker rating and thus higher cost of capital. Yet because stable borrowers with minimal short-term exposure effectively face a limit on their credit rating, there is little incentive to improve firm-level balance sheets beyond the binding constraint of the sovereign ceiling (Rodrik and Velasco 1999).

While the above distortions encourage short-term borrowing, and thus raise the probability of runs, Rodrik and Velasco (1999) show that short-term debt may in some cases *mitigate* crises by preventing defaults. Rational creditors who believe that a borrower is preparing to default have no choice but to run in period 1, forcing some costly liquidation. The beliefs of creditors are in turn dependent on the incentives faced by debtors. For high levels of short-term debt d, defaults are ruled out, as runs and the subsequent liquidation would leave the borrower with little or no income in period 2. For extremely low levels of d, on the other hand, liquidation is relatively small, and the costs low, making default the optimal choice. A sufficient amount of short-term debt can therefore create an incentive for borrowers to avoid default, leading to greater confidence from creditors and a resulting compression of risk premia.[8]

In addition to micro-level incentives, the experience of many economies in the 1980s and 1990s demonstrates that short-term debt accumulation is oftentimes associated on a macro scale with periods of mass capital inflows. Financial liberalization plays a leading role in attracting so

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[8] Interest rates are endogenized below, but are assumed to be 0 here for the sake of illustrating the pre-commitment function of short-term debt.

called "hot money", typically by curbing regulations and/or opening the capital account.[9] The

inflows that follow liberalization tend to take the form of short-term loans and deposits rather

than long-term investments such as FDI, causing a substantial rise the economy's short-term

exposure. Goldfajn and Valdes (1997) show that financial *deepening* can also magnify the size

of inflows, as an expansion of banks' intermediary function makes it both easier and cheaper for

foreign investors to access a country. From an empirical standpoint, the fact that inflows are

intermediated by the banking system suggests that variables such as the ratio of credit to GDP

should rise as capital enters the country. To the extent that such inflows are short-term in nature,

growth in the ratio of credit/GDP would push a country closer to the run condition given by

(3.1). The relationship between credit expansion and twin crises is demonstrated empirically by

Kaminsky and Reinhart (1999), who find that the ratio of domestic credit to GDP averages

roughly 20 in the months immediately preceding twin crises, compared to about 5 in normal

periods.

Hot money inflows are closely related to a country's balance-of-payments position. Net

inflows signify that a country is spending beyond what it produces domestically (Calvo and

Reinhart 2000), borrowing from foreign investors in order finance a current account deficit.

Obstfeld (2012) notes that orthodox thought gives little concern to such deficits, as they in theory

represent a rational tradeoff between spending today and saving tomorrow. However, this

explanation ignores the important fact that persistent deficits encourage sustained short-term

liability accumulation, making countries prone to crises should inflows reverse. Because a

negative current account balance necessarily requires short-term foreign funding, large and

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[9] See Kaminsky and Reinhart (1999).

persistent deficits are likely to be associated with increased vulnerability to capital flow

reversals.

Aside from introducing the possibility of runs, Rodrik and Velasco (1999) show that

higher levels of short-term debt have an important effect on the term structure of interest rates.

Investors operating with a degree of uncertainty focus not on nominal returns, but on *expected*

returns, giving some probability to default. So long as there is any risk associated investing in a

given country, this probability must be positive, and nominal returns must therefore be high

enough to equate expected values globally. Risk, in turn, is driven partially by a country's level

of short-term debt and the looming specter of coordination failure. Given these relationships,

Rodrik and Velasco (1999) endogenize both short- and long-term interest rates for various levels

of d. If the probability of a run is given by p, and the probability of repayment following a run

given by q_L, then the expected return to long-term creditors and those who roll over from period

1 is given by:

$$(1 - p)(1 + r_L) + pq_L(1 + r_L) = 1 \tag{3.2}$$

Where r_L is the interest rate on long-term debt. The authors note that for long-term debt to carry

any repayment risk, condition (3.1) must be satisfied, meaning r_L will deviate from 0 only for

sufficiently high amounts of short-term borrowing. Rodrik and Velasco define the probability of

repayment, q_L, as the ratio of period 2 income to claims, which following a run is given by:

$$q_L = \frac{R\left(k - \frac{d}{\rho}\right)}{(1 + r_L)(k - d)} \tag{3.3}$$

Plugging (3.3) into (3.2) yields:

$$(1-p)(1+r_L) + p(1+r_L)\left[\frac{R\left(k-\frac{d}{\rho}\right)}{(1+r_L)(k-d)}\right] = 1 \tag{3.4}$$

Which can be further simplified to:

$$(1-p)(1+r_L) + \frac{pR\left(k-\frac{d}{\rho}\right)}{k-d} = 1 \tag{3.5}$$

$$(1-p)(1+r_L) = 1 - \frac{pR\left(k-\frac{d}{\rho}\right)}{k-d} \tag{3.6}$$

Giving the required return on long-term debt as:

$$1+r_L = \frac{1}{(1-p)}\left[1 - \frac{pR\left(k-\frac{d}{\rho}\right)}{k-d}\right] \tag{3.7}$$

Because $\rho < 1$, the interest rate on long-term debt is increasing in the level of short-term debt d. As Rodrik and Velasco (1999) note, this holds because an increase in a borrower's short-term debt burden reduces the probability of long-term creditors being repaid.

The authors next go on to endogenize the short-term interest rate, which must be greater than 0 if $d > \rho k$ and full repayment is impossible under a run. Again taking a probability-weighted average to compute expected return, we have:

$$(1-p)(1+r_S) + pq_S(1+r_S) = 1 \tag{3.8}$$

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Where q_S is the probability of period 1 repayment in the run and is equal to:

$$q_S = \frac{\rho k}{(1 + r_S)\, d} \qquad (3.9)$$

Plugging (3.9) into (3.8) gives the expected return on short-term debt as:

$$(1 - p)(1 + r_S) + p(1 + r_S)\left[\frac{\rho k}{(1 + r_S)\, d}\right] = 1 \qquad (3.10)$$

(3.10) further simplifies to:

$$(1 - p)(1 + r_S) + \frac{p\rho k}{d} = 1 \qquad (3.11)$$

$$(1 - p)(1 + r_S) = 1 - \frac{p\rho k}{d} \qquad (3.12)$$

Yielding the required return on short-term debt:

$$1 + r_S = \frac{1}{(1 - p)}\left[1 - \frac{p\rho k}{d}\right] \qquad (3.13)$$

Recall that $r_S > 0$ only if $d > \rho k$ and short-term debt carries repayment risk. In the event of a run, then, the investor is required to liquidate his entire portfolio, leaving no assets with which to repay long-term creditors. Rodrik and Velasco show that in this case, the long-term expected return is simply the inverse probability of no run occurring, or $(1 - p)^{-1}$. Furthermore, if $d > \rho k$, then it must also be true that $d > \left(\frac{R-1}{R-\rho}\right)\rho k$, so that the long-term interest rate is given by (3.7). Thus, comparing (3.7) and (3.13) we see that, so long as (3.1) is satisfied, short-term debt must always carry a lower interest rate than long-term debt. In other words, countries are subject

to an upward-sloping yield curve. Yet while short-term debt is nominally cheaper than long-term borrowing, the Rodrik and Velasco (1999) model shows that interest rates, along with the probability of a run, are increasing in d, so that an investor's expected consumption is in fact maximized when he takes on no short-term debt and $d = 0$. Despite $d = 0$ representing the rational choice of investors, the aforementioned distortions repeatedly cause countries to expose themselves to twin crises by relying on excessive amounts of short-term funding.

In addition to a country's stock of short-term debt d, it is clear from (3.1) that the probability of a run by creditors is also influenced by the return on domestic technology R. Because capital is intermediated through the financial system, one can think of R as the return generated by the banking sector's collective assets, and k as the face value of those assets. Changes in R, then, are represented by changes in the value of assets, such as loans, which in turn are driven by the real economy. An exogenous decline in R between periods 0 and 1, due to factors such as a sudden productivity shock, lowers expected period 2 income, moving a country closer to the run condition. On the other hand, an exogenous *rise* in R makes it easier for the nation to satisfy its period 2 obligations. Fluctuations in R also affect the interest rate charged on long-term borrowing, with rates moving inversely with the domestic return on technology (as shown by [3.7]). Such pro-cyclical movements of lending premia are consistent with the financial accelerator model of Bernanke, Gertler, and Gilchrist (1996). Importantly, these developments are independent of d, indicating that crises are possible even in the presence of relatively low levels of debt (so long as the fundamental breakdown is large enough). Variables such as GDP growth and non-performing loan ratios should therefore be important in determining both the timing and magnitude of capital outflows.

This thesis further extends the Rodrik and Velasco model to allow for the inclusion of financial accelerator dynamics. Bernanke, Gertler, and Gilchrist (1996) argue that while lead-lag complications make it difficult to assess the relationship between credit scarcity and output empirically, the flight to quality is relatively easier to discern from data. The authors predict that credit tightening will disproportionately affect fragile borrowers, with investors choosing in times of stress to lend only to those with stable cash flows and large amounts of collateral. In the context of this conceptual framework, the flight to quality would entail larger outflows for nations with weak or deteriorating fundamentals, manifest in the return on domestic technology R. While the criteria for classifying a borrower as weak is inexact, a potentially useful variable through which to assess stability is the ratio of aggregate non-performing loans to assets. Because financial intermediation makes Rk equivalent to period 2 income from loans, a higher value of NPLs/assets necessarily means a lower value of Rk.[10] For any decline in Rk, the economy moves closer to satisfying (3.1), which if met leads to large capital outflows consistent with the flight to quality. A shortcoming of this interpretation is that the flight to quality is characterized not only by the flow of funds away from weak borrowers, but toward strong ones. Yet so long as global financial institutions channel cash into securities (such as U.S. treasuries), rather than simply parking it at the central bank, one can make the simplifying assumption that capital outflows from weak countries are accompanied by inflows to healthier nations and firms.

IV: Empirical Model

The preceding section provides a conceptual framework in which to analyze the underlying determinants of twin crises. In order to empirically test the theoretical predictions,

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[10] In practice, banks' assets also consist of cash, bonds, and other securities, yet for sake of simplicity we assume that all assets take the form of loans.

this thesis applies a probit econometric model to a sample of 48 emerging economies covered by the IMF *International Financial Statistics* in the 1980-2013 period. 1980 is chosen as the starting point for the sample because it coincides with the beginning of a global push toward financial liberalization, a phenomenon which is central in both the fundamental and financial panic views of twin crises. Certain countries are excluded due to a lack of data availability. Given that a large number of countries are analyzed across 34 annual periods, this thesis makes use of a short panel. Figures are obtained primarily from World Bank and IMF databases, which provide standardized presentations that improve the reliability of cross-country data.

