

The Dynamics of Global Financial Crises*

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Abstract

This paper presents a Markov chain model of the transmission of financial crises. Using bilateral trade data and a measure of exchange market pressure, a method to determine a set of transition probabilities that describes the crisis transmission dynamics is developed. The dynamics are characterized by one-month conditional crisis probabilities and the probability of a crisis occurring within one year. The framework allows for modeling and comparing various channels of contagion, such as investments and bilateral trade. Using macroeconomic data on 45 countries, the model predicts and gives insights into the following crises: Mexico (1994), Asia (1997), Russia (1998), Brazil (1999), Turkey (2001), and Argentina (2002).

Keywords: Global Financial Crises; Contagion; Risk Management.

JEL Classification: G13

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1 Introduction

Over the past decade, several financial and economic crises hit a number of developed and developing countries. While some of these crises appeared to be isolated incidents affecting one country, for example, Turkey in 2001, a far greater number of them had effects beyond the borders of the initial country in crisis. In particular, the European Monetary System crisis of 1992, the Mexican crisis of 1994, the East Asian crisis of 1997, and the Russian crisis of 1998 affected more than the initial country.

The volatile nature of these crises resulted in economic hardship, political instability, and the toppling of a few governments. What made the crises even more disturbing was how they spread from country to country in an unexplained manner. The real difficulties associated with these financial crises prompted calls for the implementation of a variety of remedies from capital controls and currency boards to restrictions in the flow of foreign direct investment. This paper develops a discrete-time stochastic model of the spread of a financial crisis from one country to another. The model for such *contagion* of financial crises is used to explore the paths a crisis can take through different countries starting with the initial country in crisis. The paper aims to make contributions in the following areas:

Markov Chain Analysis: To present a novel scheme of modelling financial crises through Markov chains in which each Markov state is a state of the world with some countries in a tranquil financial condition and some in crisis.

Mathematical Programming: To outline an optimization model in a mathematical programming paradigm. This can be used to generate a set of transition probabilities between the Markov states that are calibrated with empirical data on crisis probabilities and beliefs about contagion mechanisms.

Contagion Channels: The model developed allows for comparison of various channels of contagion. For instance, crisis probabilities can be computed using bilateral trade data, credit or investment data. The results obtained can then be compared to assess the relative efficacy of contagion channels in explaining contagion.

In the paper, we attempt to predict contagion to countries affected by Mexico (1994), Asia (1997), Russia (1998), Brazil (1999), Turkey (2001), and Argentina (2002) crises. We calcu-

late conditional probabilities of countries going into a crisis, given that a crisis in another country occurred. We calculate 1 month and 12 month transition probabilities that explain contagion.

The organization of the paper is as follows. Section 2 reviews the existing literature on the notion of contagion and current approaches to modeling crises. Section 3 gives an overview of the Markov chain framework and the optimization program. Section 4 provides model analysis. Section 5 describes model instantiation. Data is described in Section 6. Section 7 provides results and shows the application of the model to historical data.

2 Literature Review

2.1 Types of Contagion

There are several related but distinct types of contagion. The most often analyzed type, financial contagion, refers to the spread of financial crises from one country to one or more other countries. Typically, the spread of crises is marked by a sharp deterioration of several macroeconomic and financial variables such as a fall in an index of the stock market, a depreciation of the currency, decreased or negative GDP growth rates, net outflows of foreign investment, and the collapse of property prices. Although recent crises such as the East Asian crisis of 1997 have been accompanied by all of these effects, some of the recent literature has chosen to focus on currency crises as the signal that a financial crisis has occurred.

It is possible to imagine the contagion of other types of crises as well. One country may default on its sovereign debt, precipitating defaults in other countries (default contagion). The stock market in an emerging market might drop significantly followed by similar drops in other markets independent of a currency crisis (stock market contagion). Political upheavals may destabilize regions promoting turmoil in neighboring countries (political contagion). A few papers have looked at contagion using these indicators of a crisis (Baig and Goldfajn, 1999).

There is no consensus on what makes up contagion. Forbes and Rigobon (2001, b) review some of the definitions of what constitutes contagion. Early papers often point to some empirical phenomenon, for example, increased co-movement in short term interest rates (Gerlach and Smets, 1995) and try to explain the co-movement without explicitly defining

contagion. The implicit assumption is that contagion has occurred and the papers tackle the question of defining its causes.

Testing for contagion of crises requires a definition of crisis. Several papers like Glick and Rose (1999) use popular press accounts to determine the approximate start of a crisis. These types of tests have the appeal of attempting to explain the spread of an intuitive (or popular press) notion of crisis. Eichengreen, Rose, and Wyplosz (1996) point out that focusing only on instances of devaluation of the exchange rate could miss other significant episodes of market pressure. A crisis is often preceded by a speculative attack which hastens the devaluation of the currency. However, the monetary authorities could repel a speculative attack by raising interest rates. Additionally, the authorities could increase monetary reserves in non-crisis periods to preempt an attack. To account for these additional periods, Eichengreen, Rose, and Wyplosz (1996) devised an index of exchange market pressure (EMP) that incorporates the key tools that a monetary authority has at its disposal. Using the EMP index as a proxy for the incidence of a crisis, they estimate a binary probit model to test for the significance of various macroeconomic variables in explaining contagion.

2.2 Measures of Contagion

Rigobon (2001) explores a number of pitfalls in commonly used tests for contagion. Tests for contagion must account for simultaneous equations, omitted variables, and heteroskedasticity in the data. He specifically looks at the more widely adopted tests of contagion including linear regressions, logit-probit regressions, and tests based on Principal Components and develops procedures to correct for these econometric problems under special conditions. Forbes and Rigobon (2001, b) review the four different approaches that have been used to test for contagion: analysis of correlation coefficients, GARCH frameworks, cointegration, and probit models.

2.3 Mechanisms of Transmission

The literature on contagion has divided explanations for the transmission of financial crises into two types: fundamental links among economies and the behavior of investors (Dornbusch, Park, and Claessens, 2001). The fundamental links often cited as conduits of crises are trade and capital flows. Others point to rational and irrational investor behavior as

another mechanism of crisis transmission.

2.3.1 Fundamental Mechanism

Forbes (2001) reviewed the recent literature on the role of trade in transmitting crises. Gerlach and Smets (1995) present empirical evidence on the co-movement of interest rate spreads in Nordic countries during the 1992 EMS crisis. From this, they go on to develop a three-country model based on the Flood-Garber speculative attack model. They derive the time path of the exchange rates and show the dependence of the exchange rate collapse of one country on the collapse of another country. They build a story of how the collapse of the exchange rate in country 1 leads to a real appreciation of the exchange rate of country 2. This leads to a decrease in money demand in country 2 and an erosion of reserves. A decreased ability to defend the exchange rate in country 2 eventually leads to collapse. They predict that contagion effects would be stronger when wage flexibility is low and the degree of trade integration is high between the two countries relative to the anchor country.

In addition, a number of papers empirically estimate the importance of trade in transmitting crises. Glick and Rose (1999) attempt to distinguish the importance of trade and macroeconomic mechanisms in the transmission of crises. They regress the incidence of crises on an index of trade integration involving bilateral trade data. They find that trade better explains the spread of crises than macroeconomic similarity. Forbes (2001) uses bilateral trade data broken down by industry and attempts to separate the macroeconomic effects of changes of different types of trades. She divides the implications of changes in trade into three types: a competitiveness effect, where a depreciation in another country's exchange rate decreases the first country's ability to export similar goods; an income effect, where a depreciation will sharply reduce exports to that country; and a cheap import effect, where the input prices will be reduced.

2.3.2 Investor Behavior Mechanism

In 1998, a crisis in Russia led to a series of financial crises in a number of emerging markets seemingly unrelated by trade or other fundamentals to Russia. To explain this, Calvo (1999) developed a model where uninformed investors observe the actions of informed investors. The uninformed investors face a signal extraction problem where they are not sure whether the

sales of assets by informed investors reflects negative information or margin calls. The actions of these uninformed investors tend to amplify movements in the price of emerging market securities even when the markets may not be linked by trade. In general, the co-movement of financial indicators in emerging economies may be explained by their dependence on a common set of investors.

However, none of the papers attempted to propose a unified framework for studying contagion dynamics where different crisis transmission channels can be studied and compared against each other. The remaining chapters of this paper present a model of global financial crises that illustrates the time path of contagion and allows for the analysis of contagion dynamics.

3 Model

This section outlines the framework employed in modeling contagion. It presents the Markov chain formulation of the problem, the mathematical program for probability generation, and the mechanism for mapping global relationships.

3.1 Introduction to Contagion Modeling

Much of the recent work has focused on presenting and testing the significance of various linkages between economies (for example, regional similarities, trade, and common investors). Less emphasis has been placed on explicit modeling of the dynamics of the spread of a crisis. The course of a global crisis has large ramifications for investors, multinational corporations, and the people of the afflicted countries. When a neighboring country experiences a severe and unexpected financial crisis, it matters a lot whether your country will be next.

In the absence of a framework to model the dynamics of crises, several key features of the behavior of crises are overlooked. For instance, the health of a country may depend on the health of neighboring countries or on trade partners in complex ways which are not effectively captured in pairwise estimates. Figure 1 illustrates, through a two period example, how a crisis may spread from Country A to Country C through an intermediate Country B that is related to both A and B.

Figure 2 illustrates another phenomenon in which a crisis spreads from Country A to

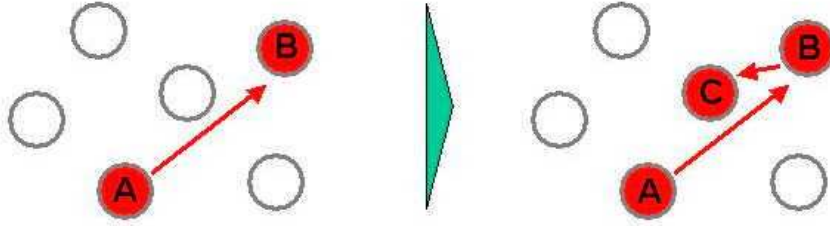


Figure 1: Contagion from Country A to Country C through Country B

Country B. Neither a crisis in Country A, nor the crisis in Country B are individually sufficient to cause a crisis in Country C, but in the second period they together produce a combined effect that is sufficient to produce a crisis in Country C.

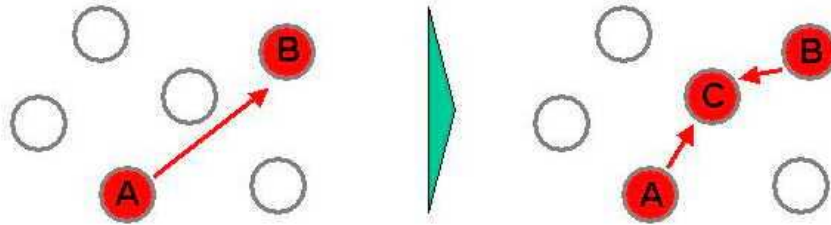


Figure 2: Contagion as a result of combined influence of two countries

Such effects are not sufficiently accounted for in the current schemes that attempt to model contagion. A comprehensive understanding of contagion of crises calls for the exploration of a dynamic model of crises dynamics and a broader model of inter-country dependencies.

3.2 Markov Chain Analysis

3.2.1 Markov Chains

The dynamics of a financial crisis can be modeled using a Markov chain in which the state changes in discrete time steps. At time t , the current state is denoted by X_t . Let S denote the set of possible states. The Markov chain is described by a set of transition probabilities p_{ij} that denote the probability that the next state is j given that the current state is i .

Explicitly,

$$p_{ij} = P(X_{t+1} = j | X_t = i) \quad i, j \in S. \quad (3.1)$$

The key assumption underlying a Markov chain is that the transition probabilities p_{ij} apply whenever state i is visited with no dependence on the history of states visited in the past.

A Markov chain model specifies: (a) the set of states $S = 1, \dots, n$ and (b) the numerical values of the transition probabilities from any state i to some other state j , p_{ij} .

3.2.2 Countries in Crisis Modeling

Each country is assumed to be in one of two states: tranquil or crisis. A state of the world then, is defined as any combination of the states of its constituent countries. Figure 3 illustrates the states for a two country case. The dark circles represent countries in crisis and the empty circles represent countries that are tranquil.

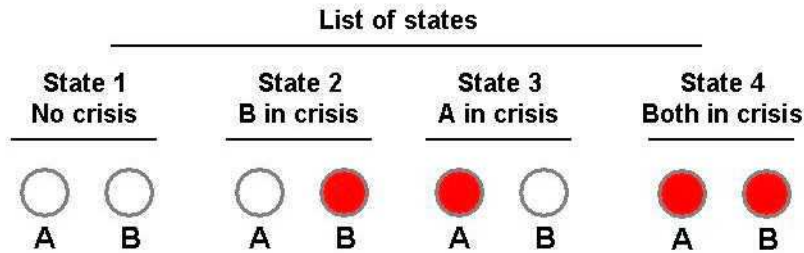


Figure 3: Markov States for Two Country Case

Figure 4 represents the Markov Chain for the two country case. Each circle represents one state of the world. The arcs between circles represent the transitions from one state to another. Each of these arcs is associated with a transition probability of going from originating state to the terminating state.

