Three Essays on International Transmission and Monetary Policy in Emerging Countries

Martha Cruz Zuniga

Western Michigan University

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THREE ESSAYS ON INTERNATIONAL TRANSMISSION AND MONETARY POLICY IN EMERGING COUNTRIES

by

Martha Cruz Zuniga

A Dissertation
Submitted to the Faculty of The Graduate College
in partial fulfillment of the requirements for the Degree of Doctor of Philosophy
Department of Economics
Dr. Mark Wheeler, Advisor

Western Michigan University
Kalamazoo, Michigan
December 2006
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ACKNOWLEDGMENTS

I have been very fortunate to be guided in this research by generous people who have shared with me their knowledge, time and experience. I am greatly indebted to my advisor, Mark Wheeler for his encouragement, comments and incredible support and assistance throughout this process. I would also like to thank Susan Pozo for her valuable insights and Catalina Amuedo-Dorantes for her useful comments.

There are others whose contribution I can only acknowledge. To my parents and siblings, who are my source of inspiration and strength: Thanks for your love, sacrifice and support. Thanks also to Faye Wingate, Tom Coder and Jin Qian for their help and genuine friendship.

Martha Cruz Zuniga
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CHAPTER 1
INTRODUCTION

This dissertation investigates two aspects of foreign shocks that affect emerging countries: U.S. monetary shocks and workers' remittances. My attention in particular centers on the macroeconomic impact of these foreign shocks. More specifically, in the first essay (Chapter 2) of the thesis I analyze the international transmission of U.S. monetary policy to emerging economies distinguishing between a direct transmission process and an augmented international transmission. In the augmented transmission mechanism, U.S. shocks may impact leading countries in different regions, and those countries' reactions then affect smaller countries. In the second essay (Chapter 3) I investigate the effects of monetary policy on stock market returns of emerging countries, distinguishing between the impact of domestic monetary policy and the impact of U.S. monetary actions, the latter is designed to capture the international transmission to stock markets. Finally, in the last essay (Chapter 4), I evaluate the impact of workers' remittances on money in developing countries\(^1\) under a framework where the monetary approach to the balance of payments and currency substitution are used.

The increasing global dimension of economic events has created the need to understand how world events such as foreign shocks, may impact emerging economies. The International Monetary Fund (IMF) (2005) recognizes that globalization has changed the environment for external imbalances and the adjustment to them. The IMF also recognizes that globalization has brought new challenges and risks. Understanding how emerging economies are affected by two

\(^1\) In this dissertation, we use the expression emerging economies and developing economies as equivalent.
particular foreign sources of risks and challenges, U.S. monetary policy actions and worker’s remittances, is the purpose of this dissertation.

“Generally speaking, globalization can be defined as the increasingly close international integration of markets for goods, services, and factors of production” (Krueger, 2002). Due to globalization, decisions made in foreign countries impact our lives. Obstfeld (2004) explains that with the increasing globalization process since the late 1970’s, developing countries have found it harder to settle into a comfortable resolution of the open-economy monetary trilemma, which is the problem that arises because of the difficulties of controlling inflation, exchange rate, and market failures in these economies.

“Globalization does not reduce national sovereignty. It does create a strong incentive for governments to pursue sound economic policies.” (International Monetary Fund, 2002) As such, globalization does not relieve central banks from their responsibility in maintaining price and economic stability, although “the integration of national economies in the global economic system does leave them more open to influences from abroad.” (Kohn, 2005) In this regard, globalization is a process that induces countries to embrace greater financial integration and macro stabilization (Aizenman and Jinjarak, 2006). However, globalization does not always work to encourage economic development, especially in the case of financial globalization, which can lead to devastating financial crises (Mishkin, 2005).

It is precisely the impact that other countries’ actions or decisions can have on emerging economies that is the focus of this research. In this dissertation we consider two sources of potential foreign shocks: U.S. monetary policy actions and workers’ remittances.

Why would these two sources have any relevance for economic research? In the case of the U.S. monetary policy, “There is no question that the United States plays a unique role in the international monetary and financial system today, as it did 40 years ago.” (Eichengreen, 2004, p.1) Calvo, Leiderman, and Reinhart (1993) have emphasized the role of economic conditions in the United States in the fluctuations of capital flows in emerging markets. Some researchers even
believe that the United States controls the world monetary policy because of the strong worldwide economic influence of its actions (Devereux, Shi and Xu, 2004). Despite these remarks, we find, surprisingly, that most of the research about international monetary transmission has been done for European countries and Japan. Although a constant topic of political discussion in emerging economies, the international transmission of U.S. monetary policy to emerging economies has not being properly studied, so there is no clear understanding of how U.S. monetary actions affect these economies.

There is even less economic research on the impact of worker's remittances. Remittances are an important way out of extreme poverty for a large number of people (Bourguignon, 2006). Nevertheless, the macroeconomic impact of remittances inflows for developing economies is somewhat unknown, “owing to both data insufficiency and political sensitivities.” (The World Bank, 2006) The International Monetary Fund (2005) argues that the implications of inflows of workers’ remittances are of particular interest in light of the significant magnitude and rapid growth in these inflows.

This dissertation contains three essays that shed some light on the process of international transmission of U.S. monetary policy to emerging economies and on the effects of worker’s remittances at macroeconomic level. The existing literature is on international transmission on the international transmission of U.S. monetary policy to developed economies; while the literature on remittances is mostly focused on microeconomic studies. In contrast, we focus first, on emerging economies and the impact they receive from U.S. monetary actions; and, second, on a new macroeconomic aspect of workers’ remittances, the impact of these inflows on money in developing countries. Both areas are relatively new so our research contains important contributions to the economic literature.

Our research is important for policy makers in emerging economies because they need to clearly understand how foreign shocks affect their countries and consider those shocks when taking policy decisions. Otherwise, their decisions may not have the desired effect. Our research
is also important for private domestic economic agents, who need to recognize the impact that foreign actions may have on their economies and how they will affect their economic environment. In addition, it is important for foreign investors to understand how emerging economies are affected by external (foreign) shocks because investors have to make financial decisions with limited information, so any further insight is helpful in this process.

The goal of this dissertation is to analyze how two different sources of foreign shocks affect emerging economies. The essays presented in Chapters 2 through 4 develop that analysis. Two important aspects of the work distinguish this dissertation from previous empirical literature. First, the focus of the investigation about the international transmission of U.S. monetary policy is on emerging economies, which appears to have been neglected in the literature. Second, the analysis of workers' remittances, itself a relatively new area of economic research, focuses on an aspect that has not been analyzed before, the impact of remittances on money demand and supply in developing economies. The rest of this section offers a brief outline of the three essays presented in Chapters 2 through 4.

The International Transmission Mechanism: The Impact of U.S. Monetary Policy Shocks on Emerging Economics

An extensive literature exists that analyzes monetary transmission at the domestic level. That is, this literature examines how domestic monetary policy decisions affect the economic conditions of the particular country where authorities modify monetary policy. Although not extensive, the literature on international transmission of monetary policy has mainly concentrated in the international transmission of monetary actions to developed economies. That is, how the actions taken by monetary authorities in one economy affect other economy. In contrast, the literature on the international transmission of monetary policy to emerging economies lacks this
detailed analysis. In Chapter 2, this gap in the literature is filled with an extensive analysis of the impact of U.S. monetary policy action on emerging economies in Asia and Latin America.

Chapter 2 explores the international transmission of U.S. monetary policy on macroeconomic variables such as output, exports, imports, consumer prices, interest rates and money. We acknowledge three possibilities. First, U.S. monetary policy shocks may directly affect other economies. Second, U.S. shocks may impact leading countries in different regions\(^2\), and those countries' reactions then affect smaller countries. Third, there is no international transmission. The first two options are not mutually exclusive.

In this chapter we conduct the empirical analysis using impulse response functions derived from vector error correction (VEC) models. Monthly data from the United States and fourteen emerging countries, for the period 1975–2003, are used. These countries are Japan,\(^3\) Korea, Malaysia, the Philippines, Indonesia, India, Thailand, Mexico, Chile, Peru, Brazil, Venezuela, Argentina, and Colombia. The variables included in each country's model are U.S. industrial production, U.S. consumer price index (CPI), the U.S. federal funds rate, and the following variables from a particular emerging economy: industrial production, exports, imports, CPI, the real exchange rate, and the nominal interest rate. We also control for exchange rate regime and seasonality through dummy variables.