The conceptual model developed in Section Three equates a crisis to a run on short-term debt. At the macroeconomic scale, runs generate mass capital outflows from a given country, and this thesis therefore follows Rodrik and Velasco (1999) in defining a crisis as a "sharp reversal in capital flows" greater than 5% of gross domestic product.[11] Capital flows are measured using IMF data on the net financial account, which excludes transactions that are undertaken between nations' respective monetary and fiscal authorities in order to satisfy balance-of-payments issues. When the decline in capital inflows to a country between year t-1 and t exceeds 5% of nominal GDP, the dummy dependent variable C_t takes on a value of 1, whereas in all other cases $C_t = 0$. Following Rodrik and Velasco (1999) and Radelet and Sachs (1998), countries are excluded from the analysis for two years following a crisis in order to avoid registering a single, multi-year episode as numerous crises. While seemingly arbitrary, the 5% threshold allows for objective identification of crises over a large sample of countries. With the notable exception of Mexico in 1994, this strategy identifies nearly all episodes which have been considered by more subjective analyses, consistent with Rodrik and Velasco (1999).

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[11] Because the 5% threshold is chosen somewhat arbitrarily, we also present results at the 4% and 3% thresholds.

Because we are interested in the underlying determinants of twin crises, this thesis uses a probit model to analyze the effect of explanatory variables on crisis probability. If the crisis dependent variable is represented by C_t, then the probit model takes the form[12]:

$$P(C_t = 1) = G(\beta_0 + x\beta) \qquad (4.1)$$

where $x\beta$ is a vector of explanatory variables. G represents the standard normal cumulative distribution function (cdf), which is given by:

$$G(\beta_0 + x\beta) = \int_{-\infty}^{\beta_0 + x\beta} \frac{1}{2\pi} e^{\left(-\frac{z^2}{2}\right)} dz \qquad (4.2)$$

for all real numbers z (Wooldridge 2009). Substituting our variables of interest into (4.1) yields the following equation to be estimated:

$$P(C_t = 1) = G(\beta_0 + \beta_1 STDR_{it} + \beta_2 DSTDR_{it} + \beta_3 BMR_{it} + \beta_4 DI_{it} \qquad (4.3)$$

$$+ \beta_5 CREDITGR_{it} + \beta_6 GDPGR_{it} + \beta_7 RER_{it} + \beta_8 CAD_{it})$$

where *STDR* measures short-term debt as a percentage of total reserves; *DSTDR* is a dummy variable that takes on a value of 1 if the ratio of short-term debt to total reserves exceeds 1 in year *t*, and 0 otherwise; *BMR* measures the ratio of broad money to total reserves; *DI* is a dummy variable that takes a value of 1 if an explicit deposit insurance scheme is in place in year *t*, and 0 otherwise; *CREDITGR* measures the percentage growth in the ratio of domestic credit to nominal GDP over the preceding four years; *GDPGR* measures the percentage growth in real GDP over the preceding four years; *RER* measures the percentage change in the real exchange rate over the preceding four years; and *CAD* measures the current account deficit as a percentage of GDP. Various lags of these variables are tested, and each is explained in further detail below.

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[12] Wooldridge (2009).

The probit model estimated in this thesis has a few key features which make it preferable to a simple linear probability model. First, linear probability models do not constrain the fitted dependent variable to values between 0 and 1, meaning estimation can yield "probabilities" which are uninformative from a practical standpoint. Probit models solve this problem by limiting the cdf to values strictly between 0 and 1 (Wooldridge 2009, p.576). Second, linear probability models take the marginal effect of an explanatory variable as constant, which in this context would amount to treating marginal effects the same for all countries regardless of their initial crisis probability. With a probit model, however, one must multiply an estimated coefficient by the derivative of the cdf with respect to that coefficient in order to obtain a marginal effect (Wooldridge 2009, p.577). The marginal effect of a given explanatory variable is therefore small for countries with very high or low initial probabilities, as the slope of the cdf for these countries is relatively flat (Demirgüç-Kunt and Detragiache 1998).

While the non-linear nature of probit models carries the above advantages, it also necessitates the use of estimation methods other than ordinary least squares. This thesis therefore follows standard practice in estimating (4.3) using maximum likelihood estimation (MLE). Rather than minimizing the sum of the squared residuals, MLE maximizes the log-likelihood of a dependent variable y conditional on a vector of explanatory variables $x\beta$. The log-likelihood of y is in turn derived from the log of the standard normal cdf given by (4.2). Wooldridge (2009) notes that in the absence of specification error, the MLE estimate of a given β is both consistent and asymptotically efficient.

When estimating binary response models such as the probit, panel data present unique challenges in obtaining consistent, unbiased estimates. Among these, most pressing is the potential for heterogeneity among cross-sectional units, as variables not represented in the

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estimated equation may differentially impact countries across time (Demirgüç-Kunt and Detragiache 1998). Practitioners working with panel data often address heterogeneity by including fixed effects in the estimated equation, which ascribe a unique intercept to each unit. Yet because each unit N receives its own intercept, the number of parameters in the equation increases as N approaches ∞. Holding the number of periods T constant, this prevents any given $\widehat{\beta_{it}}$ from converging to its actual value, creating what is known as the "incidental parameters problem" (Arellano and Hahn 2005). For linear models, the incidental parameters problem is solved by removing the unobserved effect through a series of transformations (Wooldridge 2010, p.302). However, the use of MLE with probit models prevents such transformations, ruling out fixed effects as a solution to heterogeneity.

A second approach to dealing with heterogeneity in probit models is to assume random effects, which are drawn from a probability distribution rather than fixed at a specific value over time. In order for a random effects probit to produce consistent, unbiased estimates, one must assume that the random effects are both uncorrelated with the explanatory variables and follow a normal distribution with mean 0 and constant variance (Wooldridge 2010, p.612). Demirgüç-Kunt and Detragiache (1998) argue that the strong assumption of independence is unlikely to hold in practice, introducing bias to the estimated coefficients. Due to the limitations of both fixed and random effects models, this thesis proceeds to estimate (4.3) while remaining cognizant of the potential for cross-sectional and time-variant heterogeneity. We are cautiously optimistic that the estimated equation captures the underlying drivers of twin crises, and therefore do not believe that our results are meaningfully impacted by unobserved effects.

Description of Explanatory Variables

The explanatory variables included in equation (4.3) are chosen to reflect both prevailing theory and the conceptual model developed in Section Three. *STDR*, the stock of short-term debt as a percentage of total reserves, captures the important role that short-term liabilities play in exposing countries to runs on the banking system and exchange rate regime. Our conceptual model demonstrates that, *ceteris paribus*, higher levels of short-term debt make capital flight more likely, and *STDR* is therefore presented as a continuous variable with a positive expected sign. Short-term debt is analyzed relative to reserves because a central bank's ability to defend an exchange rate peg, and thus prevent a twin crisis, is ultimately predicated on the stock of foreign reserves at its disposal. So long as reserves exceed the value of short-term liabilities that can be run-on, the exchange rate is in theory insulated from wider financial sector issues.[13] This thesis therefore includes a dummy variable, *DSTDR*, that takes on a value of 1 when short-term debt exceeds total reserves and 0 otherwise, following Rodrik and Velasco (1999). Short-term debt includes both private and government obligations in recognition of the influence public indebtedness can have on precipitating crises, such as in many Latin American countries during the early 1980s.

As a second gauge of international illiquidity, this thesis introduces a variable *BMR* that measures the ratio of broad money to total reserves. Chang and Velasco (2000) argue that broad money should serve as the true gauge of a country's international exposure due to the relationship between bank runs, capital flight, and the ensuing conversion of domestic into foreign currency. So long as countries permit free convertibility, all broad money is in essence a

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[13] In practice, central banks will often abandon a peg well before depleting all reserves, increasing the practical relevance of the continuous variable *STDR*. This phenomenon is stressed by Krugman (1979) in his first generation model.

short-term foreign liability, reconciling the *BMR* variable with our conceptual model. Previous analyses have examined the ratio of M2 to foreign reserves, yet the restriction of the money supply to M2 misses financial instruments such as bank commercial paper and certificates of deposit which can, and often are, run on in the event of a twin crisis. This concern is particularly relevant to more recent episodes such as the global financial crisis of 2008, wherein investors sold off all but the safest short-term assets *en masse*. A potential limitation to this variable is that, for countries with relatively underdeveloped financial markets, a lack of liquidity can eliminate the money-like qualities of certain assets classified as broad money. We expect the sign of *BMR* to be positive, as higher levels of broad money relative to reserves both increase the likelihood of runs and reduce the ability of a central bank to defend its exchange rate.

While the ratio of broad money to reserves is a theoretically important determinant of crisis vulnerability, measurement can encounter an endogeneity problem. As crises unfold and the financial sector comes under pressure, central banks often extend large amounts of liquidity to troubled institutions, an action that significantly expands the domestic money supply. Because the stock of broad money is measured at the end of year *t*, monetary easing that takes place throughout the year will artificially inflate the measured total. This sequence can also occur when central banks seek to preempt crises by undertaking easy money policies in the face of weakening fundamentals. Our approach of excluding countries from the panel for two years following a crisis, inspired by Radelet and Sachs (1998) and Rodrik and Velasco (1999), partially addresses this problem by avoiding measurement of the monetary easing that in many cases follows twin episodes.

A deposit insurance dummy variable, *DI*, is introduced in order to capture the effects of moral hazard. As discussed in Section Three, insurance schemes can encourage banks to take

large risks by guarding their depositors against potential losses, implying a positive relationship between deposit insurance and the probability of a crisis. However, the well-known role of deposit insurance as a "circuit breaker" during bank runs suggests that the relationship between insurance schemes and crises may in fact be negative. As a result, the expected sign of the *DI* variable is ambiguous, in line with Demirgüç-Kunt and Detragiache (1998).

Data for the *DI* variable come from work done by Demirgüç-Kunt, Kane, and Laeven (2013), who compile a database covering all IMF members and affiliated countries. A potential shortcoming of this database is that, while it covers explicit insurance arrangements, it does not account for *implicit* programs due to the inherent difficulty in identifying such schemes. Yet as the recurrence of government-assisted sales and bailouts of financial institutions demonstrates, most monetary and fiscal authorities stand ready to protect depositors and other creditors during times of stress. To the extent that market participants expect such actions, moral hazard is likely to come from other sources in addition to explicit deposit insurance programs.