3.3 Global Relationships Mapping

The next stage in modeling contagion involves mapping the dependencies between the countries under study. The dependencies are proxies for the channels through which crises spread

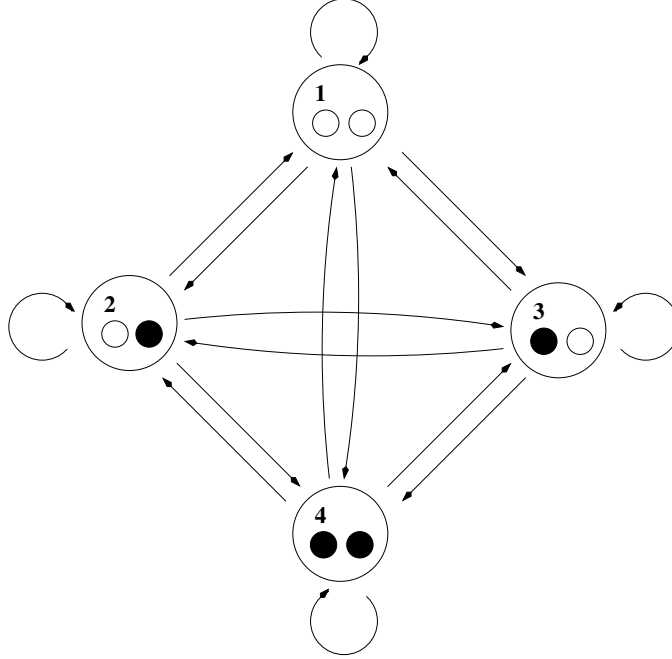


Figure 4: Two Country Markov Chain

from one country to another. The relationships between countries can be modeled as illustrated in figure 5 below. The world is represented as a directed graph in which each country is a node. Arcs represent relationships or dependencies between countries such that the thickness of each arc reflects the strength of the relationship or the magnitude of the dependency. A self loop represents a country's dependence on itself.

The model uses empirical data about countries to generate the Global Relationship Graph. The graph is represented in the model as a relationship matrix, R . This is an $n \times n$ matrix such that R_{ab} is a non-negative number which shows the dependence of country a on country b .

3.4 Transition Probabilities Generation

The final phase in modeling deals with generating transition probabilities between states in such a manner that the dependencies between countries are mapped appropriately into the probability space. That is to say, if a country A is in crisis in state S_i and country B has a high dependence on country A (as given in the relationship graph), then transitions to states in which country B is in crisis will have higher probability than states in which country B is not in crisis.

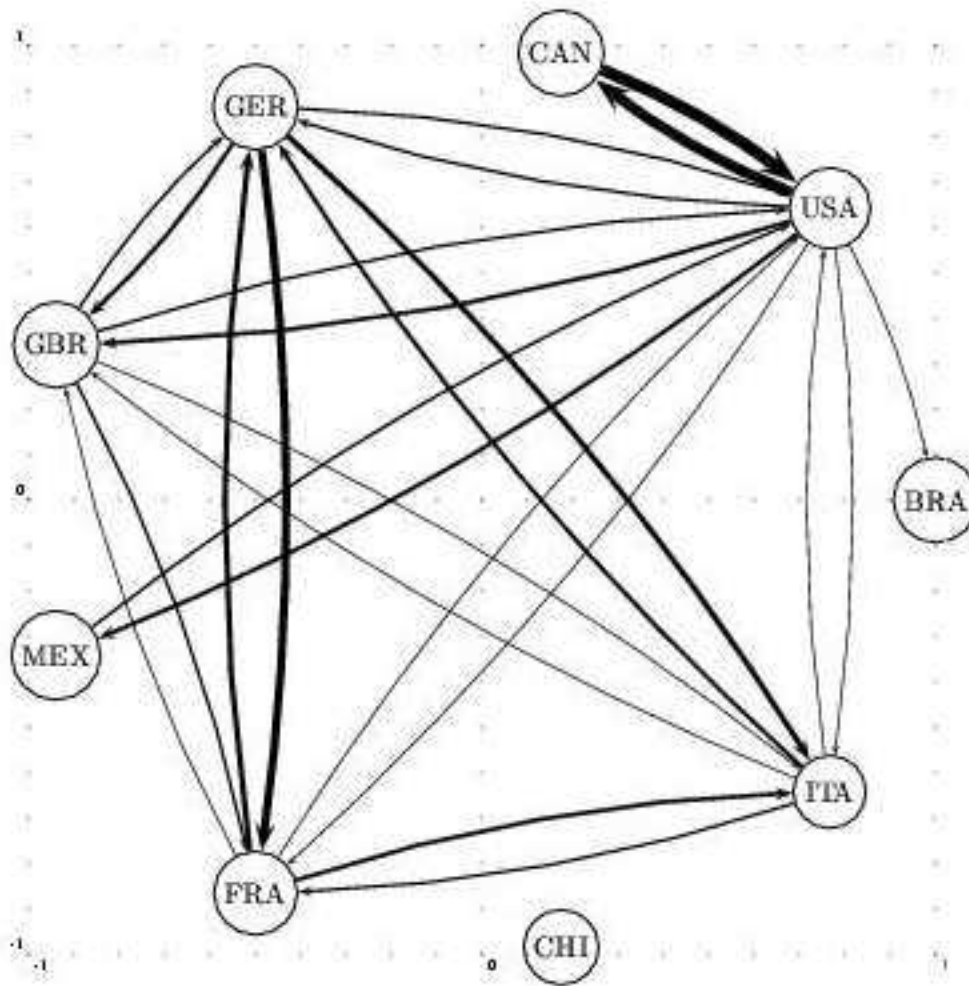


Figure 5: Global Relationship Graph for 9 countries: Canada, USA, Brazil, Italy, China, France, Mexico, United Kingdom, Germany

To generate a set of transition probabilities that satisfy the constraints of this system and preserve the relationship ordering, a mathematical program is used. This model takes two inputs:

Global Relationship Graph: This is represented by the matrix, R , described above and represents beliefs about the contagion mechanism. Various channels of contagion can be used to generate this matrix.

Unconditional Crisis Probabilities: The unconditional crisis probability for any country k is represented as π_k and is the probability of the country being in crisis in the absence of contagion effects. An empirical estimate based on historical occurrences of crises is used for π_k .

The output of the model is a matrix of transition probabilities for the Markov Chain formulation of the states of the world. The model is shown below.

Notation

Variables	Description
A_k	Country k
n	Number of countries A_1 through A_n
S	Set of all possible states S_1 through S_{2^n}
p_{ij}	Probability of transition from S_i to S_j
A_k^C	Event that country A is in crisis
A_k^T	Event that country A is not in crisis, i.e. is tranquil
I_k^i	Indicator variable = 1 if A_k is in crisis in state S_i = 0 otherwise
π_k	unconditional crisis probability of A_k
D_{ki}	Dependence of country k on state i

As shown above, the program requires the matrix D such that D_{ki} is the dependence of country k on state i . In order to transform the relationship matrix into this state dependence matrix we perform the following calculation:

$$R'_{ab} = \frac{R_{ab}}{\sum_{b=1}^n R_{ab}} \quad (3.2)$$

$$D_{ki} = \sum_{p=1}^n I_p^i R'_{kp} \quad (3.3)$$

Intuitively, if each country is thought to have one unit of *relationship* to invest, then D_{ki} represents the amount of country k 's relationship invested in crisis. The first step corresponds to normalizing each country's relationships to one unit. The second step computes the amount invested in crisis by country k .

3.5 Optimization Program

The *objective function* is chosen so as to make the unconditional crisis probabilities for each country predicted by the model as close as possible to the unconditional probabilities provided as inputs to the model. This ensures that the probabilities generated are consistent with empirically observed historical probabilities.

Min:

$$\sum_{k=1}^n (P(A_k^C) - p_{ik})^2 \quad (3.4)$$

The program then specifies a set of *constraints* to ensure that the probabilities generated are in accordance with probability laws and reflect beliefs about the transmission of crises. The first constraint sets the bounds on the program variables p_{ij} . The $[0, 1]$ interval is mandated by the fact that they are probabilities.

$$0 \leq p_{ij} \leq 1 \quad (3.5)$$

The next constraint is the total probability constraint stating that the sum of all outgoing probabilities from any Markov state should be one.

$$\sum_{j=1}^{2^n} p_{ij} = 1 \quad \forall i \in 1, \dots, 2^n \quad (3.6)$$

The next two constraints enforce the contagion effect. They ensure that the ordering of the countries in terms of the relative strength of their relationships is preserved. Countries that are closely related to other countries in crisis, are more likely to go into crisis than countries that do not have significant links.

$$(P(A_k^C|S_i) - P(A_k^C|S_j))(D_{ki} - D_{kj}) \geq 0 \quad \forall k \in 1..n, \forall i, j \in 1..2^n \quad (3.7)$$

The first contagion constraint, shown above, preserves the ordering of crisis probabilities for one country starting from two different initial states. It ensures that if more of country k 's relationships are invested in crisis in state S_i than in S_j then it is more likely to go into crisis starting from the state S_i than from S_j . This constraint ensures that the relationship ordering is preserved in the generated probabilities.

$$(P(A_k^C|S_i) - P(A_l^C|S_i))(D_{ki} - D_{li}) \geq 0 \quad \forall k, l \in 1..n, \forall i \in 1..2^n \quad (3.8)$$

The second contagion constraint preserves the ordering of crisis probabilities of two countries starting from the same initial state. It ensures that if country k has more of its relationships with countries that are in crisis in state S_i than country l , then it is more likely to go into crisis than country l if the initial state is S_i .

The probabilities used in the constraints above are related by the following equations, which are intermediate calculations to compute the value of $P(A_k^C)$ from the model variable p_{ij} .

$$P(A_k^C) = \sum_{i=1}^{2^n} P(S_i)P(A_k^C|S_i) \quad \forall k \in 1, \dots, n \quad (3.9)$$

$$P(S_i) = \prod_{k=1}^n [I_k^i \pi_k + (1 - I_k^i)(1 - \pi_k)] \quad \forall i \in 1..2^n \quad (3.10)$$

$$P(A_k^C | S_i) = \sum_{j \in S} I_k^j p_{ij} \quad \forall k \in 1, \dots, n, \forall i \in 1, \dots, 2^n \quad (3.11)$$

4 Model Analysis

4.1 Design Goals

We assess the model against the following design goals:

- Feasibility
- Computational tractability
- Optimality

The model's effectiveness can be gauged by its ability to generate the desired state transition probabilities, and its ability to reflect beliefs about the contagion mechanism in the probabilities generated. The analysis below demonstrates the existence of a feasible solution for any instance of the model. To show that beliefs about contagion are adequately represented by the model, a simple theoretical instance of the model is solved analytically.

4.1.1 Feasibility: Initial Feasible Solution

The model guarantees a feasible solution for any instance i.e. starting with any vector of unconditional default probabilities, π , and non-negative relationship matrix, R .

Solution:

Choosing

$$P(A_k^C | S_i) = D_{ki} \quad (4.12)$$

We get:

$$p_{ij} = \prod_{k=1}^n [I_k^j P(A_k^C | S_i) + (1 - I_k^j)(1 - P(A_k^C | S_i))] \quad (4.13)$$

Each D_{ki} term is between 0 and 1 by construction (equations 3.2, 3.3). Since each of the terms in the product term defining p_{ij} is between 0 and 1, the product must also be between 0 and 1. Hence constraint (3.5) is satisfied.

$$\begin{aligned}\sum_j p_{ij} &= \sum_j \prod_{k=1}^n [I_k^j P(A_k^C | S_i) + (1 - I_k^j)(1 - P(A_k^C | S_i))] \\ &= \sum_j \prod_{k=1}^n [I_k^j D_{ki} + (1 - I_k^j)(1 - D_{ki})] \\ &= 1\end{aligned}$$

Intuitively, the above sum is 1 because it is equivalent to the sum of probabilities over all outcomes of an experiment in which k coins are tossed such that the probability that coin k will come up with heads is D_{ki} . Hence the total probability constraint is satisfied.

The contagion constraints are also satisfied as shown below.

$$\begin{aligned}(P(A_k^C | S_i) - P(A_k^C | S_j))(D_{ki} - D_{kj}) &= (D_{ki} - D_{kj})(D_{ki} - D_{kj}) \\ &= (D_{ki} - D_{kj})^2 \\ &\geq 0\end{aligned}$$

$$\begin{aligned}(P(A_k^C | S_i) - P(A_l^C | S_i))(D_{ki} - D_{li}) &= (D_{ki} - D_{li})(D_{ki} - D_{li}) \\ &= (D_{ki} - D_{li})^2 \\ &\geq 0\end{aligned}$$

4.1.2 Model Robustness

As a robustness check for the methodology, the model is compared against a scenario in which the expected solution is known or can be derived analytically. One such scenario is when each country is only dependent on itself. Then the matrix R is a diagonal matrix. In this case, intuition suggests that in the optimal solution, the state transition matrix should also be the identity matrix. In the Markov chain, the self loops for each state should have probability 1 and all other arcs should have probability 0. Indeed, running the model on a diagonal matrix yields the identity matrix as the state transition matrix.

For model tractability, algorithmic complexity and runtime, see the footnote ¹.

4.2 Conditional Probability of a Crisis

If we are interested in the probability that a particular country develops a crisis within some time horizon, we can calculate the probability directly from the transition probability

¹The optimization formulated above is a quadratic programming problem. All the constraints are linear in the program variables and the objective is quadratic. The problem is solvable in polynomial time in the number of variables. However the number of variables is exponential in the number of countries. The current implementation ran the problem on a 4 processor (Pentium III, 900 MHz) machine with 4 Gigabytes of memory for up to 8 countries. The program (using AMPL and LOQO) took about 3 hours to run.

matrix. Let J represent the set of states where the country of interest is in crisis. In the two country example, country A is in crisis in state 3 and state 4. Then starting from state i , the probability that country A will be in crisis for the first time at time n , denoted f_i^n , is:

$$f_i^0 = 0,$$

$$f_i^n = \sum_{j \in J} P\{X_n = j, X_k \neq p, k = 1, \dots, n-1, p \in J | X_0 = i\}, \quad (4.14)$$

where i is an element of S . The probability of country A being in crisis within the next year starting from state i (where the time step is one month) is:

$$c_i^{12} = \sum_{n=1}^{12} f_i^n. \quad (4.15)$$

In order to calculate f_i^n , form the reduced transition probability matrix, \tilde{P} , by dropping the columns and rows corresponding to states in J . Let I be the set of these remaining states (*i.e.* $I = S \setminus J$ with $J = \{S_3, S_4\}$). In the two country example,

$$\tilde{P} = \begin{bmatrix} p_{11} & p_{12} \\ p_{21} & p_{22} \end{bmatrix}. \quad (4.16)$$

We have dropped the columns and rows corresponding to states 3 and 4. The first transition probability becomes:

$$f_i^n = \sum_{j \in J} p'_{iI} \tilde{P}^{n-2} p_{Ij}, \quad (4.17)$$

where p_{iI} and p_{Ij} are vectors. The matrix \tilde{P} is raised to the power $n-2$ because we are considering the probability of paths that enter the states represented by the reduced matrix on its first step, remain there for the next $n-2$ steps, and enter one of the states in J on the final step.