In general, the results indicate that, after a U.S. contractionary monetary shock, the exchange rate depreciates, while there are increases in output, prices and interest rates. Different reactions are found for exports, imports and money. The fact that output raises shows that these economies benefit from contractionary shocks occurring in the U.S., which clearly differs from results found for European economies (Kim, 2001). Structural differences between European and emerging economies could be the reason behind the different reaction. With respect to the second possibility of international transmission, we do find a process of "augmented transmission".

\(^2\) We consider two leaders, Japan for Asian countries and Mexico for Latin American countries.

\(^3\) Japan is a large economy, but is included because it is used as the leading country for Asian economies.
which is the case where U.S. monetary policy affects a leading country in particular region, and that country's reaction affect third countries. This augmented transmission occurs in Asia, where U.S. monetary shocks have an impact on economic variables in Japan and Japan's variables in turn impact economic conditions in other Asian economies.

In addition, we find that exchange rate volatility deepens the monetary transmission because its inclusion in the models makes the transmission to last more periods. We also find that Asian countries show more international transmission than Latin American countries. The evidence supports the existence of international transmission for emerging economies and shows how this process differs from the one taking place for developed economies.

**Monetary Policy and Stock Market: An International Analysis**

In the third chapter of this dissertation a different approach is taken to investigate the degree of monetary transmission. This topic is the reaction of the stock market of emerging economies to monetary policy. In this essay we first investigate the impact of domestic monetary policy actions on the stock market returns of a specific emerging economy. Second, we investigate the impact of U.S. monetary actions on the stock market returns in emerging countries. That is, the international transmission of U.S. monetary policy shocks.

Investigating the impact of monetary policy on stock markets will add to the relatively small literature on this topic. Moreover, because most of the research on the impact of monetary policy has been done only at domestic level, and for the U.S. economy, our study of emerging economies is even more relevant. Research on the international transmission of monetary actions to stock markets is very scarce. We could only find two studies (Stevenson, 2002; and, Cassola and Morana, 2002) that examines international transmission. These studies look at the impact of German interest rate changes on the stock market in seven other European countries.
In this essay we take a different focus from previous studies. We analyze emerging economies and take the analysis one step further and investigate not only the impact of domestic monetary actions in the stock market of a particular economy, but also the impact of foreign monetary actions on that stock market. To the best of our knowledge, there are no previous studies on this topic.

We work with a group of thirteen economies, seven in Latin America and six in Asia, using a monthly period from January 1976 and to November 2003. These countries are Korea, Malaysia, the Philippines, Indonesia, India, Thailand, Mexico, Chile, Peru, Brazil, Venezuela, Argentina, and Colombia. We use VEC models that include the following variables for each country: U.S. industrial production, the U.S. CPI, the U.S. federal funds rate; and, for each emerging economy we use the real exchange rate, the CPI, industrial production, interest rate and stock market returns.

The results presented in this essay indicate that, for a group of thirteen emerging economies, domestic monetary policy shocks cause significant impacts on the stock market returns of nine countries. Five of these countries are in Asia and four in Latin America. In seven of these nine economies, a contractionary monetary policy decreases stock market returns, which is consistent with empirical studies for developed economies, including the U.S. economy. The results are also consistent with the theoretical notion that contractionary (expansionary) monetary policy leads to lower (higher) stock prices because changes in monetary policy influence forecasts of market-determined interest rates, the equity cost of capital, and expectations of corporate profitability (Waud, 1970; Durham, 2003).

With respect to the international transmission of U.S. monetary policy to stock markets, there is some evidence that such process takes place in emerging economies. U.S. monetary policy shocks affect the stock market returns in five emerging economies in our sample, two in

---

4 These countries are Brazil, Colombia, India, Indonesia, Korea, Malaysia, Mexico, Peru, and Thailand.
Asia and three in Latin America.\textsuperscript{5} It is found that increases in U.S. federal funds rate, which correspond to contractionary monetary policy, decrease stock market returns in emerging economies.

The evidence suggests that both domestic monetary actions and U.S. monetary actions are significant for stock market returns in emerging economies.

\textbf{Money and Remittances}

The study of the impact of a particular foreign shock, U.S. monetary policy actions, presented in the previous two chapters have shown that decisions made outside of emerging economies have a significant impact in these countries. There is nonetheless doubt that other foreign shocks may also have the significant impact on emerging countries that U.S. monetary shocks evidence. Therefore, we now analyze another source of foreign shocks, workers’ remittances.

Because of data constraints, most of the literature in this area studies microeconomic aspects of these inflows. The literature on macroeconomics aspects of workers’ remittances is very limited. Few studies consider macroeconomic aspects such as the influence of remittances on exchange rates. This essay contributes to the literature with the analysis of a topic not previously explored, which is the impact of remittances on money demand and supply in developing economies.

We use the literature on currency substitution to explore the impact of remittances on the money demand, while we work with the literature on the monetary approach to the balance of payments to investigate the impact of remittances on the money supply of developing countries.

We work with panel data for a group of seven Latin American economies: Colombia, the Dominican Republic, Ecuador, El Salvador, Guatemala, Mexico, and Nicaragua. The sample data

\textsuperscript{5} These countries are Chile, Colombia, the Philippines, Thailand, and Venezuela.
is quarterly and runs from 1981:1 to 2003:4. We use a panel simultaneous equation model with three stage least squares as the method of estimation, which help us to overcome the data limitations.

The results indicate that remittances have significant impact on the money demand of Latin American countries. Increases in remittances reduce the demand of domestic money. This result may imply that remittances facilitate the currency substitution process that takes place in these countries. The results also indicate the lack of significant impact of remittances on the interest rate of these economies.

In conclusion, the results presented in this dissertation indicate that emerging economies are impacted by two specific foreign shocks: U.S. monetary actions and workers' remittances. Emerging economies seem to benefit from contractionary monetary policy actions originating in the United States because their output evidences a positive response. There is some evidence of the significance of U.S. monetary actions on stock markets in emerging economies. In these economies, stock markets receive a significant influence from domestic and foreign monetary policy actions. In particular, increases in interest rates, which correspond to contractionary monetary policy, reduce stock market returns. With respect to workers' remittances, they exert a negative impact on the demand of money in developing economies. Our hope is that the results from this dissertation will motive further research and discussion in these new, interesting, and important topics.
2.1 INTRODUCTION

The interdependence among open economies creates questions about the impact of one country's monetary actions on other countries. A large country may have an impact on other economies. How does the transmission mechanism work? The answer to this question is even more relevant when comparing countries. What makes monetary transmission a complex and interesting topic is the fact that there is not one but many channels through which monetary policy operates. The existence of such transmission, if that impact can be generalized to different economies (both developed and developing), and if monetary authorities are reacting to other countries' policy changes are still open questions in the existing literature. This chapter deals with these important issues.

This chapter examines the impact of U.S. monetary policy shocks on other countries. With regard to the transmission mechanism, there are three possibilities. One possibility is that U.S. monetary policy shocks directly affect other economies. A second possibility is that U.S. monetary policy affects leading countries in different regions, and those countries' reactions affect third countries. That is, U.S. monetary policy influences the large country in a given region. Small countries are in turn, influenced by the large country. The third possibility is that there is no impact on other countries from U.S. monetary shocks. Another issue to be considered in the transmission mechanism is the volatility of key variables such as the exchange rate and the
interest rate. Finally, a crucial consideration is the exchange rate regime that a small open economy adopts.

Understanding how the transmission mechanisms of monetary policy work at an international level “is important not only in their own right, but also because they have important lessons for monetary policy” (Mishkin, 1996, p.1). One of the most important lessons is that if a transmission process exists, “Monetary policy can be highly effective in reviving a weak economy even if short-term interest rates are already near zero” (Mishkin, 1996, p. 22).

Knowing the existence of international transmission is important to both emerging economies and the United States. For the United States, it is always of strategic importance to know if its monetary actions can cause a real impact in other economies. For emerging countries, the existence of international transmission from U.S. monetary actions should require consideration before taking domestic policy actions; otherwise, foreign shocks may end up having an effect on the economy that could oppose the desired target of domestic policy actions.

This chapter documents empirical evidence using vector of error correction (VEC) models. These models are used to construct impulse response functions (IRFs). Monthly data for the period 1975–2003 are used. Each model includes the U.S. federal funds rate as a measure of U.S. monetary policy.

Our conjecture is that the exchange rate regime influences the impact of international monetary transmission and that integration among economies is important in the transmission process. The idea is that, in the presence of a flexible exchange rate regime, little transmission will occur because the exchange rate will insulate the economy from outside shocks. In the case of fixed and managed exchange rate regimes, a foreign monetary policy may have an impact on other variables besides the exchange rate.