This thesis introduces a variable measuring the growth in domestic credit relative to GDP, *CREDITGR*, as proxy for asset quality within the financial system. Asset quality is perhaps the strongest gauge of an economy's underlying health, as it provides a direct indicator of financial stability and indirect measure of real economic performance. The analysis in Section Three shows that a deterioration in asset quality can generate runs in the style of Diamond and Dybvig (1983), a flight to quality as in Bernanke, Gertler, and Gilchrist (1996), and increased premia on both government and private debt, each of which contribute to the onset of twin crises. Yet while asset quality, manifest in the stock of non-performing loans, is clearly a variable of interest, measurement is made difficult by the tendency of banks to avoid classifying loans as non-performing during the boom that typically precedes a bust (Radelet and Sachs 1998).

Problems also arise when comparing NPL data across countries with radically different regulatory and reporting structures. For example, Chiuri, Ferri, and Majnoni (2001) document a wide variation in both degree and timing in the implementation of reporting standards throughout much of the developing world during the 1990s.

Gavin and Hausmann (1996) convincingly argue that the above issues can be avoided through the use of growth in domestic credit as a proxy for asset quality. The authors' contention is that banks hoping to rapidly grow their lending portfolios have no choice but to extend credit to borrowers and projects for which information is scarce, and it is through the blind provision of funds that asset quality begins to decline. Gavin and Hausmann's story appears prescient in light of the lending booms that preceded economic collapse in the United States, Ireland, and other nations during the global financial crisis of 2008. To capture a lending boom of this sort, this thesis uses data on the ratio of domestic credit to GDP provided by the World Bank. The percentage change in this ratio is then computed between year t-3 and t. We expect the sign of *CREDITGR* to be positive given the relationship between lending booms and twin crises.

The final three variables in equation (4.3) capture traditional, macro-driven explanations of twin crises. *GDPGR* measures the growth in real GDP over the preceding four years. As is the case with non-performing loan ratios, GDP growth serves as an indicator of an economy's underlying health and thus impacts the probability of runs and the flight to quality. Because low or negative growth signals fundamental weakness, we would expect *GDPGR* to register with a negative sign. It is important to note that interpretation of this variable may be clouded by the effects of financial asset bubbles, as bubbles tend to increase both growth and crisis vulnerability, implying a positive coefficient for *GDPGR*.

RER represents the percentage change in the real effective exchange rate over the preceding four years, following Radelet and Sachs (1998). The real effective exchange rate is calculated by Darvas (2012) as a country's year-average nominal exchange rate with respect to a weighted basket of 67 trading partners, indexed to 2007, divided by an identically-weighted consumer price index deflator. A higher value of *RER* indicates appreciation, while a lower value indicates depreciation. Significant appreciation hurts the real economy by raising the price of a country's exports, and may also stoke fears of a future devaluation, giving rise to a speculative attack à la Krugman (1979). On the other hand, *depreciation* places a burden on banks and firms holding large amounts of foreign-denominated debt. Given these competing dynamics, the expected sign of *RER* is ambiguous.

CAD measures a country's current account deficit in year *t* as a percentage of nominal GDP. Large current account deficits are made possible only by matching capital account surpluses, which in turn rely on the investment community's collective beliefs regarding the sustainability of a country's balance-of-payments position. Any development that triggers a loss of confidence in current account sustainability will send capital rushing for the exits, setting off a traditional balance-of-payments crisis and placing downward pressure on the exchange rate. The larger a country's current account deficit, the larger an eventual devaluation must be in order to restore balance. *CAD* is therefore expected to register with a positive sign, as higher values imply a larger deficit. From a theoretical perspective, there exists potential multicollinearity between the *CAD* and *RER* variables, as current account deficits are often exacerbated by an overvalued real exchange rate. However, the correlation matrix presented in Appendix Two indicates that correlation between these two variables is low, and multicollinearity is therefore of little concern.

V: Results

To determine the appropriate specification of equation (4.3), various models were estimated and compared on the basis of the Akaike information criterion (AIC) and Bayes-Schwarz information criterion (BIC). The results of these tests are reported in Appendix Two. Both the AIC and BIC measure goodness of fit by adjusting the estimated log-likelihood for degrees of freedom, with lower values signifying "better" models (Demirgüç-Kunt and Detragiache 1998). Originally proposed by Akaike (1974), AIC adjusts the estimated log-likelihood by the number of included parameters (Amemiya 1981). BIC not only penalizes models for the number of parameters, but also for sample size, and therefore provides a more conservative benchmark by which to assess model quality (Schwarz 1978). Both AIC and BIC are lowest when three fundamental variables, *CREDITGR*, *GDPGR*, and *RER*, are lagged two years, while all other variables are lagged by one. This result is unsurprising from a theoretical standpoint, as fundamental factors typically require a delay to work through balance sheets in the build-up to twin episodes. Given the above analysis, all results presented hereafter are variations of the specification where *CREDITGR*, *GDPGR*, and *RER* are lagged two years.

Table 1 reports the results of our primary probit regressions. In both specifications where it is included as a continuous variable, short-term debt as a percentage of total reserves enters with a statistically significant, positive coefficient. Furthermore, short-term debt averages roughly 115% of total reserves in countries that experience crises, compared to only 93% in non-crisis countries. Yet while the coefficient on *STDR* is highly significant, its marginal effect is surprisingly small. For a one unit increase in short-term debt as a percentage of total reserves, the probability of a twin crisis increases by only 0.01%. Put differently, a doubling of short-term debt from 100% to 200% of reserves is associated with only a 1 percentage point increase in

crisis probability. This suggests that short-term debt is most meaningful in situations where

exposure is exceptionally high, such as during Brazil's 1983 episode, wherein short-term debt

stood at 437% of nominal GDP in the year preceding the crisis. Confirming this interpretation,

the *DSTDR* variable shows no significant relationship between short-term debt/reserve ratios in

excess of one and the probability of twin crises.

      Fundamental factors appear to have a much stronger effect on the probability of twin

crises. In the best-fitting model, shown in column two of Table 1, credit growth and a current

account deficit are strongly associated with greater vulnerability. Current account deficits are

highly significant at the 1% level, with a one percentage point increase in the deficit as a

percentage of GDP leading to a 0.6 percentage point increase in crisis probability. Figure 4

below further shows that, holding all other variables at their mean, a reduction of the current

account deficit from 20% to 0% of GDP lowers predicted crisis probability from roughly 23% to

7%. *CAD* remains significant at the 1% level in each specification of the model, demonstrating a

statistically robust relationship between the current account and exposure to crises.

Figure 2: Emerging Market Crises by Year
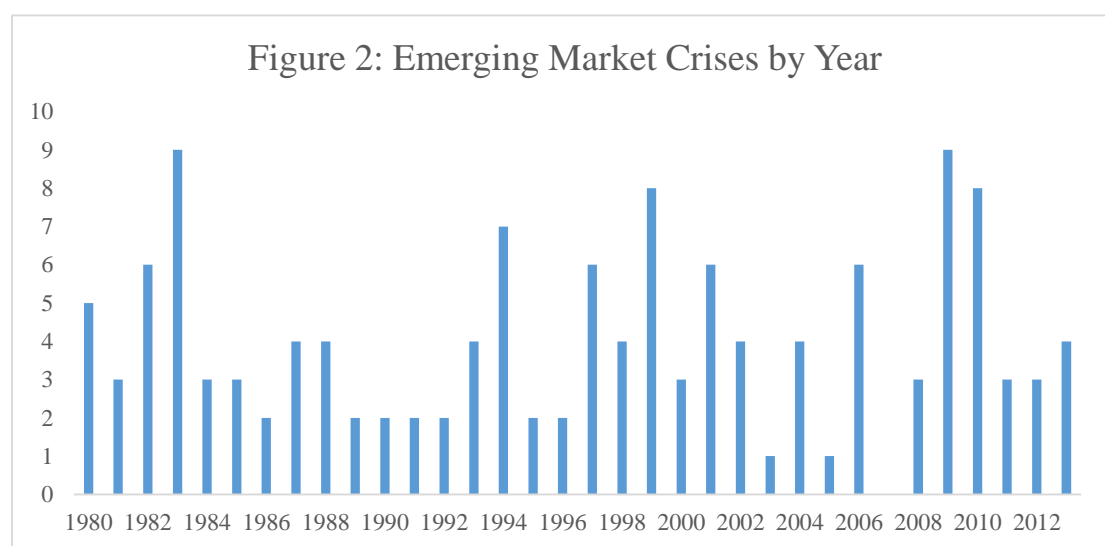
Note: Crisis defined as a reversal in capital flows between year *t*-1 and *t* greater than 5% of nominal GDP. Countries are excluded from the panel for two years following a crisis.

The coefficient on *CREDITGR* is significant at the 5% level. For a one unit increase in total growth, crisis probability increases by roughly 0.02 percentage points. Because the *CREDITGR* variable itself measures the percentage change in credit between period *t* and *t*-3, a two year lag captures the effect of a "lending boom" that begins six years before the onset of a crisis. While the effect of credit growth on crises appears small, it is important to note that this result describes a general rather than specific relationship. In their seminal work on financial crises, Kindleberger and Aliber (2011) document a historically consistent relationship between financial innovations, such as the creation of asset-backed securities, and credit-fueled financial crises. Kindleberger and Aliber's work ultimately suggests that the strongest effects of credit expansion may be reserved for highly specific, idiosyncratic episodes.

Figure 3: Crisis vs. Non-Crisis Means
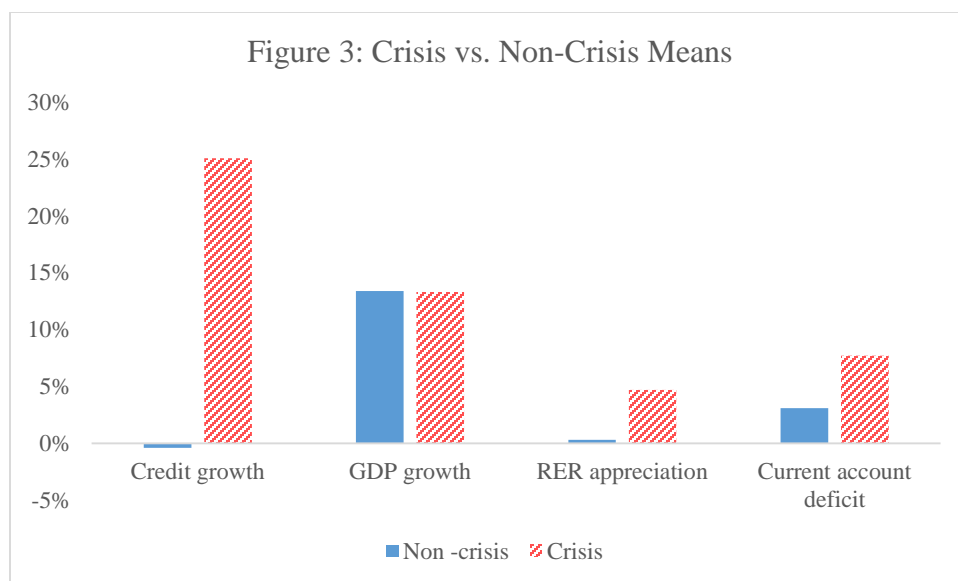
Note: Credit growth, GDP growth, and RER appreciation all measured over the four years preceding crisis, and each is lagged by two years.