5 Model Instantiation

A particular instance of the model requires a choice of the relationship matrix, R , and a choice of the unconditional crisis probabilities for each country, π_k . Together the choices represent assumptions about the world and the optimization program outputs will effectively model any system of such assumptions. The analysis presented here uses bilateral trade data between countries as a proxy for the relationship matrix and computes the unconditional probabilities of crisis on the basis of historical values of exchange market pressure.

5.1 Relationship Matrix: Bilateral Trade

The bilateral trade between any two countries is used to calculate the strength of the relationship, i.e., the thickness of the arc. For the trade metric, R is defined as follows:

$$\begin{aligned} R_{ab} &= \text{trade flow between country } a \text{ and country } b, \text{ when } a \neq b \\ R_{ab} &= \text{GDP}_a - \text{EXPORTS}_a, \text{ when } a = b \end{aligned}$$

The trade flow is calculated as the sum of the exports and imports between the two countries.

5.2 Unconditional Crisis Probabilities

Currently the unconditional crisis probabilities are estimated using a historical measure of exchange market pressure with a crisis threshold. Two methods of estimating the probabilities are employed. The first uses a simple average of historical data and the second uses extremal value theory.

5.2.1 Exchange Market Pressure

The exchange market pressure index introduced by Eichengreen, Wyplosz, and Rose (1996) captures the notion of a currency crisis in a measure that can then be used to test for the explanatory power of macroeconomic variables. The EMP index incorporates the three elements that are impacted by a speculative attack: the exchange rate, short-term interest rates, and central bank reserves. This paper follows the version of the EMP used by Forbes

(2001),

$$\text{EMP}_{k,t} = \alpha \% \Delta e_{k,t} + \beta [(i_{k,t} - i_{U,t}) - (i_{k,y} - i_{U,y})] - \gamma (\% \Delta r_{k,t} - \% \Delta r_{U,t}) \quad (5.18)$$

where: $e_{k,t}$ denotes the price of U.S. dollars in country k 's currency at time t ; $i_{k,t}$ is country k 's interest rate; $i_{U,t}$ is the U.S. interest rate; $i_{k,y}$ is country k 's interest rate calculated as a rolling average for the previous year starting at time $t - 1$, $i_{U,y}$ is the U.S. interest rate calculated as a rolling average for the previous year starting at time $t - 1$; $r_{k,t}$ is the ratio of country k 's international reserves to narrow money (M1); $r_{U,t}$ is the ratio of international reserves to narrow money (M1) in the U.S. The weights α , β , and γ are set to the inverse of the standard deviation for each series to equalize conditional volatilities. $\% \Delta$ is measured as the weekly percentage log difference, for example,

$$\% \Delta e_{k,t} = 100(\ln e_{k,t} - \ln e_{k,t-1})$$

To identify periods of crisis, a critical value of EMP is determined using the mean and standard deviation of all EMP observations for that country. In particular, if the EMP measure for a particular country k at time t is greater than the critical EMP value:

$$\text{EMP}_{k,t} > \mu_{\text{EMP}_k} + 3\sigma_{\text{EMP}_k}, \quad (5.19)$$

then country k is designated to be in crisis at time t , where μ_{EMP_k} is the mean of the EMP series for the country k , and σ_{EMP_k} is the standard deviation of the EMP series for the country k .

5.2.2 Extremal Value Theory

The probability of a crisis in a country can be obtained by dividing the number of crisis weeks by the total number of EMP observations. However, for countries that do not experience a crisis during the sample period, this value would be zero and imply that a crisis is impossible in these countries. Alternatively, to estimate the probability of crisis events, assume that the EMP of each country is a random variable with the right tail distributed according to

the following extreme value distribution:²

$$F(x_k) = 1 - D_k x_k^{-\alpha}, \quad x_k > 0, \quad (5.20)$$

where x_k takes on the EMP values of country k ; α_k is a parameter greater than zero to be estimated. We assume that $D_k = u_k^{\alpha_k}$ and that u_k is equal to the sample mean plus one sample standard deviation,

$$u_k = \hat{\mu}_k + \hat{\sigma}_k = \frac{1}{n} \sum_{j=1}^n x_j + \sqrt{\frac{n \sum_{j=1}^n x_j^2 - (\sum_{j=1}^n x_j)^2}{n(n-1)}}. \quad (5.21)$$

The cutoff, u_k , is chosen so that the density function is convex and thus better approximated by the extreme value distribution. Only EMP values for country k that are greater than the cutoff, u_k , are used to estimate the distribution. Hill's maximum likelihood estimator of α_k is (Embrechts, Klüppelberg, and Mikosch, 1997)

$$\hat{\alpha}_k = \left(\frac{1}{t} \sum_{\{x_{j,k} \geq u_k\}} \ln \left(\frac{x_j}{u_{j,k}} \right) \right)^{-1}, \quad (5.22)$$

where the t values of $x_{j,k}$ are greater than the cutoff, u_k . We estimated α_k for each country separately. Let \bar{C} be the value of the crisis cutoff. Then the estimated probability of a crisis for country k is

$$P_k(X_k > \bar{C}) = 1 - F_k(\bar{C}) = \frac{t}{n} u_k^{\hat{\alpha}_k} \bar{C}^{-\hat{\alpha}_k}. \quad (5.23)$$

where n is the number of observations in the EMP series.

When the historical measurements of unconditional crisis probabilities give non-zero values then these values are used; otherwise, extremal value calculations are used to estimate the unconditional crisis probabilities for the model.

²See Embrechts, Klüppelberg, and Mikosch (1997), pages 330-331.

6 Data

The information needed to calculate the *bilateral trade* matrix includes bilateral import and export data between various pairs of countries. Direction of Trade Statistics (DOTS) provided by the IMF were used for this purpose. The data was located online at <http://econ.bc.edu> (restricted access website).

In order to calculate (Exchange Market Pressure) EMP values, we need data for the following:

- Foreign exchange rates to the dollar
- Interest Rates
- International Reserves
- Money Supply

In general, this data was collected from the International Financial Statistics Database available on CD-ROM. The time series ran monthly from January 1988 until December 2002. The detailed methodology is described below.

6.1 Trade Data

DOTS data was gathered for 45 countries including: Argentina, Australia, Austria, Belgium, Brazil, Canada, Chile, Colombia, Czech Republic, Denmark, Ecuador, Finland, France, Germany, Greece, Hong Kong, Hungary, India, Indonesia, Ireland, Israel, Italy, Japan, Korea, Malaysia, Mexico, Morocco, Netherlands, New Zealand, Norway, Peru, Philippines, Poland, Portugal, Russia (after 1996), Singapore, Slovak Republic, South Africa, Spain, Sweden, Switzerland, Thailand, Turkey, the U.K., and Venezuela.

Data was collected for all pairs of these countries. There are 45! such pairs (for instance Argentina-Australia, Argentina-Austria, Argentina-Belgium) for both imports and exports. The online data for imports was split into 2 groups: C.I.F. and F.O.B.³ Monthly data was collected for the following period: 1990-2002.

³For more information about this online data source, please consult: <http://fmwww.bc.edu/ec-p/data/DOTS.econ.html>

GDP figures were used from the World Bank’s World Development Indicators database. For any given sample, the GDP figures from the year previous to the crisis year were used. As an example, 1996 GDP figures are used for the countries involved in the 1997 Asia Crisis.

6.2 EMP Data

For the *foreign exchange rates*, IFS line “rf” was used in comparison to the U.S. Dollar. This produced the average exchange rates on a monthly basis. *Interest rates* were taken from IFS line “60b”. For countries where line “60b” did not produce a complete set of available data, then line “60” was used as a substitute. Line “60b” represents the money market rate and line “60” is the discount rate. For Russia, we collected interest rates from the Global Financial Database. Also note that before 1995, Russian interest rates were interpolated from quarterly data to obtain monthly estimates. *International Reserves* were found on IFS line “1L”. These were end-of-month data. *Money Supply* was found on IFS line “34”. These were also end-of-month data. An exception to this was the United Kingdom money supply, which was found on Datastream under the “M0” category.

7 Results

For empirical tests of the model, six cases which correspond to historical crises were considered. The data was analyzed for these cases for groups of up to 8 countries each. The tables below show the model inputs calculated for each case. In each case, data five years before the crisis month was used to construct the historical EMP values. The trade matrix was constructed using the preceding year’s figures, as this was assumed to be the most accurate snapshot of the trade relationships before the crisis. The countries included and the time frame for each of the six cases are outlined below.

Case 1: Mexico Crisis, April, 1994: Argentina, Brazil, Canada, Ecuador, Mexico, Peru, United Kingdom, Venezuela

Case 2: Asia Crisis, July, 1997: Indonesia, Japan, Korea, Malaysia, Philippines, Singapore, Thailand, United Kingdom

Case 3: Russia Crisis, August, 1998: Indonesia, Malaysia, Thailand, Poland, Slovak Republic, United Kingdom, Russia, Czech Republic

Case 4: Brazil Crisis, January, 1999: Argentina, Brazil, Indonesia, Korea, Malaysia, Mexico, Thailand, United Kingdom

Case 5: Argentina Crisis, January, 2002: Argentina, Brazil, Chile, Mexico, Peru, Russia, United Kingdom, Venezuela

Case 6: Turkey Crisis, February, 2001: Brazil, Canada, Israel, Japan, Morocco, Russia, Turkey

The countries in each case were chosen so as to include major trading partners, countries to which crises spread, countries that are geographically close to the country in crisis, and large countries as controls. π_h indicates historical crisis probabilities estimated from the data and π_x indicates probabilities for which historical information about crises was available, or probabilities computed using the extremum value method for those countries that did not have data on historical crises probabilities. The trade data is in millions of U.S. dollars.

7.1 Mexico Crisis

7.1.1 Description of the Crisis

Mexico is commonly regarded as the first of the major financial crises of the mid- to late-1990s. In 1993 and 1994, following years of tight monetary policy and a system of managed exchange rates, the Mexican Central Bank began to greatly expand credit to the banking system. The large increases in domestic credit to the banking system resulted in decreases in international reserves. Although Mexico had enjoyed capital inflows during the early part of the decade, foreign investors became concerned that Mexico would be unable to service its significant foreign debt; they began to withdraw funds, hastening the foreign reserve losses. The Central Bank failed to enact the immediate contraction of domestic credit that would have been needed to stem the outflow, and as a result, pressures on the exchange rate became extreme. In December 1994, the government devalued the peso by 15%. Speculative outflows continued, and the government moved almost immediately to allow the peso to float. Within two days, the exchange rate shot up from 3.5 to 5.5 pesos to the dollar (Auerbach, 2001).

Following the peso devaluation, Mexican authorities put in place an economic program to stimulate confidence in the economy. Investors, however, remained uncertain that Mexico had really fixed its problems, and interest rates remained extremely high. Bank borrowers were unable to meet their payments of interest and principal, and investors grew doubtful of the banks' solvency, further exacerbating the country's financial problems (Rojas-Suarez and Weisbrod, 1995).

The results of the crisis included a reduced rate of capital inflows, higher domestic interest rates, lower demand for money and need for tighter fiscal policy, reduced growth, higher unemployment, and a more fragile financial system (Garcia, V., 1997 and Auerbach, 2001).

7.1.2 Reasons for the Crisis

Macroeconomic Indicators

Mexico's macroeconomic condition was, in general, quite favorable in the years leading up to the crisis. Confidence in the economy was buoyed by privatizations, fixed exchange rates, and fiscal deficit reduction. Inflation was low, GDP growth averaged 3% for the preceding four years, and the country enjoyed healthy foreign capital inflows and foreign exchange reserves (Treuhertz, 2000).

The crisis was precipitated, however, by certain unfavorable macroeconomic indicators. These included a widening current account deficit, financed primarily by short-term capital, high growth of bank credit to the private sector, inadequate banking regulatory framework and oversight, an overvalued currency, a diminishing of capital inflows as a result of political instability, diminished individual savings, expansionary monetary policy and growing fiscal debt, and an increase in U.S. interest rates that attracted investment away from the Mexican markets (Treuhertz, 2000). According to Martin Feldstein, the underlying cause of the Mexico crisis was an economy marked by low domestic savings, high investments, and bank lending policies that encouraged high consumption and low savings (Quiroz, 2001).

Exchange Rate Regimes

The historical pegging of the peso to the U.S. dollar made it attractive to borrow in foreign currencies, which both led to the depletion of Mexico's foreign reserves, and also exposed

Mexico to risk, as the financial community supplanted long-term capital with short-term speculative investments (Treuhertz, 2000).

Mexico used its pegged exchange rate as the key tool for stabilization, while completely avoiding capital controls. By the time of the devaluation, the peso was overvalued by approximately 48%; the government did not attempt to adjust this, and instead financed the current account deficit - which resulted from the overvaluation - by using capital inflows (Quiroz, 2001). Pressure on the peso eventually led to the peso float at the end of 1994. After the float, the depletion of foreign reserves was alleviated, but reflected in a further loss of confidence on the part of international investors in Mexico's capacity to service its short-term debt (Treuhertz, 2000).