The contributions of this research are 1) to analyze the monetary transmission mechanism in emerging economies; 2) to account for the exchange rate regime and consider the de facto
exchange regime rather than the official regime; 1) to use VEC models because of cointegration among the variables; 4) to use a long time series period for the analysis; 5) to analyze the possibility of an augmented transmission mechanism where a U.S. monetary shock has an impact on the leading economy in the region, and the leading economy has an impact on the small open economy; 6) to analyze the impact that volatility of key variables have in the transmission mechanism; and, 7) to analyze the interaction in the economy in an extended model of transmission, which includes all the domestic variables considered and not only one of them.

This chapter has four main findings. First, when the direct transmission is tested, there is evidence of international transmission mechanism from the U.S. monetary policy shocks to other economies. Second, when the augmented transmission possibility is tested, there is support for our hypothesis of an augmented international transmission process, where U.S. monetary policy affects leading countries in different regions, and those countries' reactions affect subsequent countries. Third, when exchange rate volatility is included in the model, the international transmission impacts are similar to the direct transmission process, but the duration of the impact is longer. Therefore, we can say that exchange rate volatility creates persistence in the impact of U.S. monetary shocks on open economies. Fourth, when an extended model is used, there is evidence of international monetary transmission in all economies with variations on the degree of impact; some countries exhibit a higher response than others. Therefore, we finally conclude that evidence exists of international transmission of U.S. monetary shocks to emerging economies. Monetary authorities in a small open economy need to consider these impacts in their monetary policy decisions, since a small open economy is being affected by other economies' shocks;

1 Authorities of a particular country state the official exchange rate regime. This information can be found in International Monetary Fund Statistics. The *de facto* regime reflects the current exchange rate policy implemented by a country. For instance, a country may say officially that the exchange rate is free to float, but there may be intervention in the foreign exchange market to keep the exchange rate under a certain target. In this case, the official and *de facto* regimes differ.

2 Direct transmission refers to the response of the variables of a small country to U.S. monetary shocks when the model includes U.S. variables, the small economy variable of interest, and no variable from the leading country.
therefore, the results of the monetary actions of a small open economy are strongly influenced by other countries' actions.

2.2 RELATED LITERATURE

Monetary policy can significantly influence economic behavior. Central banks implement policy changes by setting their policy instruments. Short-term interest rates have become the most common monetary instrument. As the central bank is able to control the interest rate, monetary policy can affect real output.

The term "monetary transmission mechanism" involves different responses from different authors. Some focus mostly on the credit channel aspects (Bernanke and Gertler, 1995; Stein, 1998; Mishkin, 1996; Kashyap and Stein, 1997), others emphasize the importance of price stickiness and multiple assets (Meltzer, 1995), while other authors analyze the impact of the exchange rate policy (Obstfeld and Rogoff, 1995a).

Mishkin (1996) provides a brief overview of the transmission mechanism that includes interest rates, prices, and the credit channel. In general, some authors concentrate on nominal aspects of monetary shocks, while others analyze effects on real variables.

In this chapter we consider monetary transmissions to be, as Taylor (1995, p. 11) defines, "the process through which monetary policy decisions are transmitted into changes in real GDP and inflation." However, most of the existing literature on monetary transmission concentrates on transmission at domestic levels. That is, the impact of domestic monetary policy on the domestic economy. In order to explore the international monetary transmission, it is necessary to analyze open economies.

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3 For a survey on alternative views of the monetary transmission mechanism see Taylor (2000).
4 See, for example, Sims (1992), Christiano, Eichenbaum, and Evans (1999), Chari, Kehoe, and McGrattan (2000), and Bernanke and Blinder (1992).
The support for the existence of a transmission mechanism at an international level comes from the international economics literature. The basic framework used is the Mundell-Flemming-Dornbusch (MFD) model, although some sticky-price intertemporal models have also been proposed.

Under a floating exchange-rate system, the basic MFD model predicts that an expansionary monetary policy will lead to expansion of domestic output and a fall in the output in the foreign country. Following a monetary policy expansion, the expansion of domestic output will increase imports (the income-absorption effect), leading to a temporary expansion of foreign output and a rise in the foreign interest rate. In the home country there will be a capital outflow that causes an exchange rate depreciation, which leads to an improvement in the trade balance (the expenditure-switching effect). Output in the foreign country will, in turn, fall because the change in relative prices implied by the devaluation. That will result in both domestic and foreign residents shifting from foreign towards home goods. This is the case of a "beggar-thy-neighbor" policy because it results in an expansion of domestic output at the expense of foreign output (Hallwood and MacDonald, 2000). Under a fixed exchange-rate regime, domestic monetary expansion results in a monetary expansion in the foreign country as well. At the end of the process, domestic and foreign output have grown along an increase in prices.

With imperfect capital mobility and flexible exchange rates, home country expansions of monetary policy "will be effective in stimulating output and the price level in the home country, but because the exchange rates move to ensure the current account is always balanced, there will be no output implications for the foreign country (although the foreign consumer price level will fall due to the exchange rate change)," (Hallwood and MacDonald, 2000, pp.102).

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5 See Hallwood and MacDonald (2000) for detailed explanation of this model.
6 See Svensson and Van Wijnbergen (1989) for a detailed model with a sticky-price framework and the international transmission mechanism.
7 The previous analysis corresponds to a perfect capital mobility situation.
The MFD model distinguishes between exchange rate regimes, but such a distinction has not been emphasized in the monetary literature. Explanations about the transmission mechanism differ in this literature, and the empirical evidence provides a wide range of results. Most existing studies concentrate only on the effects of domestic monetary policy on the domestic economy. Compared with the empirical literature for domestic transmission, few studies analyze monetary transmission at an international level.

For instance, Kim (2001) found that expansionary monetary shocks lead to booms in the non-U.S. G-6 countries. For the European case, similar responses to the ones found for U.S. policy shocks have been reported (Angeloni et al., 2003). Differences in the transmission mechanism can generate asymmetric behavior among countries experiencing identical shocks, which creates differences in the size of the responses of some variables as in the case of New Zealand and Australia (Haug, Karagedikli, and Ranchhold, 2005).

Exploration of monetary transmission in emerging economies is marginal. One study (Ibrahim, 2003) found that shocks in U.S. real activity and monetary policy are transmitted to Malaysian real activity, while another (Desroches, 2004) found that world output and real interest rate shocks are transmitted to emerging economies. The latter study uses aggregated measures and not country specific data, so it is not possible to distinguish the differences in the responses.

While the cited authors have analyzed models with several variables, other authors have focused on individual variables to look at the international transmission. Frankel, Smuckler and Servén (2004) explore the exchange rate and interest rate effect on the sensitivity to international interest rates for a group of 46 countries (18 industrial and 28 developing), where the U.S. interest rate is used as an explanatory variable. They find that only large industrial countries can benefit

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8 Recent studies mention the potential importance of the exchange rate. See for instance, Dahl and Lo (2003).
9 See Taylor (2002); Christiano, Eichenbaum and Evans (1999); and Mishkin (1996) for explanations in theoretical models.
10 See, for example, Christiano, Eichenbaum and Evans (2001); Fujiwara (2004); Kim (1999); Miron, Romer and Weil (1994).
from independent monetary policy. Alecke (2004) finds that movements in U.S. interest rates affect German interest rates. Other studies analyze the exchange rate alone, those studies include Eichenbaum and Evans (1995), and Kim and Roubini (2000). They find that the exchange rate initially appreciates in response to monetary policy contractions, but later it depreciates in accordance with uncovered interest parity.

Some recent theoretical studies about international transmission are mostly motivated by the European Monetary Union. The impact of one country’s actions on another country creates the need for domestic actions to face the external shocks, but in this regard there is no optimal policy (no “one-size policy may fit all”). Asymmetries among countries result in shocks causing different responses (Farina and Tamborini, 2004).

In the presence of international transmission, there is the need for policy coordination among monetary authorities because the interaction of monetary and fiscal policies is a crucial issue (Van Aarle et al., 2004; Barrell, Dury, and Hurst, 2003). International policy coordination may prevent economies from undertaking mutually harmful policies (Marktanner, 2004). However, coordination may be undesirable when “the externality from the money supply reinforces the effect of the shock requiring a greater change in the money supply. On the contrary, the cases where cooperation would be desirable are those in which the externality from the money supply offsets the effect of the shock so that the coordinated solution implies a lower change in money supply” (Diaz-Roldan, 2004, p. 9).