There is also some evidence that real exchange rate appreciation is associated with twin crises. In the model where the ratio of total external debt to GDP is controlled for, the coefficient on *RER* enters with a positive sign and is significant at the 10% level. For this

specification, a one percentage point appreciation of the real exchange rate over the previous four years is associated with a 0.06 percentage point increase in the probability of a crisis. The real exchange rate is also significant at the 10% level when the continuous short-term debt/reserves variable is replaced with a dummy variable representing short-term debt/reserve ratios in excess of one. However, once external debt/GDP is excluded from the model with *STDR*, improving overall fit, the real exchange rate becomes insignificant. The seeming lack of robustness observed for *RER* is potentially due to our conjecture that both appreciation and depreciation contribute to crises, requiring a two-tailed hypothesis test. Were one to hypothesize that only appreciation is associated with twin crises, then the real exchange rate is significant at the 10% level in both specifications.

Figure 4: Effect of Current Account Deficit on Crisis Probability
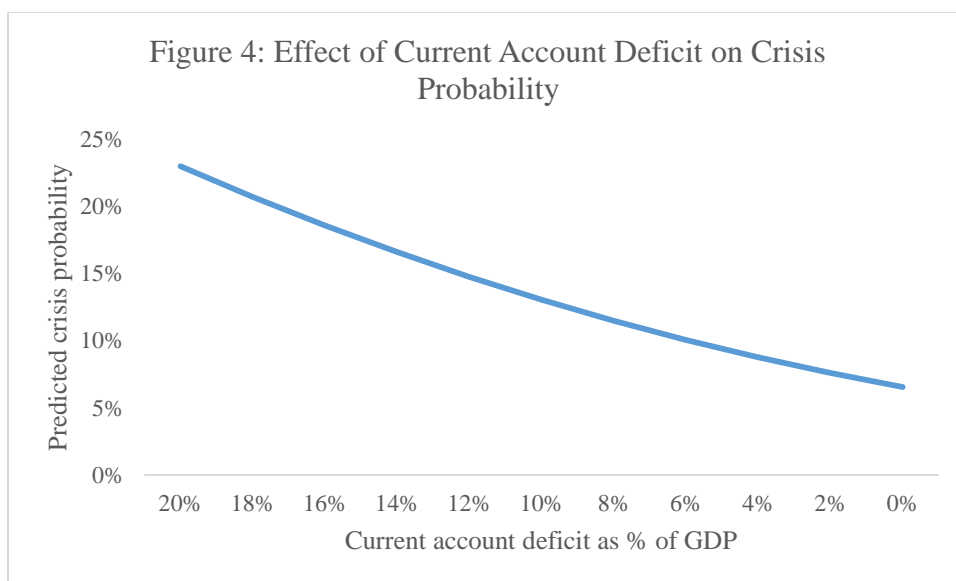
Note: Predicted probabilities calculated holding all other independent variables at their means.

Surprisingly, an increase in the ratio of broad money to total reserves is found to have a highly significant *negative* effect on crisis probability. Both previous empirical work and the conceptual model outlined in Section Three indicate that the relationship between broad money and crises should in fact be positive, placing our result at odds with the wider literature.

However, it is interesting to note that Rodrik and Velasco (1999), on whose work this analysis draws heavily, also obtain a negative sign for their money supply variable. Whether this is due to a shared feature of empirical design or methodology is unclear. One potential explanation is that measurement of broad money suffers from a substantial endogeneity problem. If prescient central banks are able to detect underlying weakness in their respective economies, then they are likely to engage in monetary easing as a means of "heading-off" future episodes. To the extent that such actions are successful, this story is consistent with an observation that the ratio of broad money to reserves tends to be higher in non-crisis countries. Additionally, the unprecedented monetary easing which has taken place over the past decade is likely to have inflated broad money values relative to previous periods.

Table 1 shows no significant relationship between deposit insurance and twin crises. Sections Three and Four above note that hypotheses on the role of deposit insurance are made difficult by the competing dynamics of moral hazard, to which explicit schemes are a contributor, and bank runs, which insurance programs help prevent. Whether moral hazard or run-breaking prevails is dependent not only on the specific micro, macro, and political characteristics of individual countries, but also on the behavior of agents involved in the banking and bank-run processes. For a useful discussion of these dynamics, see Anginer, Demirgüç-Kunt, and Zhu (2014).

Table 1: Probit Regressions

Dependent variable = 1 when reversal of capital inflows exceeds 5% of GDP

	(1)	(2)	(3)
Dummy variable for short-term debt > reserves$_{t-1}$	0.0001		
	(0.0003)		
Short-term debt as a percentage of reserves$_{t-1}$		0.0001***	0.0001**
		(0.0003)	(0.0004)
Broad money/reserves$_{t-1}$	-0.002	-0.005	-0.005
	(0.012)	(0.014)	(0.014)
Explicit deposit insurance dummy$_{t-1}$	-0.010	-0.011	-0.011
	(0.122)	(0.123)	(0.123)
4 year % change in credit$_{t-2}$	0.0002**	0.0002**	0.0002**
	(0.051)	(0.051)	(0.051)
4 year % change in real GDP$_{t-2}$	0.0003	0.0006	0.0006
	(0.501)	(0.498)	(0.521)
4 year % change in real exchange rate$_{t-2}$	0.0006*	0.0006	0.0006*
	(0.190)	(0.188)	(0.190)
Current account deficit as a percentage of GDP$_{t-1}$	0.006***	0.006***	0.006***
	(0.007)	(0.007)	(0.007)
Total external debt/GDP$_{t-1}$			0.011
			(0.1987)
Akaike information criterion	744.4	738.2	739.8
Bayes-Schwarz information criterion	785.2	779.0	785.7
Count R-squared	0.903	0.903	0.903
Total number of observations	1211	1211	1210

Coefficients represent the effect on crisis probability of a one unit increase in the explanatory variable, holding all other variables at their mean. Standard errors are in parentheses. Model estimated using maximum likelihood estimation. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

Finally, we find no significant link between real GDP growth and twin crises. While the conceptual model of Section Three suggests that slowing growth might signal underlying weakness, there remains the important caveat that sustained, *positive* growth can generate fragility if driven a speculative bubble.[14] On the basis of stylized facts, this contradiction appears true for the global episode of 2008-2010, during which 18.6% of crises in our sample occur. In the four year period from 2004 to 2007, total real GDP growth averages 18.2%, compared to only 13.5% in the full panel. While the 2008-2010 example is not representative of a larger population relationship, it nonetheless illustrates the potentially confounding effect that bubbles may have on an analysis of GDP growth and its role in stimulating crises.

The above results should be interpreted with caution, as the estimated coefficients are potentially subject to omitted variable bias due to both cross-sectional and time-variant heterogeneity. Because fixed effects are infeasible and random effects require unnecessarily strong assumptions, there is no standardized method for dealing with heterogeneity in probit models. One crude option is to group countries based on shared characteristics, which helps to account for any idiosyncrasies associated with that commonly-shared trait. Following this approach, we place countries into one of five geographic regions and one of two income groups, estimating the model for each separately.[15] The results of this exercise are reported in Appendix Two. Current account deficits are strongly associated with crisis probability in nearly every subsample, save for the Middle East and North Africa country group, which represents only 120 of 1,211 observations. Results for the remaining groups are inconclusive, likely because these

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[14] I am grateful to Professor Miguel Ramirez for raising this important issue.
[15] Turkey is excluded from this analysis given that it is the only country in the sample that hails from the Europe and Central Asia group. I am grateful to Professor Nichole Szembrot for suggesting this approach.

subsamples represent only a small piece of the overall panel. Analysis of this sort suffers from its own problems, particularly small sample issues, and so too should be interpreted cautiously.

As a final test of model quality, the explanatory variables discussed above are regressed against a crisis dependent variable that takes on a value of 1 when the reversal in capital flows exceeds 4% and 3% of nominal GDP, respectively. Our results overwhelmingly remain robust to various crisis thresholds. However, the credit growth variable becomes insignificant and takes on a negative sign once the threshold is dropped to 4%, and registers a similar result for 3%. Credit growth may suffer from the fact that, while the other explanatory variables (save for deposit insurance) are theoretically associated with *both* banking and balance of payments issues, lending booms act on crises primarily through the banking channel. It thus may be the case that outflow thresholds of 3% and 4% capture episodes that occur even in the presence of a relatively healthy banking sector, which would likely render credit growth insignificant. Putting aside the issues associated with credit growth, our results remain robust to various specifications of the model and thresholds for the dependent variable.

Table 2: Summary Statistics for Selected Crises, 1980-2013

Country	Year	Short-term debt/reserves	RER appreciation	Credit growth	Current account deficit/GDP
Chile	1982	111.1%	-6.0%	7.8%	14.5%
Mexico	1982	502.5	25.1	-8.6	6.5
Brazil	1983	437.4	4.0	-51.2	8.9
Argentina	1989	110.9	-19.7	-37.6	1.3
Egypt	1990	316.0	22.3	64.7	3.3
Turkey	1994	236.2	8.7	18.9	3.6
Venezuela	1994	34.2	13.0	-3.7	3.4
Thailand	1997	123.5	2.0	35.5	8.0
Philippines	1997	67.7	9.2	162.7	4.8
Indonesia	1997	166.2	3.6	2.4	3.4
Zambia	1997	214.0	11.2	-	6.1
Argentina	2001	112.6	6.4	24.5	3.2
Ghana	2002	122.0	-30.7	54.0	8.0
Jamaica	2002	49.0	-1.6	3.6	8.4
Senegal	2006	3.0	6.6	-7.7	7.8
Argentina	2008	41.6	3.0	-45.5	-2.6
Jamaica	2009	71.0	4.8	-8.8	20.4
Senegal	2010	0.0	10.3	23.6	6.7
Botswana	2013	5.0	3.5	-157.1	1.1
Full sample mean		115.3%	4.7%	25.1%	7.7%

Note: See Appendix for data sources and calculations. Short term debt and the current account balance are lagged by one year, while real exchange rate appreciation and credit growth are lagged by two. Real exchange rate appreciation and credit growth represent the percentage change between year *t*-5 and *t-2*. Increases in the real exchange rate indicate appreciation, while decreases indicate depreciation; see text for definition of real effective exchange rate.