Public Account Deficit and Balance of Payments

During the second half of 1994, the amount of domestic credit had increased by a quarter. The oversupply of money resulted in a loss of reserves and a high current account deficit. These changes in domestic credit and the demand for money in turn had an effect on international reserves (Garcia, 1997). The ratio of international reserves-to-base money diminished steadily, and finally dropped drastically after September, 1994. Simultaneously, short-term debt began to represent a larger and larger portion of total debt. Despite witnessing the increases in domestic credit that paved the way for the drops in reserves, the Central Bank consistently failed to allow the monetary base to contract; indeed, every time international reserves dropped, the Central Bank increased domestic credit. It also sought to keep interest rates low so as not to affect the portfolios and activities of commercial banks (Garcia, 1997).

This all took place within, as mentioned above, a system of pegged peso exchange rates. The huge increases in domestic credit, accompanied by a pegged rate, were not simultaneously sustainable, and reached the breaking point at the end of 1994. As Garcia writes, "Mexico's crisis can be explained as the classic case of a pegged exchange rate that becomes unsustainable due to an expansion of domestic credit and a reduction in money demand. The large current account deficit was only a symptom of these underlying problems." (Garcia, 1997).

Banking Regulation and Supervision

Because Mexico was the recipient of significant amounts of foreign funds, commercial banks fell into the habit - largely for personal or political reasons - of granting large numbers of private sector loans in the absence of collateral guarantees, which proved to be very dangerous for the banking system (Treuherz, 2000). As Quiroz notes, authorities were aware of the lending boom on the part of the commercial banks, and were aware of potential abuses of the system by bankers, but despite significantly increased lending and widening interest rate spreads (which in turn raised the levels of non-performing loans) (Quiroz, 2001). An awareness that Mexico had not allowed a bank to fail since the 1920s led to high-risk loans as well.

Political Factors

Political factors also figured in the onset of Mexico's financial crisis. During 1994, there was significant political upheaval as a reaction to the authoritative (and, some perceived, authoritarian) use of power by then-President Salinas. Political groups offered a growing challenge to Salinas' rule during the end of his term, and the government's ability to guide the economy during 1994 suffered at the hands of electoral competition. Additionally, the government was incentivized to make potentially unwise economic decisions as a bid to keep power.

7.1.3 Contagion Effects

The Mexico crisis was relatively self-contained (Bazdresch and Werner, 2001). Its reverberations were felt, however, in a few other countries in Latin America, as evidenced by indicators such as the market for Brady bonds and the prices of corporate equities in those countries. Argentina, in particular, was affected, due to its commitment to a fixed exchange rate (Rojas-Suarez and Weisbrod, 1995). Argentina's real income fell by 4.5% in the year after the crisis, and its own banking system was in chaos. Brazil was also affected by the Mexico crisis; between the end of 1994 and the end of March 1995, both the Brazilian and Argentine stock exchanges lost about 40% of their value (Garcia, 1997).

Table 1 provides GDP and Exports for 8 countries: Argentina, Brazil, Canada, Ecuador, Mexico, Peru, United Kingdom, and Venezuela. GDP and Exports are provided in millions of US dollars a year before the Mexico crisis. The Mexico crisis started in April, 1994. π_h

indicates historical crisis probabilities estimated from the data and π_x indicates historical crisis probabilities estimated from the data if data was available, or probabilities computed using the extremum value method for those countries that did not have data on historical crises probabilities. Table 2 provides bilateral trade data for 8 countries. Note, 8 countries are chosen as to include countries that have big trade relations with Mexico, are geographically close to Mexico, or are large countries. Table 3 reports one-month transition probabilities for Argentina, Brazil, Canada, Ecuador, Mexico, Peru, United Kingdom, and Venezuela given that no countries are in crisis and given that Mexico is in crisis. Also, the probability of each country going into crisis within a year, given that Mexico is in crisis, is calculated. The best way to analyze results in the Table 3 is to look at relative transition probabilities. Latin American countries such as Argentina, Brazil, and Venezuela were twice as likely to go into a crisis than United Kingdom following Mexican crisis. These contagion effects were recorded in the literature (Garcia, 1997). Ecuador was 4 times as likely to go into a crisis compared to other Latin American countries. These results indicate that the trade mechanism explains much of the contagion effects of the Mexico crisis. However, one country - Canada - stands out. According to the model, it has almost the same transition probability as Peru. However, in reality, Canada was not exposed to the contagion from the Mexico crisis. This can be explained by the credit channel, where a crisis travels between countries with the same sovereign ratings. However, Canada has a credit rating of Aaa, and Mexico has a credit rating of Baa. In our model, only the trading channel is considered for the transmission of crisis. Therefore, if Canada had the same credit ratings as Mexico, it would be hugely exposed to the contagion.

7.2 Asia Crisis

7.2.1 Description of the Crisis

As Jackson (1999) writes, “In mid-summer 1997, a half-century of economic progress came to a crashing halt. In direct contradiction to conventional wisdom, several Asian economies previously praised for balanced budgets, high savings and investment rates, low inflation and openness to the world marketplace, went into free fall.” (Jackson, 1999) The East Asian financial crisis began in Thailand. After several speculative attacks in 1996, the Thai baht came under significant pressure in early 1997. Thai authorities responded with significant

Table 1: Data for Mexico Crisis Case. This table reports GDP and Exports for Argentina, Brazil, Canada, Ecuador, Mexico, Peru, United Kingdom, and Venezuela a year before the Mexico crisis. GDP and Exports are reported in millions of US dollars. The Mexico crisis started in April, 1994. π_h indicates historical crisis probabilities estimated from the data and π_x indicates historical crisis probabilities estimated from the data if data was available, or probabilities computed using the extremum value method for those countries that did not have data on historical crises probabilities.

S.No.	Country	GDP (\$ Mill)	Exports (\$ Mill)	π_h	π_x
1	Argentina	250943	4789	0.042	0.042
2	Brazil	638012	7819	0.021	0.021
3	Canada	538331	4220	0.000	0.009
4	Ecuador	16803	386	0.021	0.021
5	Mexico	292078	2747	0.021	0.021
6	Peru	43788	1027	0.021	0.021
7	United Kingdom	1050118	5155	0.000	0.018
8	Venezuela	76224	1785	0.000	0.009

intervention in the spot and forward markets, and exchange and capital controls to curtail speculation. These measures were insufficient, however, to address the pressures on the baht; capital continued to flow out of the country, and the peg was abandoned (Kochhar, 1998).

The crisis spread extremely rapidly through the rest of the South East Asia, and then to the countries of East Asia; the spillover effects of the contagion were felt worldwide (Rakshit, 2002). Countries in crisis experienced sharp depreciations in exchange rates, inflation, significant slowing in money and credit growth, extreme slowing of economic activity, significant turnaround in current accounts, contraction in imports, slowed export value growth, and weakening of the corporate and financial sectors (Kochhar, 1998). As the crisis spread, banking systems suffered, which had extremely negative consequences for manufacturers whose livelihood depended on abundant capital and foreign inputs. During the first year following the crisis, the currencies of Thailand, Malaysia, the Philippines, Indonesia, and Korea depreciated by 35-80%, drastically affecting their economies (Jackson, 1999).

7.2.2 Reasons for the Crisis

The East Asian crisis can be attributed to several elements, including the borrowing of large amount of short-term debt, which was able to be quickly withdrawn from the economies,

Table 2: Sample Trade Data for Mexico Crisis Case. Each entry represents the sum of exports and imports between two countries. Trade data for Argentina, Brazil, Canada, Ecuador, Mexico, Peru, United Kingdom, and Venezuela is presented. Note, the table is not symmetric due to different procedures used in gathering data for different countries. The data is located in the Direction of Trade Statistics (DOTS), bilateral trade database.

	1	2	3	4	5	6	7	8
1	0	7941	206	158	534	313	578	257
2	8164	0	1419	282	1405	554	2059	888
3	387	1465	0	162	4154	136	6216	740
4	121	234	69	0	227	209	85	168
5	607	1702	3230	207	0	342	1037	501
6	323	567	213	239	309	0	481	246
7	610	2215	5810	135	968	243	0	508
8	226	829	505	164	451	179	644	0

fixed exchange rates in the face of large deficits, and huge amounts of foreign funds that went to problematic investment projects (Dasgupta, 2001).

Macroeconomics

Throughout the early part of the 1990s, the East Asian “miracle” economies were widely heralded for what appeared to be their very strong macroeconomic fundamentals. Prior to the crisis, all of the countries in East Asia were characterized by extremely high rates of GDP growth, investment, and savings, strong export performance, significant foreign reserves, very low inflation rates, and a high degree of openness throughout the 1990s (Blejer and Del Castillo, 2001).

Post-crisis analysis, however, calls into question several of these positive assumptions. For example, although growth was very high, it was probably unrealistic to extrapolate this rate into the future. Additionally, although investments were very high as well, much of the capital had been invested in unprofitable or even failing businesses. In many of the countries, there were demonstrated solvency gaps within the year prior to the crisis. Additionally, the countries that suffered greatly (Thailand, Malaysia, Indonesia, Korea) demonstrated either significant or rapidly growing current account deficits throughout the prior part of the decade.

Liquidity

Table 3: Transition Probabilities for Mexico Crisis Case. This table reports one-month transition probabilities for Argentina, Brazil, Canada, Ecuador, Mexico, Peru, United Kingdom, and Venezuela given that no countries are in crisis and given that Mexico is in crisis. Also, the probability of each country going into crisis within a year, given that Mexico is in crisis, is calculated.

	All tranquil	Mexico crisis, 1m	Mexico crisis, 12m
Argentina	0.007	0.024	0.189
Brazil	0.007	0.024	0.173
Canada	0.006	0.072	0.225
Ecuador	0.009	0.087	0.324
Mexico	0.007	0.508	0.579
Peru	0.009	0.072	0.285
United Kingdom	0.005	0.016	0.160
Venezuela	0.008	0.038	0.235

Consistently, the East Asian crisis countries had a mismatch of short-term liabilities and liquid assets, making them highly affected by reversals of capital inflows. As Chang and Velasco (2000) write, “Much of the borrowing was in dollars and, especially in the period right before the crisis, short term. These two factors left domestic banks exposed to exchange risk and to the mood swings of lenders who had to roll over large loan volumes at short intervals.” When capital inflow reversals came to pass in late 1997, the East Asian economies were beset by bankruptcies, moratoria, and collapses in asset prices. As foreign lenders rushed to withdraw their funds, the illiquidity of East Asian domestic institutions was made evident.

Pegged Currency and Currency Overvaluation

Many of the East Asian currencies were pegged to the U.S. dollar, and kept stable via the countries’ central authorities. All of these dollar-pegged currencies of East Asia were overvalued, and were at risk for diminished export competitiveness if their levels of inflation exceed that of the U.S. Also, the East Asian currencies pegged only to the dollar, and not to the Japanese yen; since Japan was a main trading partner, effective exchange rates were very unstable. Additionally, stable exchange rates lowered perceptions of risk in borrowing and lending short-term capital, which allowed the aforementioned accumulation of short-term external liabilities (Ito, 2001).

Weak Regulatory Frameworks and Bank Lending

The Asian banking and financial systems lacked appropriate regulatory and supervisory controls, making them vulnerable even before the 1997 crisis. The banking system was marked by a lack of transparency, weak corporate governance, prevalence of relationship banking, and lack of disclosure in the banking and financial systems. There were lengthy lending booms and relatively high percentages of bad loans in the Philippines, Malaysia and Thailand, the first countries attacked by currency speculators during the crisis (Kochhar, Loungani, and Stone, 1998).

Underlying the crisis, and related to structural weaknesses in the Asian banking systems, was the presence of an extremely large volume of short-term capital inflows in all of the countries in the region (Ito, 2001). There existed a large mismatch within domestic banks between foreign liabilities and foreign assets of Asian banks and non-bank firms. While Asian banks borrowed significant amounts from foreign banks, the majority of their loans went to domestic investors and were generally intermediated by domestic financial institutions, which exposed the institutions to currency and maturity risks (Ito, 2001).

7.2.3 Contagion Effects

The reverberations of the East Asian crisis were felt globally. The first country to fall was Thailand, followed by Indonesia, Malaysia, and the rest of ASEAN, and finally the countries of East Asia more broadly. As 1997 progressed, even countries such as Hong Kong and Taiwan, which had quite strong macroeconomic fundamentals, had fallen prey to the crisis. This contagion can be attributed to many causes, including shared structural weaknesses and policy distortions across countries, trade and financial linkages, and the pure panic argument.

Similar structural weaknesses set the stage for financial crises to hit in analogous ways across countries. Thailand, Indonesia, and Korea all demonstrated capital account convertibility, fixed exchange rate, expansive domestic lending and misuse of investments, weaknesses in banking and financial regulation and supervision, and slow political decision-making (Jackson, 1999). These macroeconomic variables helped to establish environments in which other factors spread crisis further.

Trade links played a minor role as a vehicle for transmission of the crisis. Desai (2003) writes, “For example, Thailand, Indonesia, Malaysia, and South Korea, each exported small fraction of its total exports to the remaining three partners during 1990-1997. At the same time, the East Asian contagion did not hit Russia via trade knocking down Russia’s exports to the four countries of the region, which averaged less than 1 percent of Russia’s total exports. Nor did Brazil catch the contagion via a diminished demand for its products by the East Asian four.” Indeed, as Park and Song (2001) write, “Although the trade channel was the first vehicle for contagion from the Asian crisis to reach Latin America, the financial channel was by far the most important.”

Financial links, on the other hand, contributed a great deal to the spillover of the crisis. The devaluation of the Thai baht exerted a pressure on the currencies of Thailand’s bordering countries and its trading competitors, which sparked the first wave of contagion, with Thailand, Indonesia, and Malaysia all abandoning their dollar pegs in 1997. As Blejer and Del Castillo (2001) write, “Currency depreciation and hikes in interest rates had a devastating effect on highly leveraged corporate and financial sectors, with high short-term and unhedged exposure in foreign currency.” Ito (2001) also noted that the crisis spread from Hong Kong to Singapore and Taiwan via their closely linked stock markets. Lastly, Japan’s dominance as a creditor in the region meant that Japanese banks were highly exposed and reacted to the onset of the crisis by recalling their loans, which hit the financial markets hard (Desai, 2003).