This study expands the research on international transmission with the analysis of the relation between a large economy and a small country. Specifically, the objective of this chapter is to analyze how U.S. monetary policy affects some emerging countries. This chapter investigates the monetary transmission mechanism and how U.S. monetary policy affects economic variables in other countries. With regard to the transmission mechanism, there are three possibilities. One possibility is that U.S. monetary policy shocks affect other economies directly.

11 Earlier studies in policy coordination were developed by Hamada (1976).
A second possibility is that U.S. monetary policy affects leading countries in different regions, and those countries' reactions affect third countries. That is, U.S. monetary policy influences the large country in a given region. Small countries are in turn, influenced by the large country. A third possibility is that U.S. monetary shocks have no impact on other countries. The first two possibilities are not mutually exclusive. Rather, the second possibility can be seen as an augmented effect in the transmission process.

From a theoretical point of view, transmission at international level in the monetary economics literature in the case of a small open economy model can be found in Walsh (2003), but in his case the monetary variable is money. Other types of two-country models include Obstfeld and Rogoff (1995b, 1996) models and those following their developments such as the open-economy models with optimizing agents and nominal rigidities (McCallum and Nelson (2000), Clarida, Galí and Gertler (2001,2002), Gertler, Gilchrist, and Natalucci (2001). There are also models dealing with policy coordination (Hamada, 1976).

In our research, the interest rate is the policy instrument, which more closely reflects the way in which central banks implement their policy. Taylor rule (Taylor, 1993) models have been used to describe the policy behavior of central banks (Clarida, Galí and Gertler, 2000; Bullard and Mitra, 2002). In the classical Taylor rule, the instrument is set to react to domestic inflation ($\pi_t$) and output gap. But in an open economy the variables toward which monetary policy can react is larger. Specifically, exchange rate regime influences the way in which foreign monetary actions affect the small open economy (Walsh, 2003).

We consider a simple two-country model, where one country is a large economy and the other is a small open economy. This framework is useful to analyze impacts of policy actions among economies where, as in the case of developing economies, one country's actions have little or no impact on other economies. We derive and extract results for three types of exchange

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rate regimes: flexible, managed, and fixed exchange rate regimes. The derivations are presented in the Appendix.

The results for international transmission where the interest rate is the monetary variable do not substantially differ from those reached using money as the monetary variable (as in Walsh, 2003). Therefore, from the theoretical point of view, there are clear results expected for international transmission of monetary shocks: full transmission for fixed exchange rate regimes, no transmission for pure flexible exchange regimes, and "semi" transmission for mixed or managed exchange rate regimes. Our purpose is to find if those results are really what is happening in the transmission of U.S. monetary shocks to emerging economies.

2.3  

EMPIRICAL CONSIDERATIONS

2.3.1  Methodology

The two most commonly used empirical approaches in studies of monetary transmission are vector autoregressive (VAR) models and structural macromodels. The advantages of VAR models over structural models have been well detailed in the econometric literature. Sims (1980) is well known for his criticism of traditional large macro structural models because of their implausible identification restrictions.

Identification in this method can be achieved by Choleski decomposition of the reduced-form residuals. Some authors, such as Christiano, Eichenbaum and Evans (1999) and Kim (2001), make use of the Choleski decomposition, which assumes that the contemporaneous system is recursive and hence allows identification.

In order to estimate a VAR, the appropriate lag length must be determined. One of the commonly used criteria is the Akaike information criterion (AIC). This is not a test statistic, but

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13 For extended explanation of VAR methodology, including impulse response functions, see Chapter 11 of Hamilton (1994).
rather a diagnostic tool, and it goes from a larger length to a smaller one to avoid misspecification problems.

In a VAR, the impulse response functions (IRFs) trace the effects of a shock to an endogenous variable on the variables in the VAR. When a VAR is written as a vector moving average process (Hamilton, 1994; Enders, 2004) as:

\[ y_t = \mu + \varepsilon_t + \psi_1 \varepsilon_{t-1} + \psi_2 \varepsilon_{t-2} + \ldots, \]

where the matrix \( \psi_s \) has the interpretation

\[ \frac{\partial y_{t+s}}{\partial \varepsilon_t} = \psi_s. \]

That is, the row i, column j element of \( \psi_s \) identifies the consequences of one-unit increase in the jth variable’s innovation at date t (\( \varepsilon_{t} \)) for the value of the ith variable at time t+s (\( y_{t+s} \)), holding all other innovations at all dates constant (Hamilton, 1994, p. 318).

A plot of the row i, column j element of \( \psi_s \) as function of s is called the impulse-response function. From an economic point of view, IRF measures the response of the jth component of \( Y_t \) to an unanticipated disturbance in the ith component.

When the variables have unit roots and are cointegrated, a VAR model is no longer optimal. Instead, it is appropriated to estimate a vector of error correction model (VEC). Variables can be related in the long run, and that is the idea of cointegration. The idea of cointegration is explain by Granger (2003) as the following:

Suppose that we had two similar chains of pearls, … if the pearls were set in small but strong magnets, it is possible that there would be an attraction between the two chains, and that they would have similar, but not identical, smooth shapes. In that case, the distance between the two sets of pearls would give a stationary series and this would give an example of cointegration (Granger, 2003, p.4).

An nx1 vector \( Y_t \) is said to be cointegrated if each of its elements individually is I(d) and if there exists a nonzero (nx1) vector a such that \( a' Y_t \) is stationary (Hamilton, 1994).
A VEC model is a restricted VAR that has cointegration restrictions built into the specification, so that it is designed for use with nonstationary series that are cointegrated. In a basic example, consider a two variable system with one cointegrating equation and no lagged difference terms. The cointegrating equation is \( y_{2,t} = \beta y_{1,t} \), and the VEC is

\[
\begin{align*}
\Delta y_{1,t} &= \gamma_1 (y_{2,t-1} - \beta y_{1,t-1}) + \epsilon_{1,t} \\
\Delta y_{2,t} &= \gamma_2 (y_{2,t-1} - \beta y_{1,t-1}) + \epsilon_{2,t}.
\end{align*}
\]

The right-hand side variable is the error correction term. In long-run equilibrium, this term is zero. However, if \( y_{1,t} \) and \( y_{2,t} \) deviated from long-run equilibrium during the last period, the error correction term is nonzero and each variable adjusts to partially restore the equilibrium relation. The coefficients \((\gamma_1, \gamma_2)\) measure the speed of adjustment. If the two endogenous variables \( y_{1,t} \) and \( y_{2,t} \) have linear trends in the series and a constant in the cointegrating equations, the VEC has the form

\[
\begin{align*}
\Delta y_{1,t} &= \delta_1 + \gamma_1 (y_{2,t-1} - \mu - \beta y_{1,t-1}) + \epsilon_{1,t} \\
\Delta y_{2,t} &= \delta_2 + \gamma_2 (y_{2,t-1} - \mu - \beta y_{1,t-1}) + \epsilon_{2,t}.
\end{align*}
\]

To test for the presence of cointegration, a commonly used procedure is that of Johansen (1991, 1995). Johansen’s test is usually employed where several variables are tested for cointegration.

Volatility

An additional consideration is volatility. Enders (2004) mentions that many economic time series do not have a constant mean, and most exhibit phases of relative tranquility followed by periods of high volatility. We include volatility of the real exchange rate in the VECs. Volatility is proxied using generalized autoregressive conditional heteroskedastic (GARCH)

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14 A detailed explanation of cointegration is found in Chapter 19 of Hamilton (1994).
models. GARCH specifically estimates a model of the variance of innovations, rather than simply estimating a variability measure from past outcomes (moving standard deviation). The standard GARCH (1,1) specification is given by:

\[ y_t = x_t y + \varepsilon_t \]

\[ \varepsilon_t \sim N(0, \sigma_t^2) \]

\[ \sigma_t^2 = \lambda_0 + \alpha \varepsilon_{t-1}^2 + \beta \sigma_{t-1}^2 \]

where the mean equation given by \( y_t \) is written in function of past values of \( y_t \) and/or exogenous variables with an error term. The term \( \sigma_t^2 \) is the one period ahead forecast error variance based on past information, so it is called the *conditional variance*. The equation specifying \( \sigma_t^2 \) has three terms: 1) the mean \( \lambda \), 2) news about volatility from the previous period which is measured as the lag of the square residual from the mean equation \( \varepsilon_{t-1}^2 \) (the ARCH term), and 3) the last period’s forecast variance \( \sigma_{t-1}^2 \) (the GARCH term).