Table 3: Crises By Country, 1980-2013

Country	Crises
Argentina	1989, 2001, 2008
Belize	1994, 2004, 2010
Bolivia	1980, 1985, 2003, 2006
Brazil	1983
Botswana	1987, 1993, 2010, 2013
Chile	1982, 1991, 1995, 1998, 2009
China	-
Colombia	-
Costa Rica	1981, 2009
Dominica	1983, 1993, 1996, 2001, 2006, 2013
Dominican Republic	2002
Ecuador	1983, 1999
Egypt	1987, 1990, 2006, 2011
Fiji	1989, 1999, 2008
Ghana	2002
Grenada	1983, 1988, 1999, 2010
Guatemala	1980, 2004
Honduras	2006, 2009
Indonesia	1997
India	-
Jamaica	1983, 1986, 2002, 2009, 2012
Jordan	1984, 1992, 1998, 2001, 2010
St. Lucia	1982, 1993, 2009, 2013
Sri Lanka	-
Lesotho	1999, 2010
Morocco	1995
Maldives	1982, 1985, 1994, 2001, 2012
Mexico	1982
Mauritius	1981, 2001
Malaysia	1987, 1994, 1997, 2005, 2012
Nigeria	1984, 1999, 2010
Pakistan	1998
Panama	1980, 1983, 2000, 2006, 2009
Peru	1983, 1998, 2013
Philippines	1983, 1997
Papua New Guinea	1983, 1992, 2000, 2008
Paraguay	1985, 1988, 1996, 1999
Senegal	1982, 2006, 2010
El Salvador	2004, 2009
Swaziland	1980, 1984, 1987, 1999, 2010
Thailand	1997, 2009
Tunisia	-
Turkey	1994, 2001
St. Vincent and the Grenadines	1981, 1988, 1993, 1999, 2002, 2011
Venezuela	1980, 1994
Vanuatu	1988, 1991, 1994, 1997, 2000, 2011
Samoa	1994
Zambia	1982, 1986, 1990, 1997, 2004, 2009

Note: Crisis defined as a reversal of capital flows between year t-1 and t greater than 5% of GDP. Countries are excluded from the panel for two years after registering a crisis.

VI: Discussion and Policy Implications

Discussion of Results

Current account deficits act as a robust driver of crisis vulnerability, with exposure to twin episodes increasing in the overall deficit relative to GDP. The current account maintains significance in nearly all geographic and income subsamples, confirming that it is not strongly influenced by unobserved effects. Higher levels of short-term debt relative to reserves also appear to increase vulnerability, although the marginal effect of a change in this ratio is small. Finally, there is some weak evidence that real exchange rate appreciation is associated with the onset of twin crises.

Taken in sum, our results suggest that crises cannot be rigidly classified into the "fundamental" or "financial panic" explanations commonly found in the literature. Rather, the broader story underlying twin crises is one of fragility, with surges in capital inflows and short-term credit sustaining nations until the day investors' focus shifts elsewhere, at which point flows reverse and the boom becomes a bust. Importantly, the boom-bust cycle needn't be the exclusive result of either a self-fulfilling panic or fundamental collapse. Given our finding that current account deficits are a strong indicator of vulnerability, the general outline of a crisis can be interpreted as follows:

Liberalization and other reforms attract huge flows of capital into emerging economies, a large portion of which reflect a short maturity structure. These flows are used to finance domestic investment and consumption in excess of GNP, leading a large and growing current account deficit (Calvo and Reinhart 2000). In many cases, an overvalued real exchange rate magnifies the extent of the deficit by making imports cheaper and exports less competitive. So long as the flow of capital continues, this process can go on indefinitely. At a certain point,

however, investors deem the country unworthy, and the inflows quickly reverse.[16] Shifts of this sort can be traced to either a loss of confidence in the country's BOP sustainability, an international shock which draws capital elsewhere, or self-fulfilling dynamics such as those described by Marshall (1999) and Goldfajn and Valdes (1997). A reversal of capital flows places immense pressure on the exchange rate system, forcing the central bank to either deplete reserves or devalue. At the same time, the run on the country drains assets from domestic banks and limits the ability of financial institutions to access much needed liquidity. Banks begin to fail, and thus, a twin crisis is born.

At the heart of this story is the role of external financing. Owing to both the inadequacy of domestic markets and the enthusiasm of global investors, emerging economies rely heavily on foreign capital to fund consumption and investment. Developed countries such as the United States engage in this practice as well, yet do so in their own currency and at significantly more favorable terms. For emerging economies, external capital acts as a key source of growth financing when a nation is unable to mobilize savings domestically, and in this sense serves an important function in the development process. Yet a dependence on foreign capital represents a double-edged sword, for just as it drives growth during good times, it engenders fragility that can be crippling during bad times. This is particularly true when domestic financial institutions, which serve a critical intermediary role during the boom period, operate with a severe currency and maturity mismatch. The very fact that emerging economies rely on funds from abroad, and that these funds are prone to sharp reversals, is precisely what distinguishes twin crises in developing nations from isolated, domestically-oriented episodes in wealthier countries.

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[16] Kaminsky and Reinhart (1999) draw on a well-versed quote from Calvo (1998), who states this phenomenon by noting: "If investors deem you unworthy, no funds will be forthcoming, and, thus, unworthy you will be."

Banking and currency crises are intimately linked by a rapid shift in capital flows, and this link is made possible only by an acceptance of such flows in the first place.

As the econometric results presented above indicate, a foreign funding binge and ensuing crisis vulnerability are most commonly reflected in an ever widening current account deficit. It is curious, then, why highly-developed nations such as the United States are able to sustain a negative current account balance indefinitely, while poorer nations are subject to painful oscillations between deficit and surplus. One answer lies in the fact that, while developed nations borrow in their own currency, emerging nations are often forced to borrow in reserve currencies such as the euro or U.S dollar, meaning that expectations of a future devaluation can trigger a run on debt that brings about a contraction in the current account position (Sachs, Tornell, and Velasco 1998). This phenomenon is referred to by Eichengreen, Hausmann, and Panizza (2003) as the "original sin" of emerging economies. In addition to currency mismatching, emerging economies are distinguished from developed nations by the high agency costs they face in borrowing. Bernanke, Gertler, and Gilchrist (1996) argue that external finance is likely to dry up in times of stress for those borrowers subject to high agency costs, as capital holders "fly to quality." Strong, low-cost borrowers avoid this turnaround in capital, as lenders prefer to fund enterprises with stable balance sheets. In the context of twin crises, emerging economies represent high-agency-cost borrowers, and thus are subject to the flight to quality when fundamentals or confidence deteriorate.

Policy Implications

With a clearer understanding of the factors that make countries vulnerable to twin crises, an appropriate next step is to examine what might be done to prevent them. Here it is important to note that no single policy or policy package can entirely rule out crises, as there forever

remains the potential for upper- and lower-tail events to knock an economy off course. Yet because our empirical results show the change in crisis probability for a one unit change in a given explanatory variable, they point toward measures which can reduce a country's ultimate exposure. In particular, three closely-linked policy implications emerge from our analysis: the need to reduce agency costs of borrowing, the need to ensure stability in the current account position, and the need to control the flow of international capital. We analyze each of these proposals in turn.

Limiting Agency Costs and Uncertainty

Agency costs of borrowing play a critical role in driving capital outflows, and a first-best policy for limiting crisis vulnerability centers on reducing these costs through institutional upgrading. For emerging economies, the existence of high agency costs and uncertainty relative to developed nations owes to a host of factors, chief among them a lack of transparency in data reporting, poor regulation and supervision of the financial system, macroeconomic risks such as persistent inflation, and political instability. Each of these stems from a common source, namely a weak institutional environment. Even in countries where institutions are considered strong, such as South Korea and Malaysia in the run-up to the Asian episode, agency costs can be elevated by information asymmetries that arise from physical and cultural distance, as these gaps serve to complicate the monitoring process. When asymmetries are significant, institutionally-strong countries may be grouped together with their weaker peers, subjecting them to contagion effects during times of crisis.

The first two problems in the list above, weak supervision and data reporting, are closely aligned under the umbrella of "regulatory structure." When national statistics are incomplete, if not downright false, it becomes exceedingly difficult for overseas firms to accurately gauge the

merits of a potential investment in a given country. Because information is scarce, foreign

investors must rely in part on domestic authorities to regulate and supervise those institutions

receiving external capital (Vives 2006). Vives (2006) argues that this system is fundamentally

flawed, as domestic regulators often encounter the same data and transparency problems as

foreign investors. Additionally, regulators in emerging economies are often underfunded and

understaffed, further hindering their ability to monitor the financial sector (Vives 2006).

At first glance, an obvious solution to regulatory deficiencies is for emerging economies

to subscribe to international standards such as the Basel III banking accord. Fischer (1999)

argues that adherence to international norms eases the ability of countries to tap emergency

financing from bodies such as the IMF, which (as discussed below) act as the de facto

international lender of last resort. Standardized regulation and reporting also limit information

asymmetries and thus dramatically reduce the agency costs associated with lending to developing

nations. Yet there remains skepticism as to whether rules crafted by the G-20 and other

developed-nation groups are appropriate for emerging markets. Balin (2008) argues that

developing countries may lack the technical expertise to enforce complicated programs, while

Vives (2006) contends that advanced regulatory measures can be implemented only after data

provision is improved. Given these concerns, it may be necessary for the fiscal and monetary

authorities of emerging economies to develop a standardized regulatory approach tailored to their

specific needs. The IMF and World Bank can lend valuable technical assistance to this effort,

although such an arrangement would require international organizations to accept a secondary

role behind the regulatory authorities of participating nations.