Table 4 provides GDP and Exports for 8 countries: Indonesia, Japan, Korea, Malaysia, Philippines, Singapore, Thailand, and United Kingdom. GDP and Exports are provided in millions of US dollars a year before the Asia crisis. The Asia crisis started in Thailand in July, 1997. π_h indicates historical crisis probabilities estimated from the data and π_x indicates historical crisis probabilities estimated from the data if data was available, or probabilities computed using the extremum value method for those countries that did not have data on historical crises probabilities. Table 5 provides bilateral trade data for 8 countries. Note, 8 countries are chosen as to include countries that have big trade relations with Thailand, are geographically close to Thailand, or are major world powers. Table 6 reports one-month transition probabilities for Indonesia, Japan, Korea, Malaysia, Philippines, Singapore, Thailand, and United Kingdom given that no countries are in crisis and given that Thailand

is in crisis. Also, the probability of each country going into crisis within a year, given that Thailand is in crisis, is calculated. The best way to analyze results in the Table 6 is to look at relative transition probabilities. East Asian countries such as Indonesia, Korea, Malaysia, Philippines and Singapore were highly affected by the crisis. Japan also felt the contagion of the Asia crisis. United Kingdom had the smallest transition probability into a crisis given that Thailand was in a crisis a previous month. These findings correspond to reality. Therefore, we can conclude that trade mechanism was important for crisis transmission; however, given the relative magnitudes of the transition probabilities, other channels such as financial channel were important in explaining contagion (Park and Song, 2001).

Table 4: Data for Asia Crisis Case. This table reports GDP and Exports for Indonesia, Japan, Korea, Malaysia, Philippines, Singapore, Thailand, and United Kingdom a year before the Asia crisis. GDP and Exports are reported in millions of US dollars. The Asia crisis started in July, 1997. π_h indicates historical crisis probabilities estimated from the data and π_x indicates historical crisis probabilities estimated from the data if data was available, or probabilities computed using the extremum value method for those countries that did not have data on historical crises probabilities.

S.No.	Country	GDP (\$ Mill)	Exports (\$ Mill)	π_h	π_x
1	Indonesia	186475	25694	0.021	0.021
2	Japan	5209962	108154	0.000	0.005
3	Korea	449192	37294	0.000	0.004
4	Malaysia	80882	36211	0.000	0.011
5	Philippines	70807	9047	0.000	0.005
6	Singapore	77243	47330	0.000	0.004
7	Thailand	153953	22732	0.000	0.012
8	United Kingdom	1096181	17624	0.000	0.001

Probability of countries going into crisis for the first time are calculated in the Table 6. For the Asia crisis example, the probability of Malaysia going into crisis for the first time in a month given Thailand is in crisis ($p=0.030$) is much bigger than the transition probability for Philippines going into crisis for the first time in a month ($p=0.018$). In the first couple of months, Malaysia is much more likely to be affected by crisis than Philippines. Malaysia is also more likely to go into a crisis within a year ($p=0.186$) versus Philippines (0.154). However, the slope of crisis probabilities is similar starting month 3, meaning that after month 3, both Philippines and Malaysia have the same likelihood of getting affected

Table 5: Sample Trade Data for Asia Crisis Case. Each entry represents the sum of exports and imports between two countries. Trade data for Indonesia, Japan, Korea, Malaysia, Philippines, Singapore, Thailand, and United Kingdom is presented. Note, the table is not symmetric due to different procedures used in gathering data for different countries. The data is located in the Direction of Trade Statistics (DOTS), bilateral trade database.

	1	2	3	4	5	6	7	8
1	0	20737	5784	2263	921	8879	1715	2323
2	24795	0	40702	25896	13708	26138	24184	21183
3	7640	42607	0	7631	3306	8190	3523	7340
4	2689	27352	6590	0	2056	26303	5962	4670
5	987	12150	2731	1657	0	3908	1721	1796
6	0	32132	7832	41834	4932	0	12600	7890
7	2261	24898	3264	5502	1247	9553	0	3351
8	2821	22291	5654	5343	2228	7691	3398	0

by a crisis in Thailand. The sum of imports and exports between Thailand and Malaysia is 5,502 million dollars, and between Thailand and Philippines is 1,247 million dollars. The transition probabilities are graphed over time for Malaysia and Philippines in Figure 6.

7.3 Russia Crisis

7.3.1 Description of the Crisis

In the years prior to 1995, the Russian exchange rate was allowed to fluctuate within a set corridor of rubles per US dollar. In 1996, as part of Russia’s policy of stabilization, this system was replaced by what was termed a “sliding corridor”, which was maintained until 1998, when the Central Bank widened the corridor significantly. Russia’s ability to maintain this policy, however, was thrown into doubt due to perceptions of political turmoil, fiscal imbalances, and a deteriorating external situation.

Russia experienced contagion effects from the 1997 East Asian crisis; these contagion effects were felt even more pronouncedly, as a result of the political unrest within Russia. Then-President Yeltsin was re-elected in 1996, and soon thereafter, the ruble came under strong pressure due to diminishing investor confidence in Russia’s economy. (In part, this lack of confidence stemmed from suspicions of corruption in the high levels of the government, and Yeltsin’s dismissal of the government in early 1998.) (Treuhertz, 2000). In August 1998,

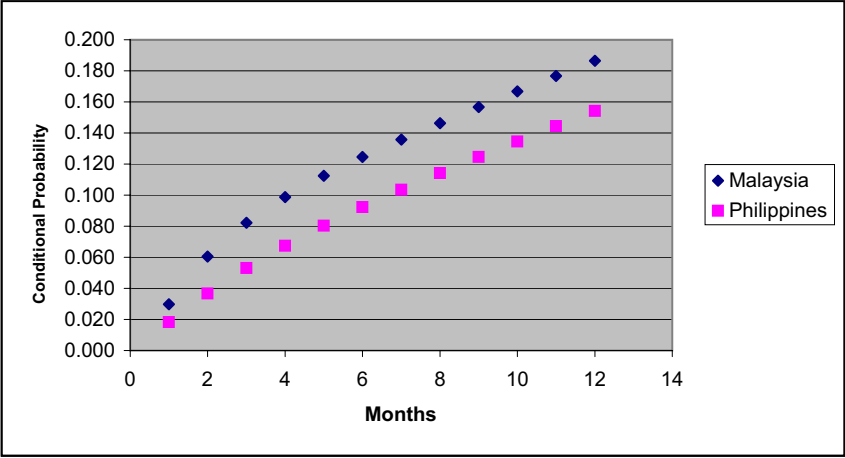


Figure 6: Probability of Going to Crisis Over Time

Table 6: Transition Probabilities for Asia Crisis Case. This table reports one-month transition probabilities for Indonesia, Japan, Korea, Malaysia, Philippines, Singapore, Thailand, and United Kingdom given that no countries are in crisis and given that Thailand is in crisis. Also, the probability of each country going into crisis within a year, given that Thailand is in crisis, is calculated.

	All tranquil	Thailand crisis, 1m	Thailand crisis, 12m
Indonesia	0.006	0.014	0.134
Japan	0.005	0.013	0.092
Korea	0.006	0.014	0.126
Malaysia	0.007	0.030	0.186
Philippines	0.007	0.018	0.154
Singapore	0.008	0.048	0.209
Thailand	0.007	0.504	0.566
United Kingdom	0.004	0.012	0.116

the situation reached a breaking point, and then-Prime Minister Sergei Kiriyenko declared a devaluation of the ruble, defaulted on government domestic debt, and ceased payments to foreign creditors by domestic commercial banks (Treuerherz, 2000 and Desai, 2003).

7.3.2 Reasons for the Crisis

When East Asia melted down, outside observers were by and large taken by surprise by the crisis. This was not the case in Russia. In Russia, as Desai (2003) writes, its “fundamentals were weak, its institutional underpinning was inadequate for the challenges of a market economy, and its policies were volatile.”

Macroeconomics

During 1997, the Russian government managed to cut inflation down to under 1% per month and the economy stabilized greatly. However, governmental budgetary management and health were poor, and deficits were high. Due to excessive tax evasion, the government was unable to raise taxes in sufficient quantity to fill the gap, and had been prohibited by the IMF from central bank borrowing. Instead, it engaged in tight monetary policy and borrowed heavily from the market, selling government issues to foreign investors; indeed, this generated an inflow of foreign funds that exceeded the foreign exchange resources available to finance their withdrawal (Desai, 2003 and Treuerherz, 2000).

Russia experienced a loss of foreign exchange reserves due to the Central Bank's efforts to maintain the value of the ruble. The losses of foreign reserves undermined the country's image on the international stage, which was already suffering from the East Asian crisis and its own bank failures. The use of monetary policy as a tool to stabilize the exchange rate, and the inadequate management of the government deficit, also contributed to the financial crisis (Treuhertz, 2000).

As a result of Russia's large fiscal deficits during 1996 and 1997, the country's debt burden ballooned, particularly the short-term portions of the burden. Additionally, decreases in the market prices of Russia's exports led to a deterioration in Russia's terms-of-trade by the middle of 1998 (Baig and Goldfajn, 2001). In reaction to the worsening of the balance of payments, interest rates increased sharply, beginning in mid-1997 (Baig and Goldfajn, 2001). Due to increasing investor withdrawals from the government debt market, and dramatic decreases in Russia's international reserves, the government faced a serious cash-flow problem (Baig and Goldfajn, 2001). This situation was made worse by the weakening banking sector, which had already felt a negative impact from the recession and low demand for credit, by the devaluation, and by Russia's default on its internal debt. Bank liquidations sparked further loss of confidence on the part of foreign investors (Treuhertz, 2000).

External Shocks

As a result of these factors, the ruble was vulnerable to external shocks. The shocks arrived in the form of the collapsing of currencies around East Asia, which led to investor withdrawals in emerging markets generally, and the decreases in the prices of oil and non-ferrous metals, both of which took place in 1997. The price of oil on the international markets also fell prior to the crisis, lowering trade revenues and raising Russia's debt. This eventually helped to lead to the currency devaluation, the restructuring of government internal debt, and a 3-month moratorium on foreign debt servicing (Treuhertz, 2000).

7.3.3 Contagion Effects

The Russia crisis was transmitted quickly to other economies around the world. Its effects were felt in both emerging markets and developed economies such as the United States, in

which the Russia crisis nearly destroyed the hedge fund Long-Term Capital Management (Masson, 2001).

For the emerging markets, the collapse of the ruble and the subsequent debt default had deleterious results deriving from a general reevaluation of emerging market risk. Investors panicked, liquidating their investment positions in other liquid markets. Anticipating the devaluation of the Brazilian real, investors began to hedge risk in Brazil with speculation in Mexican peso futures, thereby affecting the peso exchange rate (Baig and Goldfajn, 2001).

Indeed, Brazil was the main victim of Russian contagion. As Baig and Goldfajn write, "Subsequent to the crisis in Russia, and preceding the real's devaluation, foreign investors reduced their exposure to Brazil as maturing obligations came due." (Baig and Goldfajn, 2001). Brazil's highly liquid government bonds were sold as a means of covering losses in the Russian markets. As Treuherz (2000) writes, "Evidently, such sales depressed the prices of these securities and undermined investors' confidence in the Brazilian economy, battered at that time by current account deficits, political problems, and other financial imbalances." Baig and Goldfajn conclude that contagion to Brazil was due to panic from the Russian crisis triggering speculation against the real and that the locus of contagion was likely to have been the off-shore Brady markets (Baig and Goldfajn, 2001). (Brazilian residents themselves also withdrew their money from the markets during the Russian crisis, further contributing to their own country's troubles.) (Baig and Goldfajn, 2001).

The Russia crisis also had significant contagion effects in Central Asia, ultimately affecting Kazakhstan, the Kyrgyz Republic, Tajikistan, Turkmenistan, and Uzbekistan. The primary cause of the contagion was significant decreases in commodity exports from Central Asia to Russia. The IMF identifies four main channels of transmission of the Russian crisis into Central Asia: the effects of the crisis on central Asia's imports and exports; a loss of market shares of central Asian exporters to Russian businesses that derived benefits from the ruble's devaluation; the reduction in capital flows to central Asia; and the potential acceleration of reforms in central Asia that resulted from the crisis (Dungey, Fry, Gonzalez-Hermosillo, and Martin, 2002).

Eastern European countries such as Poland and Bulgaria experienced contagion due to Russia crisis (Dungey, Fry, Gonzalez-Hermosillo, and Martin, 2002).

Table 7 provides GDP and Exports for 8 countries: Czech Republic, Indonesia, Malaysia,

Poland, Russia, Slovak Republic, Thailand, and United Kingdom. GDP and Exports are provided in millions of US dollars a year before the Russia crisis. The Russia crisis started in August, 1998. π_h indicates historical crisis probabilities estimated from the data and π_x indicates historical crisis probabilities estimated from the data if data was available, or probabilities computed using the extremum value method for those countries that did not have data on historical crises probabilities. Table 8 provides bilateral trade data for 8 countries. Note, 8 countries are chosen as to include countries that have big trade relations with Russia, are geographically close to Russia, or are major world powers. Table 9 reports one-month transition probabilities for Czech Republic, Indonesia, Malaysia, Poland, Russia, Slovak Republic, Thailand, and United Kingdom given that no countries are in crisis and given that Russia is in crisis. Also, the probability of each country going into crisis within a year, given that Russia is in crisis, is calculated. The best way to analyze results in the Table 9 is to look at relative transition probabilities. According to the model, high relative transition probabilities of a country going into a crisis given that Russia is in crisis correspond to East European countries that are geographically close to Russia and trade a lot with the country. Countries like Czech Republic, Poland, and Slovak Republic have 10 times more probability of going into a crisis compared to a large country like United Kingdom. The model corresponds to the real data.

7.4 Brazil Crisis

7.4.1 Description of the Crisis

For five years prior to the 1999 financial crisis in Brazil, the country had been buffeted by the economic crises in Mexico, East Asia, and Russia, which sparked anxiety in Brazil's financial markets and depleted its foreign reserves. The Brazil crisis, however, had been precipitated by conditions within the country itself.