For this research, we work with VEC models and use the corresponding impulse response functions with two-standard-deviations confidence intervals, and variance decompositions with standard errors. The VEC lag length is determined using the AIC. We also include measures of volatility of the exchange rate, for which we work with the GARCH methodology.

2.3.2 Data

This chapter uses VEC models to show the impact of U.S. monetary policy actions. We use monthly data from 1975:1 through 2003:11\(^{16} \) for the United States and fourteen countries. These countries are Japan,\(^ {17} \) Korea, Malaysia, the Philippines, Indonesia, India, Thailand, Chile, and Argentina at 1977:1; Korea and Colombia at 1980:1; the Philippines at 1981:1; and Thailand at 1987:1. Japan is a large economy, but is included because it is used as the leading country for Asian economies.

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\(^{16} \) Due to data availability, Peru’s sample starts at 1979:1; Chile and Argentina at 1977:1; Korea and Colombia at 1980:1; the Philippines at 1981:1; and Thailand at 1987:1.

\(^{17} \) Japan is a large economy, but is included because it is used as the leading country for Asian economies.
Mexico, Chile, Peru, Brazil, Venezuela, Argentina, and Colombia. The U.S. monetary policy instrument is the federal funds rate.  

The variables considered for the U.S. economy are industrial production, the consumer price index, and the federal funds rate. For the fourteen countries the variables included are industrial production, exports, imports, consumer price index (CPI), nominal interest rate (usually it is the money market rate), money, and real exchange rate. All the variables, except the interest rate, are in real terms, in logs, and are not seasonally adjusted. The data is obtained from the International Financial Statistics CD-ROM and Datastream. We control for seasonality by including seasonal dummies in each VEC model.

We use the real exchange rate instead of the nominal exchange rate. Moreover, we include a dummy variable indicative of the exchange–rate regime because, from the theory and the model derived in the Appendix, the choice of exchange rate regime influences the way in which foreign monetary actions affect the small open economy. Levy-Yeyati and Sturzenegger (2005) constructed a *de facto* classification of exchange rates based on changes in the nominal exchange rate, the volatility of these changes, and the volatility of international reserves. The *de facto* measures provides an alternative to the recognized inconsistencies between reported and actual policies. We use this classification for the exchange rate regime, and we use dummy variables for *de facto* fixed and managed exchange rate regimes. Table 2.1 presents details about the *de facto* exchange rate regime for the countries analyzed.  

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18 Bernanke and Blinder (1992) argue that the federal funds rate is the most appropriate variable to reflect U.S. monetary policy actions.

19 Data from Levy-Yeyati and Sturzenegger ends in 2000, but we follow their criteria for 2001–2003.
2.4 EMPIRICAL RESULTS

2.4.1 Hypothesis

The objective is to analyze how U.S. monetary policy affects small open economies, with a focus on emerging countries. There are three possibilities with regard to the transmission mechanism. One possibility is that U.S. monetary policy shocks affect other economies directly. A second possibility is that U.S. monetary policy affects a leading country in a particular region, and that country’s reaction affects small third countries. That is, U.S. monetary policy influences the large country in a given region, and small countries are in turn, influenced by the large country in their region. The third possibility is that there is no effect on a country from U.S. monetary policy shocks. The first two possibilities are not mutually exclusive.

The data exhibit the presence of mixed exchange rate regimes for each country during the period of analysis, i.e., flexible, managed, and fixed, so we expect to find some evidence of international transmission, although the degree of such transmission is uncertain. Another important consideration is the volatility of a key variable, the exchange rate, which we measure using GARCH techniques. Finally, we estimate the effects of U.S. monetary policy via the analysis of the impact of positive innovations (or shocks) to the federal funds rate; which are indicative of a contractionary monetary policy.

2.4.2 Unit Roots, Cointegration and Volatility

2.4.2.1 Unit roots and Cointegration

Ignoring the presence of unit root in a conventional linear regression can lead to serious errors in inferences. We use the augmented Dickey-Fuller (ADF) test\(^\text{20}\) with MacKinnon critical

\(^{20}\) Sixteen lags is the maximum number of lags considered for both constant and constant-and-trend estimations. The selection criteria was the number of lags that minimize the AIC criterion.
values to test the presence of unit roots in the variables. The null hypothesis of a unit root is rejected against the one-sided alternative if the t-statistic is less than (lies to the left of) the critical value.

Almost all the variables included in our estimation have one unit root, as Table 2.2 shows.\textsuperscript{21} However, it appears that the U.S. CPI has two unit roots. To confirm this we performed a test of structural change as in Perron (1989) and Enders (2004). Perron (1989) establishes that when there is a structural break, Dickey-Fuller and Phillips-Perron test statistics are biased toward acceptance of a unit root, even when the series can be stationary in sub periods. The idea is “to test whether $Z_t$ is an integrated process or not, i.e., to test whether the shocks $\{e_t\}$ have persistent effects that do not vanish over a long horizon” (Perron, 1989, p.1387). After performing the test, we conclude that there is a structural break in the U.S. CPI. After controlling for the structural break, the series exhibits only one unit root.

We also need to take into account any potential cointegration. As explained in Section 2.4.2, the presence of cointegration can create problems in the estimation when there is no error correction term in the original model. In this study, the variables are integrated of order one and after testing for cointegration with the Johansen test, cointegration is found.\textsuperscript{22} Therefore, we need to use VEC models. Using VAR models, as previous studies have done, can lead to erroneous inferences.

2.4.2.2 Volatility

Interest in analyzing exchange rate volatility has gained ground in the economic discussion following the financial crisis of the 1990s. Among studies focusing on large currency speculative episodes are Kanas (2005), Eichengreen and Wyplosz (1993), Buiter, Corsetti and

\textsuperscript{21}The conditional variance of the exchange rate is integrated of order zero.

\textsuperscript{22}For space availability we do not include the results of the tests (6 tests times fourteen countries, and this times 3 sections –test for direct, augmented, and extended transmission). They are available upon request.
Pesenti (1998), and Sachs, Tornell and Velasco (1996). Other studies analyze the co-movements and volatility of variables such as interest rates (Laopodis, 2004a, 2004b). GARCH modeling builds on advances in the understanding and modeling of volatility in the last decade. It provides accurate forecasts of variances and covariances through its ability to model time-varying conditional variances. Two examples of GARCH modeling applications to exchange rate analysis are Baillie and Bollerslev (1989) and Neely and Weller (2000).

An important question is which exchange rate is more appropriate for this study: the nominal or the real exchange rate? Nominal exchange rates can overestimate exchange rate uncertainty. The reason is that price movements partly offset the real effects of fluctuations in the exchange rates. These offsetting movements are taken into account in the real exchange rates. Therefore, we use the real exchange rate.

To decide the GARCH model that best fits the data, we follow the procedure described in Enders (2004). The number of lags for estimating the conditional variance of the exchange rate was chosen, minimizing the AIC criterion. The results for the mean equation of the exchange rate and its conditional variance were estimated in differences because the exchange rate is integrated of order 1 for each country.

We first ruled out the possibility of structural breaks in the real exchange rate because they can mimic the presence of volatility. We use Chow tests for this purpose. Structural breaks are present in the real exchange rate series of Indonesia (1996), Mexico (1994), and Korea (1997), all of which correspond to years of financial crisis in these economies. Although volatility was found in subsamples posterior to the structural break point, there is no evidence of volatility in subsamples prior to that point; therefore, because few observations will be available for VEC estimation, we do not estimate volatility for these countries.

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23 The idea of the breakpoint Chow test is to fit an equation for each subsample and find whether there are significant differences in the estimated equations. A significant difference indicates a structural change in the relationship. Potential breakpoints were identified using a plot of each real exchange rate.
Next, to identify the presence of significant ARCH factors in each exchange rate, we estimate the LM test for ARCH developed by Engle (1982). The null hypothesis is that there is “no ARCH” up to order q in the residuals obtained from a regression of the square residuals on a constant and on the lagged squared residuals up to order q. Table 2.3 present the results of the test. The null hypothesis cannot be rejected for India, Japan, Venezuela, Argentina, Colombia, and Peru. Consequently, those countries are excluded from volatility estimations.

For the countries where the null hypothesis of “no ARCH” was rejected, we estimate the GARCH model that best fits the data. Table 2.4 details the GARCH models for Brazil, Chile, Malaysia, the Philippines, and Thailand.

Figure 2.1 shows the extracted measure of exchange rate volatility. Brazil has experienced several highly volatile periods in the early 1990s and from the year 2000 to the present. Malaysia’s highest volatile period was 1997–2000, which corresponds to the Asian financial crisis. Similarly, Thailand’s highest exchange rate volatile period was 1995–2000. The Philippines also reveals high volatility during the Asian crisis period (1997–98), but their highest period of volatility was 1983–86. Chile’s highest volatile periods are the early 80s, especially 1984–85.