Closely related to the notion of agency costs is that of uncertainty, which in many

emerging economies is raised by persistent macroeconomic and political instability. Uncertainty

contributes to capital flight by driving away investors who seek clarity as to the nature and timing of their returns, both in tranquil and stressful times. On the macroeconomic side, policy makers in emerging nations face a difficult task in attempting to promote full employment, stable inflation, and external competitiveness, as international capital flows can drive unwelcome changes in domestic interest rates and the real exchange rate. Known as the "trilemma"[17] this problem is summarized neatly by Cordero and Montecino (2010), who note that "a country cannot maintain, at the same time, full capital mobility, a fixed or managed exchange rate, and an independent monetary policy." Limiting uncertainty through the promotion of macroeconomic stability therefore requires adoption of either capital controls or a purely floating exchange rate, both of which are discussed in further detail below. On the political front, it is appropriate to simply note that instability is "bad for business." A solution to political troubles in the developing world remains beyond the scope of this thesis.

Perhaps the most concrete proposal for combatting uncertainty on a global scale is the creation of an international lender of last resort. Fischer (1999) provides a useful discussion of the potential advantages, disadvantages, and design of such an institution. The international lender of last resort would in Fischer's (1999) view act as both a stabilizing and coordinating agent in times of crisis. In this role, the LOLR would stand ready to provide foreign exchange to countries facing huge calls on liabilities denominated in currencies other than their own. By guaranteeing that countries have access to needed foreign exchange, the LOLR removes the incentive by creditors to be "first in line" at the central bank in order to secure foreign currency before it runs out. The lining-up phenomenon is paramount to the bank run process described by Diamond and Dybvig (1983), and applies in an international setting to situations in which

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[17] Obstfeld and Taylor (1997).

foreign capital flows rapidly reverse course. If investors are assured constant access to foreign

currency, then there is a reduced incentive to join the herd in pulling capital, and thus the risk of

coordination failure is limited *ex ante* (Fischer 1999). Coordination of private actors is a key

function of the lender of last resort in Fischer's (1999) view, as a central authority through its

role as "crisis manager" can align expectations around a particular outcome, thereby reducing

uncertainty.

From a practical perspective, Fischer (1999) argues that the IMF already acts as a type of

international lender of last resort, providing emergency financing in the wake of crises across the

globe. However, relying on the IMF to act as the LOLR imparts a distinctly political element to

a role that in theory should be rules based, as the Fund is ultimately beholden to its member

countries. Stiglitz (2010), Radelet and Sachs (1998), and others show that the Fund's

requirements for post-crisis financing often impose onerous, inappropriate conditions on

recipient nations. Any international lender of last resort must therefore be created as an

independent, apolitical body which operates under a clearly defined set of guidelines. Finally, an

international lender of last resort would likely generate a high degree of moral hazard in nations

which have access to it. Fischer (1999) contends that adherence to clearly defined policies,

along with regulatory improvements such as those discussed above, would minimize the impact

of moral hazard. Ultimately, a decision on whether to create an international lender of last resort

should rest on a determination of the willingness of participating countries to implement and

enforce agreed-upon rules and regulations.

Ensuring Current Account Stability

Policy makers seeking to limit exposure to twin crises also have a vested interest in

ensuring current account stability. From an empirical standpoint, there remains little evidence

regarding the optimal deficit or surplus for a given country, complicating efforts to target a specific balance-of-payments position. Governments should therefore pursue policies that ensure a smooth transition between deficit and surplus, as opposed to the sudden and painful shifts that often accompany crises.

An effective measure for promoting fluidity in the balance-of-payments is the imposition of a flexible exchange rate regime. The primary advantage of purely flexible, also known as floating, rates is that they are determined by market forces and adjust in real time. Countries running a current account deficit will in the long-run experience a depreciation in their real exchange rate, which through the trade channel will tend to push the country back toward balance. This process contrasts with the dynamics present under a hard peg, wherein fluctuations in the domestic price level relative to trading partners drive persistent changes in the real exchange rate that foster long-run imbalances. A decline in the domestic price level relative to trading partners leads to depreciation of the real exchange rate, while a rise in domestic prices generates appreciation, allowing the country to accumulate a large current account deficit. For balance to be achieved in the case of appreciation, countries must pursue either a nominal devaluation of the currency or an "internal devaluation" through a contraction in the domestic price level (Friedman 1953). Nominal devaluations of course wreak havoc on the balance sheets of firms with foreign-denominated liabilities, generating and exacerbating twin crises (See Section Two). Internal devaluations also carry enormous costs, as they force large declines in real economic activity given nominal price rigidity (Calvo and Reinhart 2000; Obstfeld 2012; Friedman 1953).

Implicit in this analysis is the assumption that countries must pursue either a pure float or hard peg regime. In reality, many emerging nations operate somewhere in between, employing

either a managed float or soft peg. Under a managed float, the monetary authority allows the exchange rate to fluctuate but intervenes when it deems appropriate, typically in periods of high volatility. Under a soft peg regime, the exchange rate is either fixed at a specific value by the monetary authority (as opposed to by law under a currency board), or allowed to move within a predetermined band. Soft pegs have received significant criticism from authors such as Fischer (2001), Friedman (1953) and Obstfeld and Rogoff (1995), among others. For Fischer (2001), the failure of soft pegs is illustrated by the fact that no regime of this sort, from Bretton Woods in the post-war era to emerging nations in the 1990s, has ever survived long-term. Obstfeld and Rogoff (1995) argue that the impermanence of soft pegs arises from credibility issues, as central banks are faced with a tradeoff between defending the exchange rate and inflicting damage on the domestic economy through interest rate hikes.

In his celebrated 1953 analysis, Milton Friedman offers perhaps the strongest critique of soft peg systems. In Friedman's (1953) view, the chief shortcoming of soft pegs is that they promote destabilizing speculation by marking a clear point which traders can attack. Similar to Obstfeld and Rogoff (1995), Friedman stresses the importance of credibility, arguing that traders will attack a currency only when they believe that their actions will be successful. So long as the central bank has any control over the exchange rate, it will in Friedman's view at one point or another turn toward domestic objectives and let the peg collapse, validating traders' initial expectations. Hanke (2008) highlights Friedman's focus on credibility by noting that he was in fact an advocate of *hard-pegs* in certain cases, as these regimes are not subject to discretion and are therefore viewed as permanent. However, as the Argentine experience of 2001 illustrates, even strong fixes are not immune to the vagaries of international capital markets.

Calvo and Mishkin (2003) agree with Friedman's assessment that hard pegs such as currency boards or dollarization represent the only sustainable fixed regimes, yet give closer attention to credibility issues associated with floats. According to Calvo and Mishkin (2003), the institutions which support an exchange rate system are more important for stability purposes than the system itself. If a central bank lacks public support or political independence, it is unlikely to be able to influence market expectations, limiting the effectiveness of monetary policy and thus removing a central advantage of floating rates (Calvo and Mishkin 2003). Furthermore, Calvo and Mishkin (2003) note that a lack of credibility hampers the central bank's ability to act as a lender of last resort, as liquidity provision to the financial sector is likely to generate inflationary expectations that do not arise when the monetary authority is well-respected. These issues demonstrate that credibility problems are likely to arise any time domestic institutions are weak or lack transparency, further reinforcing the importance of institutional upgrading for emerging economies.

Just as fixed currencies are subject to speculation in financial markets, so too are flexible ones. The key difference between speculation against fixed and flexible systems is that, while flexible currencies tend to experience greater *volatility* (that is, movements both up and down), fixed rates maintain their value until the bottom falls out at once, generating sudden shifts in capital that force large contractions in the current account. Given that flexible rates both avoid these one-time shifts and ensure a smoother transition between current account positions, policy makers with an eye toward crisis prevention would be wise to consider some form of a floating regime. Here the choice is between a pure float, which Calvo and Reinhart (2005) show exists only in a select few countries such as the United States, or a managed float, wherein the monetary authority uses its discretion to conduct direct or sterilized intervention in the foreign

exchange market. Managed floats would seem to fall outside the realm of criticism offered by Friedman in his 1953 paper, as the central bank does not commit to a specific peg but rather intervenes only when it sees fit. Because the exchange rate is allowed to fluctuate except for in certain cases, managed floats can facilitate current account adjustment while avoiding a degree of the volatility that often plagues floating currencies in emerging economies.

Cordero and Montecino (2010) note that managed floats, while more flexible than pegged exchange rates, are not immune from the policy trilemma, as central banks will likely exercise "discretion" whenever domestic interest rate hikes draw in capital and place significant pressure on the currency to appreciate. The central bank typically reacts to appreciation by selling the domestic currency, driving interest rates back down and nullifying any anti-inflationary measures. In this sense, the managed float effectively becomes a peg and is rendered inconsistent with domestic macroeconomic policy. Cordero and Montecino (2010) argue forcefully for the use of capital controls as a means of avoiding this trilemma, as restrictions on flows make interest rate arbitrage impossible or prohibitively costly. The arguments in favor of capital controls are compelling in that they offer a viable framework under which to maintain current account stability, and as such we analyze the nuances of control programs below.

Controlling International Capital Flows

Restrictions on the flow of international capital allow countries to pursue policies which are consistent both with macroeconomic stability and an exchange rate that prevents sudden and costly shifts in the current account. Yet perhaps the strongest advantage of capital controls comes from the fact that they may be useful in preventing the accumulation of unsustainable current account positions in the first place. By the simple balance-of-payments identity, current account deficits must be offset by matching capital/financial account surpluses (Calvo and

Reinhart 2000), and policies which impede capital inflows therefore also act to trim deficits. Furthermore, because the inflows that fund deficits often reflect high liquidity and/or a short maturity structure, capital controls could be effective in reducing the level of short-term debt held in the economy, an action that our empirical results suggest would lessen overall fragility.

In an analysis of capital account policies during the 1990s, Montiel and Reinhart (1999) find that explicit controls are generally successful in altering the maturity composition of inflows away from short-term liabilities and toward FDI, though they find no evidence that these policies reduce overall flows. Calvo and Reinhart (2000) reach a similar conclusion, although their study is admittedly similar to Montiel and Reinhart (1999) and is thus likely to echo any methodological or data shortcomings. Finally, De Gregorio, Edwards, and Valdés (2000) find evidence that Chile's capital control system reduced short-term flows while leaving total flows relatively unchanged. Together, these studies lend support to the notion that the primary achievement of capital controls is a reduction in the accumulation of short-term liabilities, the dangers of which are discussed at length in Section Three.

Montiel and Reinhart (1999) estimate the effect of capital controls by constructing an index that takes on a value of 1 when controls are in the form of strict prudential regulations, and a value of 2 when policies consist of "prohibitions, deposit requirements, or financial transaction taxes." This analysis yields valuable insights as to the efficacy of capital controls in general, yet it fails to make the critical policy distinction between price-based and quantitative measures. In a more specific case study approach, Cordero and Montecino (2010) explore this distinction by highlighting the major components of inflow control programs in Malaysia (1989-1995), Colombia (1993-1998), Chile (1989-1998), and Brazil (1992-1998).