In response to years of destructively high levels of inflation (reaching the 4-digit level by 1994), Brazil's finance ministers developed a new stabilization program and austerity plan (the Real Plan), the two elements of which were fiscal adjustment and a new indexing system that would lay the foundation for a new currency (Baer, 2001). The plan had a positive effect; over the period of 1995 to 1998, inflation fell and growth increased.

Despite this, however, the high exchange rate (used to manage inflation and maintain

Table 7: Data for Russia Crisis Case. This table reports GDP and Exports for Czech Republic, Indonesia, Malaysia, Poland, Russia, Slovak Republic, Thailand, and United Kingdom a year before the Russia crisis. GDP and Exports are reported in millions of US dollars. The Russia crisis started in August, 1998. π_h indicates historical crisis probabilities estimated from the data and π_x indicates historical crisis probabilities estimated from the data if data was available, or probabilities computed using the extremum value method for those countries that did not have data on historical crises probabilities.

S.No.	Country	GDP (\$ Mill)	Exports (\$ Mill)	π_h	π_x
1	Czech Republic	52036	5980	0.000	0.014
2	Indonesia	202132	6883	0.021	0.021
3	Malaysia	88832	8953	0.021	0.021
4	Poland	127085	4138	0.021	0.007
5	Russia	337709	8562	0.021	0.021
6	Slovak Republic	18377	3202	0.000	0.002
7	Thailand	168280	6381	0.021	0.021
8	United Kingdom	1126740	8985	0.000	0.006

price stability) led to deteriorating trade balances. Concurrently, the fiscal situation of the government was also worsening. At the end of 1998, in light of the drastically decreased foreign reserves, Brazil worked quickly with the IMF to design and implement a loan package that emphasized tax hikes and spending cuts. The IMF plan, however, was soon rendered irrelevant; monetary policy did not prevent exchange rate collapse. High interest rates were dragging the economy into recession, and were not achieving their purpose of halting capital outflows. As Cardoso and Hedwege (2001) write, “Capital outflows, lack of fiscal progress, strong resistance by the domestic business community to the record high interest rates and growing demands for correction of the overvalued exchange rate forced the government to adopt a new exchange rate regime.” In January 1999, the real was floated; within six weeks, it had depreciated sharply.

7.4.2 Reasons for the Crisis

Macroeconomics

The macroeconomic conditions in Brazil differed from those of other crisis countries due to the significant foreign reserves that Brazil maintained through its own crisis (Treuerherz, 2000). Since 1991, Brazil had received huge amounts of foreign capital inflows, stimulated

Table 8: Sample Trade Data for Russia Crisis Case. Each entry represents the sum of exports and imports between two countries. Trade data for Czech Republic, Indonesia, Malaysia, Poland, Russia, Slovak Republic, Thailand, and United Kingdom is presented. Note, the table is not symmetric due to different procedures used in gathering data for different countries. The data is located in the Direction of Trade Statistics (DOTS), bilateral trade database.

	1	2	3	4	5	6	7	8
1	0	64	161	2560	2389	5093	84	2112
2	22	0	1985	117	155	10	1784	2063
3	34	2486	0	77	213	7	4576	3930
4	2485	212	216	0	3970	927	176	3403
5	1901	102	237	3205	0	1561	93	4132
6	4822	36	33	994	1702	0	24	459
7	0	1883	3978	123	104	0	0	2833
8	2173	2233	4435	3136	3975	298	2853	0

by the large interest rate differential between high domestic rates at home and low domestic rates abroad. Beginning in 1996, foreign capital investments became the main source of net capital inflows to Brazil, resulting in significant foreign reserves that buffered the Real Plan, allowing Brazilian authorities to maintain the exchange rate anchor for many years (Garcia and Valpassos, 2000). Brazil had also successfully initiated a privatization plan during 1996-1997, which added to the country's reserves of foreign exchange (Treuhertz, 2000).

Those attributes of Brazil's macroeconomic situation had negative effects. For example, Brazil's healthy reserves allowed the government to be lax in its reform efforts, and there was little move to balance the budget, engage in tax and pension reforms, move towards privatization and public sector reform, or guide the economy towards greater openness (Garcia and Valpassos, 2000). Additionally, the high interest rates that attracted foreign investors to Brazil increased the country's exposure to growing inflows of short-term investment capital (Treuhertz, 2000). High interest rates also created an economic downturn in industrial output and stimulated large layoffs, resulting in growing unemployment (Treuhertz, 2000).

Exchange Rate Anchor

Although the exchange rate anchor featured in the Real Plan had greatly lowered inflation, and contributed to high growth and rising salaries, it had significant macroeconomic

Table 9: Transition Probabilities for Russia Crisis Case. This table reports one-month transition probabilities for Czech Republic, Indonesia, Malaysia, Poland, Russia, Slovak Republic, Thailand, and United Kingdom given that no countries are in crisis and given that Russia is in crisis. Also, the probability of each country going into crisis within a year, given that Russia is in crisis, is calculated.

	All tranquil	Russia crisis, 1m	Russia crisis, 12m
Czech Replibc	0.009	0.165	0.543
Indonesia	0.008	0.014	0.217
Malaysia	0.008	0.022	0.259
Poland	0.009	0.165	0.477
Russia	0.008	0.518	0.617
Slovak Republic	0.009	0.245	0.583
Thailand	0.008	0.017	0.227
Unided Kingdom	0.007	0.022	0.205

flaws. Although the use of the exchange rate as the key instrument of macroeconomic policy controlled inflation, it also resulted in the degradation of the trade balance. After a decade of surplus, the trade balance moved into a four-year deficit starting in 1995, as a result of rapidly rising imports and a decline in export growth (Baer, 2001). In this manner, the overvaluation of the real put great pressure on the balance of payments.

Fiscal Deficits and Foreign Borrowing

The government's fiscal situation began to deteriorate in 1998, weighed down by bloated personnel ranks and public sector payroll. Fiscal reform, although desperately needed, was not prioritized by the deeply divisive Cardoso government. The mounting current account deficit was financed through loans from the domestic and international financial markets; inflows of foreign capital, attracted by the country's high interest rates and stable currency exchange rate, resulted in rising external indebtedness (Baer, 2001). Because of the inflows of foreign investment capital and the privatization of public companies, Brazil's authorities were again not forced to reduce the public deficit in any immediate time frame (Treuerherz, 2000). Public debt grew to over 40% of GDP between 1993 and 1998 (Baer, 2001).

High interest rates - the value of which rose even higher as inflation fell - were key to the financing of this expanding public sector deficit. The East Asia and Russia crises led

to increases in interest rate spread as the government tried to both finance the deficit and maintain the pegged exchange rate; this exerted an even stronger pressure on the deficit, which more than doubled between 1996 and 1998. As Baer (2001) writes, “Thus the government found itself in a vicious circle: to maintain the exchange rate and to finance its deficit it had to borrow at a rising interest rate, which in turn worsened the fiscal situation and, by extension, further undermined investor confidence.”

Political Factors

Prior to the crisis, Brazil was plagued by a political re-election campaign that focused on combating the public deficit and initiating needed macroeconomic reforms. These delays resulted in a loss of confidence on the part of international investors in Brazil’s ability to honor its financial commitments (Treuhertz, 2000). Additionally, the Brazilian central bank is not an independent institution; the potential governmental influence on the central bank may have, for example, led it to hold off on more aggressive monthly currency depreciations (one thing that might have held the crisis at bay). (Treuhertz, 2000).

7.4.3 Contagion Effects

Brazil experienced contagion from both the East Asian crisis and the Russia crisis. Brazil’s markets suffered from the crisis in East Asia first; both its stock exchanges and its offshore markets, such as the Brady-bond market, experienced spillover effects from the east. As the turbulence hit Brazil, the prices of emerging-market bonds and stocks suffered severely, and banks issued strict margin calls and “haircuts.” Brazil responded to the Asian crisis with a \$20 billion fiscal effort, a doubling of interest rates, and a relaxation of capital inflows (Franco, 2002). Franco notes, however, that the domestic policies initiated in response to the Asia crisis failed to develop as had been envisaged, and did not produce a suitable fiscal package.

For this reason, when the Russia crisis hit, the international financial markets viewed Brazil as being very fragile, and negotiation of an agreement with the IMF was inevitable (Franco, 2002). The Russia crisis led to a worldwide reevaluation of financial instruments in emerging economies, and to withdrawals of funds across the globe. As Franco writes, “The

Russia crisis had a deep impact on Brazil in view of Brazil's 30 to 45 % share in emerging-market portfolio and of the specific hedging strategies used by investors directly enduring losses in Russia." (Franco, 2002). The mechanism for the spread of contagion from Russia to Brazil was, once again, the Brady-bond market; due to the perception of risk in the bond markets of emerging economies, there was intense pressure to get out of the Brazilian bond market quickly, or to short Brazilian bonds in order to lower their prices and thereby reduce losses in the Russian markets (Franco, 2002).

Argentina experienced deleterious spillover from the Brazil crisis. The Argentine currency board maintained the peso pegged to the U.S. dollar; while the peso was depreciating alongside the dollar against the euro and the yen, it was rising against the Brazilian real, such that capital flowed out of Argentina, while the currency was appreciating against the currency of its most important partner (Kubarych, 2001).

Table 10 provides GDP and Exports for 8 countries: Argentina, Brazil, Indonesia, Korea, Malaysia, Russia, Slovak Republic, Thailand, and Untied Kingdom. GDP and Exports are provided in millions of US dollars a year before the Brazil crisis. The Brazil crisis started in January, 1999. π_h indicates historical crisis probabilities estimated from the data and π_x indicates historical crisis probabilities estimated from the data if data was available, or probabilities computed using the extremum value method for those countries that did not have data on historical crises probabilities. Table 11 provides bilateral trade data for 8 countries. Note, 8 countries are chosen as to include countries that have big trade relations with Brazil, are geographically close to Brazil, or are large countries. Table 12 reports one-month transition probabilities for Argentina, Brazil, Indonesia, Korea, Malaysia, Russia, Slovak Republic, Thailand, and Untied Kingdom given that no countries are in crisis and given that Brazil is in crisis. Also, the probability of each country going into crisis within a year, given that Brazil is in crisis, is calculated. The best way to analyze results in the Table 12 is to look at relative transition probabilities. According to the model, Argentina is 10 times more likely to go into crisis than other countries analyzed in the case, given that Brazil is in crisis. This is exactly what happened in the data. Argentina was the sole victim of contagion from the Brazil crisis. Therefore, the model accurately predicted the country that would experience contagion in this case.

Table 10: Data for Brazil Crisis Case. This table reports GDP and Exports for Argentina, Brazil, Indonesia, Korea, Malaysia, Mexico, Thailand, and United Kingdom a year before the Brazil crisis. GDP and Exports are reported in millions of US dollars. The Brazil crisis started in January, 1999. π_h indicates historical crisis probabilities estimated from the data and π_x indicates historical crisis probabilities estimated from the data if data was available, or probabilities computed using the extremum value method for those countries that did not have data on historical crises probabilities.

S.No.	Country	GDP (\$ Mill)	Exports (\$ Mill)	π_h	π_x
1	Argentina	305712	6824	0.000	0.001
2	Brazil	748180	9106	0.000	0.000
3	Indonesia	197903	7767	0.021	0.021
4	Korea	511767	19493	0.021	0.021
5	Malaysia	97156	11505	0.021	0.021
6	Mexico	337454	1700	0.021	0.021
7	Thailand	156692	7490	0.021	0.030
8	United Kingdom	1227671	7458	0.000	0.008

7.5 Argentina Crisis

7.5.1 Description of the Crisis

In 1991, following almost thirty years of chronic inflation, Argentina delineated a Convertibility Plan, which established a currency board pegging the Argentine peso to the U.S. dollar at a one-to-one ratio. This initiative was effective; in the several years following the initiation of the Plan, inflation fell to between 5 and 25%. Low inflation was accompanied by high prosperity and was facilitated by structural reforms that included privatization, deregulation, and a general opening of the economy. Capital inflows led to high growth in domestic credit, consumption, and investment (Corbacho, Garcia-Escribano, and Inchauste, 2003).

During the second half of 1998, after nearly ten years of good macroeconomic performance, the Argentine economy entered into a deep recession (Corbacho, Garcia-Escribano, and Inchauste, 2003). Conditions worsened steadily over the next three years. At the end of 2001, in response to popular discontent and unrest, the Argentine administration resigned. At the beginning of 2002, in a swirl of economic and political unrest, Argentina abandoned its pegged exchange rate. By the beginning of 2003, the peso had depreciated by over 300%. Social indicators, which had declined over the previous decade, fell still more dramatically.

Table 11: Sample Trade Data for Brazil Crisis Case. Each entry represents the sum of exports and imports between two countries. Trade data for Argentina, Brazil, Indonesia, Korea, Malaysia, Russia, Slovak Republic, Thailand, and United Kingdom is presented. Note, the table is not symmetric due to different procedures used in gathering data for different countries. The data is located in the Direction of Trade Statistics (DOTS), bilateral trade database.

	1	2	3	4	5	6	7	8
1	0	11229	169	752	401	772	303	806
2	11758	0	357	1748	515	1747	326	2781
3	168	494	0	4650	1942	204	1746	1687
4	602	2119	6526	0	6803	2309	2803	6875
5	275	376	2988	5902	0	353	5225	4652
6	489	1641	372	3414	1135	0	515	1996
7	298	342	2077	2680	4636	436	4	2819
8	796	2827	2329	6247	4835	1604	2931	0

Poverty increased to nearly 50%, accompanied by rising unemployment and income inequality (Corbacho, Garcia-Escribano, and Inchauste, 2003). The country was in the throws of crisis and experienced either negative or very low growth for the past three years (Desai, 2003).