2.4.3 Direct Transmission

A Choleski decomposition is used to construct IRFs. Because of this, the ordering of the variables matters. The basic VEC model follows the ordering24 U.S. industrial production, U.S. CPI, U.S. federal funds rate, the real exchange rate, the conditional exchange rate volatility estimated from the GARCH models (when volatility is present),25, 26 and one of the domestic

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24 A similar ordering is used in studies such as Kim (2001) and Mojon and Peersman (2001).
25 In general, with the inclusion of exchange rate volatility, the responses in each country are not substantially different than the responses when volatility is not included. What is noticeable is that the inclusion of the exchange rate volatility strengthens the transmission from U.S. monetary shocks because
variables. The model also contains dummy variables for exchange rate regime and for seasonality, which are exogenous. The ordering puts large country variables first because they may have an impact on the small-economy variables. But changes in small-economy variables will not have a contemporaneous impact on U.S. variables. It would be hard to argue that a small economy may have an impact on U.S. variables, so the order seems the most appropriate.

The ordering of the variables may have an impact on the results from impulse responses and variance decompositions. "The key point is that the decomposition forces a potentially important asymmetry on the system" (Enders, 2004, p. 275), which happens because, for instance, in a two-variable model, shocks from the variable that is put first are going to contemporaneously affect both variables, but shocks from the second variable will not affect the first one. "Unfortunately . . . identification necessitates imposing some structure on the system. The Choleski decomposition provides a minimal set of assumptions that can be used to identify the structural model" (Enders, 2004, p.276). Changing the order may alter some results, but the researcher must decide on the ordering using any "theoretical reason to suppose that one variable has no contemporaneous effect on the other" (Enders, 2004, p.275). That is why we order U.S. variables first.

We followed the marginal method, which consists of adding to the basic model, one by one, variables from an emerging country. In this way more precise estimates are obtained and the significant responses last more periods. Hence, exchange rate volatility creates the persistence of the impact of U.S. monetary shocks on the open economies.

27 We also estimated VEC models with the inclusion of interest rate volatility. The inclusion of interest rate volatility does not alter the pattern of the responses. Therefore, we omit those results.

28 One dummy accounts for fixed exchange rate regime and a second dummy, for managed regime. In the case of Japan, no dummy is required because the exchange rate was floating during the entire period of analysis. For Peru, Colombia, India, and Thailand, only a dummy for managed regime was required. Those countries had flexible and managed exchange rate regimes only.

29 The exchange rate regime is assumed exogenous in the estimation in this chapter. However, the exchange rate regime may not be exogenous if the volatility of the exchange rate is high.

30 The ordering of the variables does not matter for estimation purposes, but it will matter in the IRFs.

Kim (2001) uses this method in his estimation of U.S. monetary policy and the international transmission to non-U.S. G-6 countries.
complexities about interdependence are avoided. This means that a VEC model is estimated for each variable and for each country. For instance, in regard to Chilean industrial production, the model contains U.S. industrial production, U.S. CPI, U.S. federal funds rate, real exchange rate, exchange rate conditional volatility, and Chilean industrial production. For Chilean exports the model contains U.S. industrial production, U.S. CPI, U.S. federal funds rate, real exchange rate, exchange rate conditional volatility, and Chilean exports; and so on for each variable in each of the countries analyzed. Chilean variables are always placed last in the ordering.

IRFs with forecast horizons of 48 periods (four years) are constructed and 1,000 Monte Carlo simulations are used to derive the confidence bands. Innovations are to the U.S. federal funds rate. In the following figures we present for each estimated VEC the significant impulse responses corresponding to the real exchange rate and the variable of interest (i.e. industrial production, exports, imports, CPI, interest rate or money). That is, the real exchange rate and the industrial production graphs presented in one figure correspond to a different VEC model than the real exchange rate and exports graphs that appear next in the figure.

To contrast our results with previous analysis, the baseline model was estimated with U.S. data. Although the results from this model are not included, the results are consistent with previous findings. In response to contractionary monetary policy shocks, output decreases, and the federal funds rate impact decreases at a slow rate over time —both results are expected from the theory. Prices, however, initially increase. This is the price puzzle also found, among others, by Sims (1992) for France, Japan, United Kingdom, and the U.S., by Christiano and Eichengbaum (1995), and by Peersman and Smets (2001) for Euro area countries.

Next, we present a summary of all responses for direct transmission in Table 2.5. We arrange countries according to their level of response. Countries’ reactions to U.S. monetary

31 An extended model is estimated for each economy in the last part of this section.
32 For space availability and to facilitate our analysis, we find it more convenient to present the results using this organization, but the complete set of IRFs from each VEC estimated is available upon request.
shocks are classified in five groups. The classification is based on responses expected at a theoretical level. Although these countries have mixed exchange rate regimes during the period of analysis, their responses to U.S. monetary shocks allow us to identify responses that correspond to a particular regime. A first inference is that the empirical results match the expected results from the MFD theory, even though these countries have mixed exchange rate regimes. This reveals the fact that analysis of international transmission that only takes into account traditional theoretical results cannot fully explain the international transmission occurring in emerging economies. And, as it will be seen later, similar errors in the analysis of international transmission can arise if the international transmission to emerging economies is thought to happen in the same way that it occurs for developed economies.

In our classification, countries with a high response in their variables, except in the exchange rate, are consistent with the expected effects of fixed exchange rates. Countries with response in their exchange rate and other variables correspond to a managed regime. Finally, we have a group of countries where we do not observe significant response, which we interpret as an absence of international transmission.

In the first group are countries whose exchange rates have no significant reaction, but whose other variables exhibit a high response to U.S. monetary shocks. That is, the exchange rate does not insulate the economy from foreign shocks, so variables in the small economy are directly affected. We called this group “Fix-High Transmission.” This group, which includes Korea, evidences full international transmission.

Figure 2.2 shows the response of Korean variables to a U.S. contractionary shock. It is observable that following a U.S. monetary shock, the real exchange rate does not have a

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33 Japan is the only country that, during the entire period of analysis, had a flexible exchange rate. All the Japanese variables and the exchange rate react significantly to U.S. interest rate shocks. We interpret this as a sign of the interactions between two large economies. In a world of perfect capital mobility, the MFD model predicts that a contractionary U.S. monetary policy shock will cause an increase in Japanese output, which is the present case. The expected depreciation is also present.

34 High response means that most variables exhibit significant responses to U.S. monetary shocks.
significant reaction, but most of the domestic variables do have significant responses to a U.S. shock. Exports and imports increase showing that the trade balance is affected. Also, interest rates and prices increase, so the transmission channel is also through these variables. Money decreases. Five of the six variables in the analysis have a significant response, so we consider this a case of high international transmission.

Hsiao (1999) explains that Korean monetary authorities, especially in the 1990s, raised interest rates to stabilize the exchange rate and limit the negative impact of the financial crisis. Therefore, in the presence of intervention, the expected existence of international transmission occurs. According to Cook and Devereux (2006), Korea developed a reputation as “miracle” economy because of its rapid growth in the post-war period. Perhaps that opening to the rest of the world can explain why this country is impacted by U.S. monetary shocks.

The second group, “Fix-Moderate Transmission,” consists of countries with no significant reaction in their exchange rate (the same as “Fix-High Transmission” countries), but where fewer variables respond to U.S. monetary shocks. This group still offers evidence of high international transmission because output is impacted. This group includes Indonesia, Colombia, and Venezuela.

After a U.S. contractionary shock, output decreases in each of the three countries. The channel of transmission, however, differs. In Indonesia (Figure 2.3) imports increase, which means that the trade balance is negatively affected. In Colombia (Figure 2.4) exports decrease, so the trade balance is the channel through which output is negatively affected. In Venezuela (Figure 2.5) prices increase.

The negative response of output for these three countries reveals that a contractionary monetary policy in the large economy does not benefit the small economy. This contrasts with the benefit that Korea exhibited in the first group.