Malaysia, Chile, and Colombia all experimented in the 1990s with some form of an unremunerated reserve requirement (URR), which requires foreign creditors to deposit a specified percentage of their investment at the central bank. These accounts are held for a fixed period of time and pay no interest, acting as a price-based control by effectively placing a tax on all inflows (Rodrik and Velasco 1999). Cordero and Montecino (2010) show that in Malaysia and Chile, the URR was successful in pushing the composition of inflows toward longer-dated securities, while in Colombia evidence is mixed. Malaysia and Brazil imposed quantity-based measures, which in the former acted in addition to a URR and included a ban on the issuance of securities with a maturity of less than one year to foreign investors (Cordero and Montecino 2010). Brazil's quantity-based measures were aimed directly at balance sheets, placing a limit on the stock of liabilities firms could hold in dollars (Cordero and Montecino 2010). Cordero and Montecino (2010) note that there remains disagreement on the effectiveness of Brazil's program, suggesting that quantity-based controls may be less effective than price-based measures in addressing inflow problems.

In order to develop a deeper understanding of the operational characteristics of price-based control systems, one can look to Chile in the 1991-1998 period, whose experience is summarized by Rodrik and Velasco (1999). Responding to a high volume of inflows, Chile in 1991 imposed an unremunerated reserve requirement of 20%, later raised to 30% in 1992 (Rodrik and Velasco 1999; Edwards 1999). This account was held for three months to one year, effectively placing a tax on inflows that Edwards (1999) estimates reached as high as 5.5% for the shortest investments. Cordero and Montecino (2010) argue that the main impetus behind the URR system was a desire by the Banco Central de Chile to conduct an anti-inflationary monetary policy without placing upward pressure on the exchange rate. In this strategy one finds a

practical application of the trilemma-breaking advantages that Cordero and Montecino (2010) use in making their case for capital controls.

Between 1991 when controls were implemented and 1998 when they were removed, Chile's short-term exposure did in fact decline, although total flows continued to increase, consistent with more general empirical work (Edwards 1999). However, Edwards (1999) finds that capital controls significantly raised the cost of capital for Chilean firms. The Chilean experience illustrates the inherent conflict in pursuing policies that limit crisis exposure on the one hand, yet have a potentially negative impact on growth and investment on the other. As Edwards (1999) argues, macroeconomic policy makers must ultimately evaluate programs within the context of their country's broader vulnerability to twin crises, weighing whether the benefits of stabilization exceed the costs of slower growth and inflow-fueled investment. A large factor in this calculus is whether the country has a properly developed regulatory and monitoring structure, as nations with strong prudential regulation are better able to deal with inflows and thus less likely to require capital controls (Edwards 1999).

Crisis Response: A Brief Overview

While this thesis is concerned with identifying the general determinants of twin episodes and what measures might be undertaken to prevent them, it bears discussing briefly the role of response policies in stemming or exacerbating crises. Following the outbreak of a twin crisis, authorities are faced with two, potentially opposing, objectives: stabilizing the exchange rate while also propping-up the financial sector. The typical mechanism used to prevent depreciation is an increase in domestic interest rates, as higher returns theoretically draw capital from abroad and increase demand for the domestic currency. Furman et al. (1998) call attention to an important flaw in this theory, noting that interest rate hikes raise the debt burden of leveraged

borrowers and thus increase bankruptcy risk. The authors argue that in cases where interest rates push bankruptcy risk to excessively high levels, capital will in fact leave the country, placing downward pressure on the exchange rate and preventing authorities from achieving either of their objectives. Radelet and Sachs (1998) reach a similar conclusion, noting that IMF-mandated, pro-cyclical monetary policy placed an undue burden on debtors in the wake of the Asian crisis, deepening the extent of the contraction. Radelet and Sachs (1998) further note that currencies continued to depreciate in Asia following the implementation of tight monetary policies.

It is clear from both the theoretical and historical analyses done by Furman et al. (1998), Radelet and Sachs (1998), and others that higher interest rates are not guaranteed to stabilize an exchange rate, and in many cases inflict further damage on the banking system through a financial accelerator mechanism akin to that described by Bernanke, Gertler, and Gilchrist (1996). This calls into question the standard policy package offered by the IMF in the wake of many twin crises. Surveying the alternatives to tight monetary policy, it is not clear that a viable option exists, meaning that authorities may ultimately have to choose between saving the exchange rate and saving the banks. One proposal is the imposition of controls on capital outflows, which Edwards (1999) argues tend to fail due to easy and widespread evasion. Edwards (1999) finds that Argentina, Brazil, and Mexico in the 1980s experienced long downturns even after the imposition of outflow controls, although Cordero and Montecino (2010) find that Malaysia's use of outflow controls was effective in stabilizing the economy following the 1997 episode. Whether or not outflow controls are the appropriate mechanism for stabilizing a crisis-stricken economy, it is evident from the stylized facts that the use of tight monetary policy as has historically been advocated by the IMF is not the way forward.

Related to the issue of monetary policy is that of fiscal policy, which plays an equally important role in the response to twin episodes. Radelet and Sachs (1998b) note that the IMF required Asian nations to pursue fiscal austerity measures as a means of reducing current account deficits following the regional crisis. The authors argue that pro-cyclical tightening was unnecessary given that capital outflows and real exchange rate depreciation were forcing a quick shift in the current account in the absence of changes to fiscal policy. If the aim of IMF-led austerity measures is to bring about a reduction in the current account deficit, then the negative consequences of these measures only further highlight the importance of pursuing policies that limit deficit accumulation *ex ante*.

Stiglitz (2010) is also critical of standard post-crisis fiscal policies for their adverse effects on real economic performance, arguing that austerity measures imposed on developing nations far exceed those implemented in developed countries. Weisbrot (2015) points to Argentina's experience post-2001 as an example of a successful stimulus-driven recovery, although the persistence of mid-double digit inflation as of writing should temper enthusiasm for the Argentine model. Rather than pointing to the Argentinian experience, U.S and Eurozone nations, along with the institutions they lead, should instead look toward their own policies in the aftermath of the Great Depression, which represents the most successful implementation of Keynesian demand management in modern history. A revival of these strategies would likely prove useful in the developing world.

The above discussion of crisis response measures is by no means an exhaustive one, yet is meant to highlight the basic observation that the pro-cyclical policies required by international institutions tend to aggravate downturns without a clear benefit of stabilization. Future research is needed on both the efficacy and consequences of monetary policy in addressing crises in open,

emerging economies. A relevant research agenda should also focus on ways to design fiscal

policies that promote aggregate demand stabilization without stoking inflation or placing a

burden on a country's long-term financial situation. Given the complex issues surrounding crisis

response, we believe appropriate prevention measures such as those discussed above are the most

effective way to achieve macroeconomic stability while promoting long-run growth.

VII: Conclusion

Since the latter portion of the twentieth century, the recurrence of twin crises has defined

the financial histories of much of the developing world. The large swings in output that follow

twin crises have acted as an impediment to financial development, capital investment, and broad

economic growth, generating upheaval that has extended beyond economics to the political and

social realms. Within the theoretical and empirical literature, the debate has centered on whether

fundamental factors are to blame, or whether crises are driven primarily by financial panic and

contagion.

This thesis contributes to the wider debate by analyzing the underlying determinants of

twin crises through a probit econometric study across a panel of 48 countries during the 1980-

2013 period. Current account deficits are found to be a robust driver of crisis vulnerability, with

the probability of twin episodes increasing in the overall deficit as a percentage of GDP. We

also find evidence that real exchange rate appreciation and higher levels of short-term debt

relative to reserves act to increase crisis vulnerability. These results should be interpreted

cautiously, as they are potentially subject to bias that arises from cross-sectional and time-variant

heterogeneity.

While fundamental weakness or international illiquidity may explain the specifics of

certain episodes, it is the fragility of international capital markets that ultimately lies at the heart

of twin crises. The boom-bust nature of capital flows drives emerging nations between periods of rapid growth followed by equally swift decline, as shifts in investor sentiment lead to sharp reversals in the direction of funds. Because foreign capital is oftentimes used to finance a current account deficit, outflows place immense pressure on the exchange rate regime, while a run on the country simultaneously drains assets from the banking system. High agency costs play a central role in this process, subjecting emerging nations to a "flight to quality" in times of stress.

In order to avoid the substantial costs of twin crises, emerging nations must commit to policies that reduce agency costs, ensure current account stability, and control the flow of international capital. Institutional improvements, particularly in terms of data transparency and reporting, would be effective means of limiting information asymmetries and lowering agency costs, ultimately reducing the likelihood of panic-driven capital shifts. Emerging nations can also promote fluidity in the current account by implementing a managed float exchange rate regime, which combined with price-based controls on capital inflows would help authorities achieve monetary independence while avoiding destabilizing currency volatility. The promotion of long-run growth and development in emerging economies relies heavily on conditions of financial stability, and by pursuing programs that prevent the outbreak of twin crises, policy makers can lay the groundwork for measures that bring sustained prosperity to a large portion of the global population.