7.5.2 Reasons for the Crisis

Macroeconomics

Argentina's macroeconomic situation demonstrated certain structural weaknesses in the years leading up to the crisis. Although inflation had been maintained at a very low level since the 1991 adoption of the peso-dollar peg, the Convertibility Plan had the negative effect on the steadily growing fiscal deficits; the currency board also did not establish borrowing limits. (Desai, 2003 and Corbacho, Carcia-Escribano, and Inchauste, 2003). The country was highly dependent on private capital flows. This density of private capital resulted in growing external debt, and led to fears of debt default on the part of domestic and foreign investors. Argentina lost significant access to external capital markets, unemployment rose and job security fell as a result of rigidities in the labor market. Worsening social conditions and freezes on bank deposits led to increasing social and political unrest. (Corbacho, Carcia-Escribano, and Inchauste, 2003). By the middle of 2001, Argentina was unable to prop itself

Table 12: Transition Probabilities for Brazil Crisis Case. This table reports one-month transition probabilities for Argentina, Brazil, Indonesia, Korea, Malaysia, Mexico, Thailand, and United Kingdom given that no countries are in crisis and given that Brazil is in crisis. Also, the probability of each country going into crisis within a year, given that Brazil is in crisis, is calculated.

	All tranquil	Brazil crisis, 1m	Brazil crisis, 12m
Argentina	0.008	0.160	0.380
Brazil	0.008	0.510	0.590
Indonesia	0.009	0.017	0.210
Korea	0.009	0.023	0.202
Malaysia	0.010	0.026	0.236
Mexico	0.008	0.036	0.222
Thailand	0.009	0.016	0.221
Unided Kingdom	0.007	0.017	0.162

up any longer from the effects of years of stagnant economic growth, falling exports, a weak banking system, and rising fiscal deficits (Auguste, Dominguez, Kamil, and Tesar, 2002). As Desai writes, “The combination of the weak fundamentals and the growing foreign debt liabilities provided the ingredients for the crisis in late 2000.” (Desai, 2003).

Currency Overvaluation

The pegged peso-dollar exchange rate resulted in an overvaluation of the peso as compared to the currencies of Argentina’s trading partners, since the U.S. dollar was strong with regard to the currencies of Argentina’s trading partners. The fixed peso also appreciated as a result of Argentine inflation inertia and wage rigidity. Finally, the devaluation of the Brazilian real in 1999 diminished the peso’s competitive standing in Latin American trading markets (Desai, 2003).

Fiscal and Current Account Deficits and Foreign Debt

As introduced above, the use of a currency board had negative consequences for Argentina’s macroeconomic condition. Interest rates could not be changed in response to GDP growth-rate cycles. Also, money-supply growth was explicitly linked to foreign exchange earnings, which suffered at the hands of the overvalued peso; this resulted in low liquidity,

which ultimately dampened private savings and investment, in turn slowing growth (Desai, 2003).

The currency boards did not establish the required discipline of governments either at the center or in outlying areas regarding appropriate levels of debt (Desai, 2003). The central bank did also not act in keeping with the exigencies of the fiscal situation. It failed to act as a lender of last resort, and thereby forced the treasury to borrow abroad, augmenting government debt and reducing private investment. By the end of 2000, Argentine foreign debt had risen to half of the country's GDP, resulting in investor panic and worry over the stability of the currency. Six months later, the situation had worsened further, as the currency peg was threatened by capital outflows and falling deposits in Argentine banks that the holders converted into dollars (Desai, 2003).

Government Ineffectiveness

Argentina had, in general, relatively weak democratic institutions, and its administrative history was spotted with military coups and prolonged periods of populist rule, both of which had muted the needed discourse regarding fiscal management. The Argentine government was also very bloated in the years leading up to the crisis, as a result of various big-government policies carried over from previous administrations. These included granting workers extremely generous unemployment and medical insurance, lack of regulation of provincial government spending, and bailouts of provincial governments that had overspent. (Desai, 2003). In the years leading up to the crisis, Argentina also experienced endemic tax evasion, perpetuated by a currency board with insufficient tax-collecting authority and by a poorly regulated banking sector. This tax evasion resulted in massive losses of revenue (Desai, 2003).

7.5.3 Contagion Effects

Contagion From Other Countries Towards Argentina

Argentina was a victim to a far lesser extent than the countries of East Asia to what Desai describes as “excessive and indiscriminate short-term capital inflows,” continuing to grow throughout the East Asian crisis. (Desai, 2003 and Corbacho, Garcia-Escribano, and

Inchauste, 2003). The country did, however, experience deleterious spillover from the Brazilian crisis. The Argentine currency board maintained the peso pegged to the U.S. dollar; while the peso was depreciating alongside the dollar against the euro and the yen, it was rising against the Brazilian real, such that capital flowed out of Argentina, while the currency was appreciating against the currency of its most important trading partner (Kubarych, 2001). Argentina also suffered badly from the worldwide reversal of capital flows to emerging markets following Russia's default on debt in 1998 (Corbacho, Garcia-Escribano, and Inchauste, 2003).

Contagion From Argentina Towards Other Countries

The Argentine crisis was relatively self-contained. Desai (2003) comments that creditors anticipated Argentina's debt default in a way that they did not anticipate the Russian financial crisis; these creditors had adjusted their balance sheets, "preempting an extensive turbulence." As Desai (2003) comments, "The escalating Argentine financial troubles did not create a global crisis - panicky investors did not flee from emerging markets causing their currencies to tumble."

Argentina's financial and trade linkages with other Latin American countries contributed to the spillover effects that did obtain. Ten percent of Brazil's exports, for example, went to Argentina; it is unsurprising that Brazil was more pronouncedly affected by the Argentine crisis than were Chile or Mexico, for whom exports to Argentina were of relatively less importance. Brazil, which had acquired a significant current account deficit financed by capital flows, experienced spillover effect that shook the real and upset Brazil's economic recovery (Desai, 2003). The ups and downs of Argentine bond prices also affected Brazil, which had engaged in extensive speculation in the Argentine bond market; the exchange of short-term instruments for long-term instruments was more worrying to them than to, for example, Mexican investors, who were more involved in the American than the Argentine financial sector (Desai, 2003). Lastly, reverberations from the Argentine crisis were also felt in Uruguay; Uruguay had expensive financial links to Argentina, and it was threatened by banking sector collapse when Argentines rushed to withdraw cash from Uruguayan banks; the banks were closed temporarily and Uruguay received monetary support from the U.S. (Desai, 2003).

Table 13 provides GDP and Exports for 8 countries: Argentina, Brazil, Chile, Mexico, Peru, Russia, United Kingdom, and Venezuela. GDP and Exports are provided in millions of US dollars a year before the Argentina crisis. The Argentina crisis started in January, 2002. π_h indicates historical crisis probabilities estimated from the data and π_x indicates historical crisis probabilities estimated from the data if data was available, or probabilities computed using the extremum value method for those countries that did not have data on historical crises probabilities. Table 14 provides bilateral trade data for 8 countries. Note, 8 countries are chosen as to include countries that have big trade relations with Argentina, are geographically close to Argentina, or are major world powers. Table 15 reports one-month transition probabilities for Argentina, Brazil, Chile, Mexico, Peru, Russia, United Kingdom, and Venezuela given that no countries are in crisis and given that Argentina is in crisis. Also, the probability of each country going into crisis within a year, given that Argentina is in crisis, is calculated. The best way to analyze results in the Table 15 is to look at relative transition probabilities. According to the model, Brazil and Chile have one-month transition probabilities of 0.219 and 0.258 respectively given that Argentina is in crisis a previous period. These transition probabilities are more than 10 times bigger than transition probabilities for Mexico, Peru, Russia, United Kingdom and Venezuela that did not experience contagion from the Argentina crisis. These results correspond to the real data. Therefore, the model well predicts the contagion in the Argentina crisis case, and confirms that the trading channel was responsible for the contagion.

7.6 Turkey Crisis

7.6.1 Description of the Crisis

In the seven years leading up to Turkey's financial crisis in 2001, the country had experienced periods of both positive and negative growth. Overall, however, macroeconomic fundamentals were weak and unstable as compared to, for example, the crisis countries of East Asia. Inflation, for instance, had been high throughout the period, and budget deficits were extreme. For most of the fifteen years leading up to the crisis, Turkey's current account balance had been in deficit, requiring extreme levels of foreign borrowing (Desai, 2003). The crisis hit in November 2000, precipitated by the failures of ten commercial banks and the resulting panic on the part of foreign investors; sudden withdrawals of funds pushed overnight

Table 13: Data for Argentina Crisis Case. This table reports GDP and Exports for Argentina, Brazil, Chile, Mexico, Peru, Russia, United Kingdom, and Venezuela a year before the Argentina crisis. GDP and Exports are reported in millions of US dollars. The Argentina crisis started in January, 2002. π_h indicates historical crisis probabilities estimated from the data and π_x indicates historical crisis probabilities estimated from the data if data was available, or probabilities computed using the extremum value method for those countries that did not have data on historical crises probabilities.

S.No.	Country	GDP (\$ Mill)	Exports (\$ Mill)	π_h	π_x
1	Argentina	268773	7609	0.042	0.042
2	Brazil	502509	9086	0.042	0.042
3	Chile	66450	2703	0.021	0.021
4	Mexico	617820	2127	0.021	0.021
5	Peru	54047	1231	0.042	0.015
6	Russia	309951	2458	0.021	0.021
7	United Kingdom	1424094	3350	0.000	0.003
8	Venezuela	124948	1566	0.021	0.003

interbank lending rates to 2,000% (Desai, 2003).

Following the start of the crisis, the IMF stepped in and committed a \$10 billion support package, three quarters of which were new loans. This buoyed the markets for several months, until political instability sparked panic again three months later, and overnight interest rates shot up to 7,200% (Desai, 2003). In February 2001, in an effort to bring down the skyrocketing interest rates and to curtail outflows of foreign capital, the government abandoned the exchange rate crawling-peg, which had been a key element of the IMF aid package. (The IMF itself, however, stood in support of abandoning the peg.) (O’Daly, 2001).

7.6.2 Reasons for the Crisis

Macroeconomic Environment

One key characteristic of the Turkish macroeconomic environment over the thirty years preceding the crisis has been high inflation and unsuccessful programs for its reduction. Typical inflation levels were between 20% in the 1970s and 80% in the late 1990s. This number periodically reached nearly 100% annually. As Kubarych (2001) notes, “Even in the midst of a business recession, consumer prices were rising by close to 65 percent per year by late 1999.”

Table 14: Sample Trade Data for Argentina Crisis Case. Each entry represents the sum of exports and imports between two countries. Trade data for Argentina, Brazil, Chile, Mexico, Peru, Russia, United Kingdom, and Venezuela is presented. Note, the table is not symmetric due to different procedures used in gathering data for different countries. The data is located in the Direction of Trade Statistics (DOTS), bilateral trade database.

	1	2	3	4	5	6	7	8
1	0	8880	1993	621	231	174	369	154
2	8842	0	1482	1582	373	949	2215	1186
3	2158	1518	0	944	458	62	684	256
4	443	1697	979	0	215	115	1114	686
5	218	379	551	228	0	14	621	301
6	156	840	59	90	41	0	2870	17
7	378	2282	627	896	196	2891	0	530
8	170	837	255	572	269	11	560	0

Fiscal Deficits

Despite Maastricht regulations stipulating that annual government deficits must remain below 3% of GDP in order for a country to gain admission to the euro currency block, Turkey's public sector deficit stood at a level of approximately 10% in the years leading up to the crisis. Financing this deficit fell primarily to short-term capital inflows from abroad, which required very high interest rates. Kubarych (2001) notes that credit rating agencies, in response to this economic predicament, rated Turkish public sector debt among the five riskiest in the world.

Turkey's susceptibility to financial crisis also rose in 1998 and 1999, when it suffered the effects of the Russian crisis, general political elections, and two very destructive earthquakes, which collectively led to a declining public sector fiscal balance. The share of primary surplus in the GDP decreased, while the public debt-to-GDP ratio increased. At the end of 1999, the government launched an IMF-backed disinflation program, replete with multiple structural changes, to try to counter this phenomenon. The program was accompanied by a new banking law establishing many rules and procedures consistent with the regulatory and supervisory statutes of the Basel committee (Ertugrul and Selcuk, 2002).

Banking Sector Maladies

Table 15: Transition Probabilities for Argentina Crisis Case. This table reports one-month transition probabilities for Argentina, Brazil, Chile, Mexico, Peru, Russia, United Kingdom, and Venezuela given that no countries are in crisis and given that Argentina is in crisis. Also, the probability of each country going into crisis within a year, given that Argentina is in crisis, is calculated.

	All tranquil	Argentina crisis, 1m	Argentina crisis, 12m
Argentina	0.008	0.503	0.643
Brazil	0.010	0.219	0.487
Chile	0.011	0.258	0.581
Mexico	0.009	0.021	0.314
Peru	0.011	0.058	0.444
Russia	0.007	0.021	0.280
United Kingdom	0.007	0.013	0.235
Venezuela	0.009	0.023	0.365

The banking sector was plagued with serious problems. As short-term capital began to be withdrawn from the money markets in February 2001, interest rates soared, and illiquid state banks had to borrow huge amounts of money on the interbank market due to “duty losses” on the part of the banks. Lacking Central Bank funding, these banks had to go to the markets, despite the interest rates (O’Daly, 2001).

Turkey did not address the very real problems in the banking sector, which led to the popular perception that the country would be unable to keep the exchange rate within its established band, and that devaluation would be unavoidable. This resulted in investor flight, significant loss of foreign currency reserves, and a skyrocketing of interest rates on overnight deposits. Despite efforts to support the currency and maintain monetary austerity, investors lacked confidence in the Turkish currency, and the government was forced to devalue the lira. The currency immediately dropped by close to one third; as Ertugrul and Selcuk (2002) write, this “jeopardized the entire policy framework that underlay the IMF program. It would arouse inflationary pressures, wreck the financial health of many highly indebted Turkish companies, and worsen the already precarious financial position of numerous Turkish banks.”