What do these three economies have in common? Colombia and Venezuela are neighbors. They share a process of promoting industrialization in the 1970s, and also showed
symmetric variations in their exchange rate in the 1990s (Escaith, Ghymers, and Studart, 2002). But what do they have in common with Indonesia? Colombia and Indonesia exhibited procyclical fiscal policies during the period 1990–2003 (Calderón, Duncan, and Schmidt-Hebbel, 2004). All three countries are oil exporters. During the 1990s, Venezuela obtained nearly four-fifths of its export revenues from crude oil, while Colombian oil represented 23% of its exports, and Indonesian oil export was 15% (Goldstein, 2005). Also in the late 1990s and early 2000s, Indonesia and Venezuela had to tighten monetary policy because they faced “large exchange rate depreciations caused, among other factors, by markets’ losing confidence in fiscal policy. Colombia confronted a similar policy dilemma” (Mohanty and Scatigna, 2003, p. 52). Therefore, these similar economic conditions may explain their reaction to U.S. monetary shocks.

The third group of countries corresponds to countries with some significant reactions of their exchange rates and some significant responses in other variables to U.S. monetary shocks. We called this group “Managed” because the responses are related to what is expected under managed exchange rate regime. This group evidences international transmission and we distinguish among countries with high and moderate international transmission.

Countries in the “Managed - High Transmission” group exhibit significant response by their exchange rates and the other variables. The countries in this group are Brazil (Figure 2.6), Chile (Figure 2.7), Malaysia (Figure 2.8), Philippines (Figure 2.9) and Thailand (Figure 2.10). After a U.S. contractionary monetary shock, in general, the exchange rate depreciates, while there are increases in output, prices and interest rates. Mixed reactions are found for exports, imports and money. The fact that output raises shows that these economies clearly benefit from contractionary shocks occurring in the U.S., which clearly differs from results found for European economies (Kim, 2001). These economies exhibit full international transmission and that exchange rate fluctuations have not insulated the economy from foreign shocks.

These five economies share underlying factors that may explain their response to U.S. monetary shocks. The Asian economies, Malaysia, the Philippines and Thailand, were part of the
“miracle” countries that exhibit a fast growth in the post-war period (Cook and Devereux, 2006). These economies also share the financial crisis in the 1990s, which affected Brazil and Chile (Edwards, 2000). Chile and Malaysia share efforts during the late 1990s to impose controls on capital to avoid future financial crisis (Magud and Reinhart, 2006).

The impact on Malaysia and the Philippines are consistent with findings of Sun and Sun (2004) that U.S. monetary policy affects these economies. Canova (2005) also finds, as we do, that U.S. disturbances have an important impact on Brazilian exchange rates. Our results support the argument by Holland and Vilela’s (2004) that Brazil’s exchange rate system has not been able to insulate the economy.

In the “Managed - Moderate Transmission” group are two economies, India and Argentina. After a U.S. contractionary monetary shock, these countries exhibit exchange rate depreciation. There is also an impact on trade variables. In general, exports and imports increase, which differs from the results found for developed economies. Here, depreciation has the expected effect on exports and imports. Indian exports increase but output decreases (Figure 2.11). In Argentina, exports and imports increase while money decreases (Figure 2.12). This group indicates that there is international transmission, although the final impact on the trade balance from a U.S. contractionary shock could be cancelled by increases in both exports and imports when they show significance.

What does this group of countries have in common? India attracted massive private capital inflows during the 1990s. A similar experience to attract private capital was undertaken by Argentina. Argentina appears to share “the absence on an established track record in sound macroeconomic management and a rich history of failed stabilization plans” (Calvo and Reinhart, 1996, p. 2). The decrease in money in Argentina supports Geiregat’s (2004) findings with respect to U.S. monetary shocks.

The last group of countries, Mexico and Peru, show almost no significant response in their variables, including the exchange rate. We called these countries “No Response.” A slight
reaction occurs in Peru’s imports, but in general, there is no significant response to U.S. monetary shocks. Because of its ties to the U.S. economy, Mexico’s lack of significant response is surprising.

What can explain the results for these economies? Canova (2005) affirms that Mexico exhibited a combination of flexible rates, partial inflation targeting, and no dollarization. He also finds that international factors, not necessarily linked to developments in the U.S. economy, account for an overwhelming portion of the variability in economic variables in Peru.

Results in Table 2.5 comprise evidence of an international transmission mechanism from the U.S. monetary policy shocks to emerging countries. In general, the real exchange rate reacts with depreciation, which can be expected from theoretical considerations. Also, in general, following a U.S. contractionary monetary shock, output increases. Exports and imports, when they significantly react, experience increases, which differs from responses in developed countries. Finally, when prices, interest rates, and money significantly react, they exhibit increases. An interesting result is that Asian countries show more international transmission than Latin American countries.

2.4.4 Transmission Including a Leading Economy

The idea of an augmented transmission mechanism can be understood if economies share some common links. The literature in financial contagion has developed the idea of a domino, or contagion, effect. Corsetti et al. (2000) analyze the international transmission of exchange rate movements that produce financial contagion in economies. They take the initial devaluation in one country as an exogenous shock, and focus on the welfare repercussions of this shock on the economies of their trading partners or competitors. Baig and Goldfajn (1999) and Chung (2005) found evidence of cross-border contagion between the Asian financial markets. Spillover effects were also found after the Mexican peso crisis in 1994 from Mexican bond prices to Latin
America (Han, Lee, and Suk, 2003). Frankel and Smuckler (1998) show that a negative shock in Mexican equities is transmitted to Latin America, suggesting that the contagion is more regional than global.

In this section we take the aforementioned evidence from financial contagion one step further by testing the possibility of an augmented transmission through the inclusion of a leading economy that reacts to the shocks of a large economy, and those reactions (the lead-economy reactions) have an impact on a small open economy.

The baseline model includes three U.S. variables: industrial production, prices, federal funds rate. Add to them the variables corresponding to the leading country’s (either Japan or Mexico) real exchange rate, industrial production, CPI, and interest rate; followed by real exchange rate for the small open economy, exchange rate conditional variance, and the variable of interest (of the small economy). As before, exogenous variables included in the model are dummies for exchange rate regimes and for seasonality. The same procedure of adding one variable at a time is followed.

Because of space limitations, we present only significant responses. In the figures, the first set of graphs is the response of a variable from a small open economy to U.S. contractionary monetary actions. The second set of graphs shows the response of a small open economy variable to the leading economy monetary actions, represented by interest rates. For a response to be evidence of augmented transmission two conditions must be met. First, the leading economy monetary variable (interest rate) should significantly react to U.S. monetary shocks. Second, the variable of analysis in the small economy should have a significant response to both U.S. monetary shocks and the leading economy monetary shocks.

The leading economies we chose are Japan for Korea, Malaysia, the Philippines, Indonesia, India, and Thailand; and Mexico for Chile, Peru, Brazil, Venezuela, Argentina, and

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The real exchange rate is equal to the nominal exchange rate of the small open economy with respect to the U.S. multiplied by the U.S. CPI and divided by the CPI of the small economy.
Colombia. Our decision to select Mexico and Japan as leading economies takes into consideration the highest GDP in the region and the geographic situations among the countries included in the estimation.\textsuperscript{36} In order for augmented transmission to take place, U.S. monetary policy shocks must have an impact on the interest rate in the leading economy. Our empirical results show that U.S. monetary shocks do not have an impact on Mexico’s interest rate. Because Mexico is considered leading economy in Latin America, augmented transmission cannot take place in the Latin American countries.

Table 2.6 presents a summary of the responses of the Asian countries. The first subgroup of Asian countries contains countries that show augmented transmission and no reaction in the exchange rate, the “Fix-Augmented” countries. Korea is in this group; it was in the Fix group when direct transmission was analyzed, so its reactions are consistent.

In Korea (Figure 2.13 and 2.14), the variables that respond significantly to both U.S. and Japanese monetary actions are imports, interest rate, and prices with increases in response to U.S. shocks, but decrease with respect to Japanese shocks. The sign of the responses follows the patterns of the previous section. That is, there are positive responses to U.S. contractionary policy, and the same reactions occur in response to the leading economy shocks. Therefore, the inclusion of leading economy variables augments the impact of the monetary transmission.

According to Sun and Sun (2004), the fluctuation in Japanese monetary policy has caused a surge of Japanese bank flows to Korea, where large quantities of loans come from foreign funds. Because of this, it makes sense that Japan reaction to U.S. monetary policy also has an impact on Korea.

In the second subgroup of Asian countries we place economies showing augmented transmission and that also have reaction in their exchange rates. This group is referred to as

\textsuperscript{36} For the Latin American countries in the sample, Brazil was tested as alternative leader. However, with the exception of significant responses in Peruvian imports and Argentine output, the rest of the variables present smaller responses to monetary shocks than the response observed when Mexico is considered the leading economy for the region.
“Managed-Augmented” and includes Malaysia (Figure 2.15 and 2.16), the Philippines (Figure 2.17 and 2.18), Thailand (Figure 2.19 and 2.20), and India (Figure 2.21 and 2.22). These countries show significant response in trade variables and interest rates, as in the “Fix-Augmented” case, but here the real exchange rate responds to foreign shocks.