Appendix

Appendix One:
Data notes, sources, and calculations

Countries included in full panel shown in Table 1: Argentina, Belize, Bolivia, Brazil, Botswana, Chile, China, Colombia, Costa Rica, Dominica, Dominican Republic, Ecuador, Egypt, Fiji, Ghana, Grenada, Guatemala, Honduras, Indonesia, India, Jamaica, Jordan, St. Lucia, Sri Lanka, Lesotho, Morocco, Maldives, Mexico, Mauritius, Malaysia, Nigeria, Pakistan, Panama, Peru, Philippines, Papua New Guinea, Paraguay, Senegal, El Salvador, Swaziland, Thailand, Tunisia, Turkey, St. Vincent and the Grenadines, Venezuela, Vanuatu, Samoa, Zambia

East Asia and Pacific country group: China, Fiji, Indonesia, Malaysia, Philippines, Papua New Guinea, Thailand, Vanuatu, Samoa

Latin America and Caribbean country group: Argentina, Belize, Bolivia, Brazil, Chile, Colombia, Costa Rica, Dominica, Dominican Republic, Ecuador, Grenada, Guatemala, Honduras, Jamaica, St. Lucia, Mexico, Panama, Peru, Paraguay, El Salvador, St. Vincent and the Grenadines, Venezuela

Middle East and North Africa country group: Egypt, Jordan, Morocco, Tunisia

South Asia country group: India, Sri Lanka, Maldives, Pakistan

Sub-Saharan Africa country group: Botswana, Ghana, Lesotho, Mauritius, Nigeria, Senegal, Swaziland, Zambia

Upper middle income group: Argentina, Brazil, Botswana, Chile, China, Colombia, Costa Rica, Dominica, Dominican Republic, Ecuador, Grenada, Jamaica, Jordan, St. Lucia, Maldives, Mexico, Mauritius, Malaysia, Panama, Peru, Thailand, Tunisia, Turkey, St. Vincent and the Grenadines, Venezuela

Lower middle income group: Belize, Bolivia, Egypt, Fiji, Ghana, Guatemala, Honduras, Indonesia, India, Sri Lanka, Lesotho, Morocco, Nigeria, Pakistan Philippines, Papua New Guinea, Paraguay, Senegal, El Salvador, Swaziland, Vanuatu, Samoa, Zambia

Table 4: Data sources and calculations

Variable	Definition	Source
C	Equals 1 when $(FA_{t-1} - FA_t)/(GDP_{t-1}) < 0.05$ and $FA_{t-1} < 0$, where FA = net financial account. Negative values indicate capital inflows.	Net financial account per IMF *International Financial Statistics* (IFS). Certain values are interpolated for missing years.
STDR	Short-term external debt as a percentage of total reserves (including gold). Short-term defined by the World Bank as all debt with an original maturity of one year or less. Data in USD millions.	World Bank *World Development Indicators* (WDI). Central bank sources are used where *WDI* data is unavailable. Certain values are interpolated for missing years.
DSTDR	Dummy variable equals 1 when short-term debt exceeds total reserves, and 0 otherwise.	*WDI*. Central bank sources are used where *WDI* data is unavailable.
BMR	Ratio of broad money to total reserves. Includes M2 plus certificates of deposit, large time deposits, and commercial paper. Data in USD millions.	*WDI*. Certain values are interpolated for missing years.
DI	Dummy variable equals 1 when explicit deposit insurance scheme is in place in year *t*, and 0 otherwise. Insurance schemes identified using a World Bank 2010 survey along with official sources from individual countries. Only explicitly recognized programs are set equal to 1.	Demirgüç-Kunt, Kane, and Laeven (2013).
CREDITGR	Growth in the ratio of domestic credit to nominal GDP between year *t* and *t*-3. Credit data converted to USD millions at average annual LCU/USD exchange rate.	Credit, GDP, and exchange rate data per *WDI*. Certain values are interpolated for missing years.
GDPGR	Percentage change in real gross domestic product between year *t* and *t*-3. Data in USD millions indexed to 2010.	*WDI*. Certain values are interpolated for missing years.
RER	Percentage change in real effective exchange rate between year *t* and *t*-3. Nominal effective exchange rate calculated as trade-weighted average USD cross rate for 67 trading partners. CPI deflator calculated with identical weights. Indexed to 2007.	Darvas (2012).
CAD	Current account balance as a percentage of nominal GDP. Data in USD millions.	Current account data per *IFS*. Nominal GDP data per *WDI*. Certain values are interpolated for missing years.

Table 5: Determination of lags for primary model

Dependent variable = 1 when reversal of capital inflows exceeds 5% of GDP

	One Lag		Fundamental variables two lags		Fundamental and CAD two lags	
	Number of Lags		Number of Lags		Number of Lags	
	(1)	(2)	(1)	(2)	(1)	(2)
Short-term debt as a percentage of reserves	0.0001		0.0001		0.0001	
Broad money/reserves	-0.005		-0.005		-0.005	
Explicit deposit insurance dummy	-0.012		-0.011		-0.011	
4 year change in credit	0.0000			0.0002		0.0002
4 year change in real GDP	-0.0004			0.0006		0.0005
4 year change in real exchange rate	0.0003			0.0006		0.0006
Current account deficit as a percentage of GDP	-0.006		-0.006			-0.006
Akaike information criterion	767.2		738.2		739.3	
Bayes-Schwarz information criterion	808.2		779.0		780.0	
Count R-squared	0.902		0.903		0.902	
Total number of observations	1249		1211		1207	

Coefficients represent the effect on crisis probability of a one unit increase in the explanatory variable. Model estimated using maximum likelihood estimation.

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Table 6: Country group results

Dependent variable = 1 when reversal of capital inflows exceeds 5% of GDP

	East Asia	Latin America	Middle East-N.Africa
Short-term debt as a percentage of reserves$_{t-1}$	0.0001	0.0001	0.0010**
	(0.0010)	(0.0004)	(0.0004)
Broad money/reserves$_{t-1}$	-0.002	-0.002	-0.028
	(0.056)	(0.020)	(0.097)
Explicit deposit insurance dummy$_{t-1}$	-0.010	0.003	-0.051
	(0.302)	(0.174)	(0.466)
4 year % change in credit$_{t-2}$	0.000	0.000	0.006
	(0.008)	(0.203)	(0.945)
4 year % change in real GDP$_{t-2}$	-0.001***	0.004**	-0.001*
	(1.060)	(0.721)	(2.041)
4 year % change in real exchange rate$_{t-2}$	0.004	0.000	0.003
	(0.892)	(0.299)	(1.000)
Current account deficit as a percentage of GDP$_{t-1}$	0.003*	0.009***	0.000
	(0.013)	(0.009)	(0.035)
Akaike information criterion	197.1	418.7	82.5
Bayes-Schwarz information criterion	226.2	454.1	104.8
Count R-squared	0.889	0.882	0.908
Total number of observations	280	618	120

Coefficients represent the effect on crisis probability of a one unit increase in the explanatory variable. Standard errors are in parentheses. Model estimated using maximum likelihood estimation. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively. See Appendix One for countries included in each group.

Table 7: Country group results (cont.)

Dependent variable = 1 when reversal of capital inflows exceeds 5% of GDP

	South Asia	Sub-Saharan Africa
Short-term debt as a percentage of reserves$_{t-1}$	-0.0006	0.0001
	(0.0022)	(0.0006)
Broad money/reserves$_{t-1}$	0.153**	-0.005
	(0.092)	(0.022)
Explicit deposit insurance dummy$_{t-1}$	-	0.009
	-	(0.448)
4 year % change in credit$_{t-2}$	-0.0411	0.0002**
	(1.200)	(0.054)
4 year % change in real GDP$_{t-2}$	0.2327	0.002
	(3.797)	(1.116)
4 year % change in real exchange rate$_{t-2}$	0.8021**	0.0004
	(3.951)	(0.290)
Current account deficit as a percentage of GDP$_{t-1}$	0.134**	0.007***
	(0.061)	(0.013)
Akaike information criterion	37.5	160.8
Bayes-Schwarz information criterion	55.2	188.7
Count R-squared	0.957	0.897
Total number of observations	92	242

Coefficients represent the effect on crisis probability of a one unit increase in the explanatory variable. For South Asia, coefficients represent maximum likelihood estimates rather than marginal effects. Standard errors are in parentheses. Model estimated using maximum likelihood estimation. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively. See Appendix One for countries included in each group.

Table 8: Income group results

Dependent variable = 1 when reversal of capital inflows exceeds 5% of GDP

	Upper Middle Income	Lower Middle Income
Short-term debt as a percentage of reserves$_{t-1}$	0.0001**	0.0001
	(0.0004)	(0.0004)
Broad money/reserves$_{t-1}$	-0.005	-0.003
	(0.021)	(0.017)
Explicit deposit insurance dummy$_{t-1}$	0.009	-0.027
	(0.150)	(1.820)
4 year % change in credit$_{t-2}$	-0.000	-0.000
	(0.025)	(0.004)
4 year % change in real GDP$_{t-2}$	0.001	-0.001*
	(0.564)	(0.761)
4 year % change in real exchange rate$_{t-2}$	0.001	0.001
	(0.293)	(0.219)
Current account deficit as a percentage of GDP$_{t-1}$	0.007***	0.006***
	(0.008)	(0.009)
Akaike information criterion	515.8	427.2
Bayes-Schwarz information criterion	553.0	463.7
Count R-squared	0.892	0.903
Total number of observations	777	711

Coefficients represent the effect on crisis probability of a one unit increase in the explanatory variable. Standard errors are in parentheses. Model estimated using maximum likelihood estimation. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively. See Appendix One for countries included in each group.

Table 9: Robustness to various crisis thresholds

Dependent variable = 1 when reversal of capital inflows exceeds specified % of GDP

	5% threshold	4% threshold	3% threshold
Short-term debt as a percentage of reserves$_{t-1}$	0.0001***	0.0001**	0.0001**
	(0.0003)	(0.0003)	(0.0003)
Broad money/reserves$_{t-1}$	-0.005	-0.006	-0.006
	(0.014)	(0.013)	(0.012)
Explicit deposit insurance dummy$_{t-1}$	-0.011	-0.005	0.005
	(0.123)	(0.109)	(0.099)
4 year % change in credit$_{t-2}$	0.0002**	-0.0000	-0.0001
	(0.051)	(0.021)	(0.021)
4 year % change in real GDP$_{t-2}$	0.0006	-0.0001	-0.0005
	(0.498)	(0.459)	(0.426)
4 year % change in real exchange rate$_{t-2}$	0.0006	0.0007*	0.0010**
	(0.188)	(0.173)	(0.159)
Current account deficit as a percentage of GDP$_{t-1}$	0.006***	0.008***	0.001***
	(0.007)	(0.006)	(0.006)
Akaike information criterion	738.2	923.7	1118.7
Bayes-Schwarz information criterion	779.0	964.5	1159.5
Count R-squared	0.903	0.862	0.810
Total number of observations	1211	1211	1211

Coefficients represent the effect on crisis probability of a one unit increase in the explanatory variable. Standard errors are in parentheses. Model estimated using maximum likelihood estimation. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

Table 10: Correlation matrix for explanatory variables

	STDR	BMR	DI	CREDITGR	GDPGR	RER	CAD
STDR	1.0000	0.7572	-0.0699	-0.0097	-0.1644	0.0107	-0.0523
BMR	0.7572	1.0000	0.1226	-0.0156	-0.0522	-0.0462	-0.1107
DI	-0.0699	-0.1226	1.0000	-0.0157	-0.0253	0.0821	0.2201
CREDITGR	-0.0097	-0.0156	-0.0157	1.0000	-0.0412	-0.0017	-0.1006
GDPGR	-0.1644	-0.0522	-0.0253	-0.0412	1.0000	-0.0294	0.1015
RER	0.0107	-0.0462	0.0821	-0.0017	-0.0294	1.0000	-0.0245
CAD	-0.0523	-0.1107	0.2201	-0.1006	0.1015	-0.0245	1.0000

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