Fractured Politics and Public Perception

Since the establishment of a modern Turkish republic in 1923, Turkey had failed to

create internal democratic institutions. It had experienced years of martial law and military governments, resulting in a military-supported technocratic government. In-fighting between the Turkish population and Turkey's Kurdish minority was endemic. The anemic government failed to establish the fiscal austerity or banking sector reform needed to spur steady growth (Desai, 2003).

There were doubts on the part of people, both domestically and internationally, that the government would be able to sustain the reform policies they were attempting to put in place. General concern swirled, as well, about the rising current-account deficit, and the appreciation of the lira under the crawling-peg exchange regime (O'Daly, 2001).

Contributing further to the situation, in the second half of 2000, there was a slowdown in general economic reforms and opposition from some parties inside the government to privatization of certain state enterprises. This led to a general suspicion that the IMF-backed disinflation program inaugurated at the end of 1999 was about to end.

7.6.3 Contagion Effects

Turkey's problems resulted from what Desai (2003) describes as "a combination of political, institution, and policy weaknesses: the coalition government was fragmented, the banking system was weak, and the crawling peg exchange rate regime was under constant pressure from fiscal abandon." The country had relatively few trade links with other emerging markets, and foreign investors represented a very small percentage of asset holders in the economy (Desai, 2003) As Desai (2003) writes, "the financial turmoil in Turkey remained localized with minimum impact on neighboring emerging markets." In early 2001, the bond markets in some emerging economies fell in reaction to the currency and financial problems in Turkey. Around the same time, the Moscow stock market dropped 9%. Both of these reactions, however, were worked out of the system within days and had no real lasting effect. All in all, Turkey's financial crisis was relatively insulated from the rest of the world and had very little contagion effect.

Table 16 provides GDP and Exports for 7 countries: Brazil, Canada, Israel, Japan, Morocco, Russia and Turkey. GDP and Exports are provided in millions of US dollars a year before the Turkey crisis. The Turkey crisis started in February, 2001. π_h indicates historical crisis probabilities estimated from the data and π_x indicates historical crisis probabilities

estimated from the data if data was available, or probabilities computed using the extremum value method for those countries that did not have data on historical crises probabilities. Table 17 provides bilateral trade data for 7 countries. Note, 7 countries are chosen as to include countries that have big trade relations with Turkey, are geographically close to Turkey, or are major world powers. Table 18 reports one-month transition probabilities for Brazil, Canada, Israel, Japan, Morocco, Russia and Turkey given that no countries are in crisis and given that Turkey is in crisis. Also, the probability of each country going into crisis within a year, given that Turkey is in crisis, is calculated. The best way to analyze results in the Table 18 is to look at relative transition probabilities. According to the model, Russia has the highest one-month transition probability ($p=0.087$) given that Turkey was in crisis the previous month. In the real data, Russia experienced contagion after the Turkey crisis. Other countries did not experience contagion. Therefore, the model is a good predictor of contagion in this case, and trade channel is responsible for crisis transmission in the Turkey crisis case.

Table 16: Data for Turkey Crisis Case. This table reports GDP and Exports for Brazil, Canada, Israel, Japan, Morocco, Russia and Turkey a year before the Turkey crisis. GDP and Exports are reported in millions of US dollars. The Turkey crisis started in February, 2001. π_h indicates historical crisis probabilities estimated from the data and π_x indicates historical crisis probabilities estimated from the data if data was available, or probabilities computed using the extremum value method for those countries that did not have data on historical crises probabilities.

S.No.	Country	GDP (\$ Mill)	Exports (\$ Mill)	π_h	π_x
1	Brazil	788024	4138	0.042	0.042
2	Canada	693149	6468	0.000	0.006
3	Israel	106383	1963	0.021	0.021
4	Japan	5687635	11546	0.000	0.000
5	Morocco	39324	380	0.000	0.001
6	Russia	357322	6171	0.021	0.021
7	Turkey	204651	2213	0.000	0.010

Table 17: Sample Trade Data for Turkey Crisis Case. Each entry represents the sum of exports and imports between two countries. Trade data for Brazil, Canada, Israel, Japan, Morocco, Russia and Turkey is presented. Note, the table is not symmetric due to different procedures used in gathering data for different countries. The data is located in the Direction of Trade Statistics (DOTS), bilateral trade database.

	1	2	3	4	5	6	7
1	0	1575	594	5356	296	1613	208
2	1671	0	663	15691	228	441	291
3	514	573	0	1813	1	678	868
4	5018	14316	1767	0	413	4568	891
5	349	254	0	348	0	414	140
6	1108	300	500	3251	180	0	3313
7	321	352	1178	1472	145	3742	0

Table 18: Transition Probabilities for Turkey Crisis Case. This table reports one-month transition probabilities for Brazil, Canada, Israel, Japan, Morocco, Russia and Turkey given that no countries are in crisis and given that Turkey is in crisis. Also, the probability of each country going into crisis within a year, given that Turkey is in crisis, is calculated.

	All tranquil	Turkey crisis, 1m	Turkey crisis, 12m
Brazil	0.003	0.002	0.035
Canada	0.002	0.002	0.034
Israel	0.010	0.056	0.205
Japan	0.000	0.000	0.006
Morocco	0.000	0.002	0.039
Russia	0.008	0.087	0.216
Turkey	0	0.461	0.450

8 Conclusion

The goal of the paper is to propose a unified framework for analyzing contagion dynamics where different crisis transmission channels can be studied and compared against each other. The paper develops a discrete-time stochastic model. The paper makes contributions in the following areas: Contagion Channels, Mathematical Programming, and Markov Chains. The model was applied to six different crises: Mexico crisis (April, 1994), Asia crisis (July, 1997), Russia crisis (August, 1998), Brazil crisis (January, 1999), Argentina crisis (January, 2002), and Turkey crisis (February, 2001). In the model, the trade channel is used as a crisis transmission channel. The results of the model analysis show that the model adequately replicates empirically observed crises in the data. It offers a general paradigm to model the dynamics of financial crises and is able to capture non-linearities in the spread of crises.

There are limitations of using the trade channel as the sole channel for explaining contagion. For example, in the Mexico crisis case, the model predicted that Canada was likely to go into a crisis given that Mexico went into a crisis a month before. Therefore, other channels such as investment and credit channels should be modeled. Our mathematical model is constructed in such a way that it allows for the input of other channels as well as for the input of multiple channels. Once several channels are considered in the model, it is possible to analyze their relative strengths on the spread of contagion.

References

- Auerbach, N. *States, Banks, and Markets: Mexico's Path to Financial Liberalization in Comparative Perspective*. Boulder, CO: Westview Press, Perseus Books Group, 2001.
- Auguste, S., Dominguez, K., Kamil, K., and Tesar, L. "Cross-Border Trading As a Mechanism For Capital Flight: ADRs and the Argentine Crisis." *National Bureau of Economic Research*, 9343. November 2002.
- Baer, W. *The Brazilian Economy: Growth and Development*. Westport, CT: Praeger Publishers, 2001.
- Baig, T. and Goldfajn, I., 1999, "Financial Market Contagion in the Asian Crisis." *IMF Staff Papers*, 46(2, June), pp. 167-195.
- Baig, T. and Goldfajn, I. "The Russian Default and the Contagion to Brazil." *International Financial Contagion*. Claessens, S. and Forbes, K., Editors. Norwell, MA: Kluwer Academic Publishers, 2001.
- Bazdresch, S. and Werner, A. "Contagion of International Financial Crises: The Case of Mexico." *International Financial Contagion*. Claessens, S. and Forbes, K., Editors. Norwell, MA: Kluwer Academic Publishers, 2001.
- Blejer, M. and Del Castillo, G. "Contagion: From higher risk to risk aversion and the danger of protectionism." *The Political Economy of the East Asian Crisis and its Aftermath: Tigers in Distress*. Lukauskas, A. and Rivera-Batiz, F., Editors. Northampton, MA: Edward Elgar Publishing, 2001.
- Cardoso, E. and Helwege, A. "The 1990s crisis in emerging markets: the case of Brazil." *Capital Flows Without Crisis? Reconciling capital mobility and economic stability*. Dasgupta, D., Uzan, M. and Wilsom, D., Editors. New York, NY: Routledge, 2001.
- Calvo, G., 1999, "Contagion in Emerging Markets: When Wall Street is a Carrier." *University of Maryland, Mimeo*.
- Chang, R. and Velasco, A. "The Asian financial crisis in perspective." *Private Capital Flows in the Age of Globalization*. Dadush, U., Dasgupta, D., and Uzan, M., Editors. Northampton, MA: Edward Elgar Publishing, 2000.
- Corbacho, A., Garcia-Escribano, M., and Inchauste, G. Argentina: Macroeconomic Crisis and Household Vulnerability. *IMF Working Paper WP/03/89*. April 2003.
- Dasgupta, D., Uzan, M. and Wilsom, D., Editors. *Capital Flows Without Crisis? Reconciling Capital Mobility and Economic Stability*. New York, NY: Routledge, 2001.
- Desai, P. *Financial Crisis, Contagion, and Containment: From Asia to Argentina*. Princeton, NJ: Princeton University Press, 2003.
- Dornbusch, R., Park, Y.C., and Claessens, S., 2001, "Contagion: Why Crises Spread and How This Can Be Stopped." *International Financial Contagion*. Claessens, S. and Forbes, K., Editors. Norwell, MA: Kluwer Academic Publishers, 2001, pp. 19-41.
- Dungey, M., Fry, R., Gonzalez-Hermosillo, B., and Martin, V. "International Contagion Effects from the Russian Crisis and the LTCM Near-Collapse." *IMF Working Paper WP/02/74*. April 2002.

- Eichengreen, B., Rose, A., and Wyplosz, C., 1996, "Contagious Currency Crises." *National Bureau of Economic Research Working Paper*, 5681.
- Embrechts, P., Klüppelberg, C., and Mikosch, T., 1997, *Modelling Extremal Events*, Springer.
- Ertugrul, A. and Selcuk, F. "Turkish Economy: 1980-2001." *Inflation and Disinflation in Turkey*. Kibritcioglu, A., Rittenberg, L., and Selcuk, F. Burlington, VT: Ashgate Publishing, 2002.
- Forbes, K.J., 2001, "Are Trade Linkages Important Determinants of Country Vulnerability to Crises?" *National Bureau of Economic Research Working Paper*, 8194.
- Forbes, K.J. and Rigobon R., 2001, a "No Contagion, Only Interdependence: Measuring Stock Market Co-Movements." *Journal of Finance*.
- Forbes, K.J. and Rigobon R., 2001, b "Measuring Contagion: Conceptual and Empirical Issues." *International Financial Contagion*. Claessens, S. and Forbes, K., Editors. Norwell, MA: Kluwer Academic Publishers, 2001.
- Franco, Gustavo. "The Real Plan and the Exchange Rate." *Essays in International Finance, No. 217*. Princeton, NJ: International Finance Section, Department of Economics, Princeton University, 2002.
- Garcia, M. and Valpassos, M. "Capital Flows, Capital Controls, and Currency Crisis: The Case of Brazil in the 1990s." *Capital Flows, Capital Controls, and Currency Crises: Latin America in the 1990s*. Larrain, F., Editor. Ann Arbor, MI: University of Michigan, 2000.
- Garcia, V. *Black December: Banking Instability, the Mexican Crisis, and Its Effect on Argentina*. Washington, D.C.: The World Bank, 1997.
- Gerlach, S. and Smets, F., 1995, "Contagious Speculative Attacks." *European Journal of Political Economy*, 11(1, March), pp. 45-63.
- Glick, R. and Rose, A., 1999, "Contagion and Trade: Why are Currency Crises Regional?" *Journal of International Money and Finance*, 18(4, August), pp. 603-617.
- International Monetary Fund, 2001, *Direction of Trade Statistics*.
- International Monetary Fund, 2002, *International Financial Statistics*, CD-ROM.
- Ito, T. "Growth, Crisis, and the Future of Economic Recovery in East Asia." *Rethinking the East Asian Miracle*. Stiglitz, J. and Yusuf, S., Editors. Washington, D.C.: The World Bank and Oxford University Press, 2001.
- Jackson, K. "Introduction: The Roots of the Crisis." *Asian Contagion: The Causes and Consequences of a Financial Crisis*. Jackson, K., Editor. Boulder, CO: Westview Press, Perseus Books Group, 1999.
- Kochhar, K., Loungani, P. and Stone, M. "The East Asian Crisis: Macroeconomic Developments and Policy Lessons." *IMF Working Paper*. August 1998.
- Kubarych, R. *Stress Testing the System: Simulating the Global Consequences of the Next Financial Crisis*. New York, NY: Council on Foreign Relations, 2001.

- Masson, P. "Multiple Equilibria, Contagion, and the Emerging Market Crises." *Financial Crises in Emerging Markets*. Glick, R., Moreno, R., and Spiegel, M., Editors. New York, NY: Cambridge University Press, 2001.
- O'Daly, R., Editor. *Turkey Country Report*. New York, NY: Economist Intelligence Unit, April 2001.
- Park, Y. C., Song, C-Y. "Financial Contagion in the East Asian Crisis: With Special Reference to the Republic of Korea." *International Financial Contagion*. Claessens, S. and Forbes, K, Editors. Norwell, MA: Kluwer Academic Publishers, 2001.
- Quiroz, O. *The Political Economy of Mexico's Financial Reform*. Burlington, MA: Ashgate Publishing, 2001.
- Rakshit, M. *The East Asian Currency Crisis*. New York, NY: Oxford University Press, 2002.
- Rigobon, R., 2001, "Contagion: How to Measure It?" *National Bureau of Economic Research Working Paper*, 8118.
- Rojas-Suarez, L. and Weisbrod, S. *Financial Fragilities in Latin America: The 1980s and 1990s*. Washington, D.C.: International Monetary Fund, 1995.
- Treuhertz, Rolf Mario. *The Crisis Manual For Emerging Countries*. Palo Alto, CA: Fabrizio Publications, 2000.