In response to U.S. and Japanese monetary shocks, in general, output, prices and interest rates raise. Mixed reactions appear for exports, imports and money. The responses found in this section are consistent with the responses found in the previous.

The responses in Malaysia, Thailand, the Philippines and India to Japanese shocks may be explained because of financial ties. In Thailand and the Philippines, private corporations borrowed much more with international loans than banks did, especially from Japanese banks. Most of those foreign funds were invested in volatile real estate investments so Japanese monetary policy has spillover effects on Thailand’s economy (Sun and Sun, 2004). Moreover, Asian emerging economies, led by Thailand and the Philippines, have the highest shares of yen-denominated liabilities (Goldstein, 2005).

Although financially close to Japan, the fact that exports from India negatively react to a Japanese monetary shock, while they benefit from U.S. monetary shocks, can be understood considering that in the 1990s, “The weakness of the yen revived Japanese exports, placing Japan in direct competition with its major trading partners in Asia, as the cheaper yen stimulated exports of Japanese durable goods and capital goods to Asia, while reducing imports from the region” (Yam, 1997 Asian Monetary Conference Speech).

Results in this section support the hypothesis of an augmented international transmission process, where U.S. monetary policy affects leading countries in different regions, and those countries’ reactions affect third countries. In our sample, this augmented transmission exists for Asian economies.
2.4.5 Robustness: Extended Model

We now consider an extended model. That is, we no longer add domestic variables one by one into the baseline model, but we use one model where all variables interact. We begin by using the first three U.S. variables: industrial production, CPI, federal funds rate. Later we add the domestic variables: real exchange rate, CPI, output, exports, imports, and interest rate.

Table 2.7 summarizes the results from impulse response functions. As before, we identify countries with similar reactions to U.S. monetary shocks and put them in groups to facilitate the analysis.

The first group, “Fix-1-Extended”, contains three countries with almost identically high responses in variables other than the exchange rate. These countries are Korea, Thailand, and the Philippines. These countries were also present in this group in the high direct transmission section, so the results show consistency. In these countries, following a U.S. contractionary monetary shock, exports and imports increase. Also prices and interest rates increase.

The second group, “Fix-2-Extended,” belongs to countries that also show significant reaction in variables other than the real exchange rate, but where fewer variables react in comparison with the first group. These countries also show evidence of international transmission from U.S. monetary shocks. This is the case for Indonesia, Colombia, Venezuela, Mexico, and Chile. After a contractionary U.S. monetary policy, Indonesian imports increase, Colombian

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37 All figures are available upon request.
38 In the case of Japan, the results in this extended model are consistent with the results in previous sections. That is, Japanese variables respond significantly to U.S. monetary shocks. Following a contractionary monetary shock, Japanese output, exports, and imports increase, which is consistent with the MFD idea of the beggar-thy-neighbor where one country benefits from the actions of other. This result differs from previous studies of Japan.
output decreases initially and increases later, Venezuelan prices increase and output decreases, Mexican exports and imports increase, and Chilean output increases.

The results for Indonesia, Colombia, and Venezuela are consistent with the results found in the direct transmission estimations. Previously, Mexico showed almost no response to U.S. monetary shocks, but two variables are affected by U.S. policy actions, exports and imports. Because the United States is the main commercial partner to Mexico, it is understandable that these two variables will be mainly affected.

In the third group, "Managed-Extended," are those countries with significant response to U.S. monetary shocks, and also reaction in the exchange rate. India, Malaysia Argentina, and Peru are in this group. The results for India, Malaysia, and Argentina are consistent with the findings when direct transmission was estimated since they also belonged to the Managed group.

After a U.S. contractionary monetary shock, output decreases (for India, Peru, and Argentina); exports increase (India and Argentina); and imports decrease (India and Peru). The transmission is done through exchange rate depreciation for India and Argentina, and through exchange rate appreciation and price decreases for Peru. In Malaysia, the exchange rate depreciates and prices increase, although no real variables are affected. There is evidence of international transmission in this group. The last group, "Flexible-Extended," corresponds to countries where the exchange rate significantly responds to U.S. monetary shocks while the other variables in the economy do not. This is the case in Brazil, although this contrast with the response found in the previous section.

In general, when an extended model is used, the results are consistent with previous findings for direct transmission. There is evidence of international monetary transmission: Following a U.S. contractionary shock, the real exchange rate depreciates; prices increase; output’s reaction is mixed (half of the countries with significant response exhibit increases, while the other half shows decreases); exports increase; imports increase; and interest rates increase. Asian countries show significant responses in more variables than Latin American countries.
2.5 CONCLUSIONS

This chapter examines the international transmission of U.S. monetary policy to emerging economies. With regard to the transmission mechanism, there are three possibilities. One possibility is that U.S. monetary policy shocks directly affect other economies. A second possibility is that U.S. monetary policy affects leading countries in different regions, and those countries' reactions affect third countries. These two possibilities are not mutually exclusive. The third option is that there is no transmission from U.S. monetary policy to small open economies. Another issue considered is volatility of the exchange rate. A crucial consideration in the transmission is the exchange rate regime that a small open economy adopts; here the de facto regime is included.

The contributions of this research are: 1) analyze monetary transmission mechanism in emerging economies, 2) account for the de facto exchange rate regime, 3) use vector error correction (VEC) models because of cointegration among the variables, 4) use a long time series period, 5) analyze the possibility of an augmented transmission mechanism with a leading economy in the region that results in having an impact on the small open economy, 6) analyze the impact that volatility of key variables have in the transmission mechanism, and 7) analyze the interaction in the economy in an extended model of transmission. Previous studies have not considered the exchange rate regime, the volatility impact, or an augmented transmission idea.

We rely on impulse response functions derived from VEC models. Exchange rate volatility is estimated using GARCH models. Monthly data for fourteen economies for the period 1975–2003 are used. In our VEC models we first add one domestic variable at a time to the basic model. Subsequently, we estimate an extended model.
From the results, several important conclusions arise. First, there is evidence of an international transmission mechanism of U.S. monetary policy shocks to other economies. The responses of countries can be classified in groups according to the degree of response, which goes from countries with the highest response, such as Korea and the Philippines, to countries with almost no response, such as Peru.

Second, there is support for our hypothesis of an augmented international transmission process according to which U.S. monetary policy affects leading countries in different regions, and those countries' reactions affect third countries. This is the case for Asian economies.

Third, the inclusion of exchange rate volatility in the model extends the duration of the significant response of domestic variables to foreign shocks. As such, we can say that exchange rate volatility enhances the persistence of U.S. monetary shock's impact on open economies.

Fourth, when an extended model is used, there is evidence of international monetary transmission in all economies with varying scale of response. Therefore, our results are consistent with earlier evidence of a direct transmission.

Overall, despite variations from country to country, there is both evidence of an international transmission of U.S. monetary shocks to emerging economies and of an augmented international transmission, at least in Asia. A small open economy ends up being affected by the large economy monetary shocks and by the leading regional economy reaction to the large economy shocks. Due to the evidence presented, monetary authorities in a small open economy need to consider these impacts in their monetary policy decisions, because the results of the monetary actions of a small open economy are strongly influenced by other countries' actions.
Table 2.1: *De facto* Exchange Rate Regime Classification
by Levy-Yeyati and Sturzenegger *

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<thead>
<tr>
<th>Year</th>
<th>Japan</th>
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Notes: Original data contain several managed regimes, but we list all those regimes under Managed. Original sample ends at 2000. Author's calculations used for 2001-2003.
Table 2.2: Augmented Dickey-Fuller (ADF) Unit Root Test

<table>
<thead>
<tr>
<th>Country</th>
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<th>Intercept and Trend</th>
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<td>-5.436**</td>
<td>1 -1.617 10</td>
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<td>16 -4.897*** 15</td>
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<td>X</td>
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<td>15 -4.495*** 14</td>
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<td>M</td>
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<td>12 -4.239*** 11</td>
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<tr>
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<td>13 -4.730*** 12</td>
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<td>M</td>
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<td>Int.</td>
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<td>0 7.691*** 0</td>
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<td>X</td>
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<td>4 3.428*** 3</td>
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<td>X</td>
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<td>13 -4.238*** 12</td>
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<td>M</td>
<td>-0.853</td>
<td>12 -5.906*** 11</td>
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<td>-10.142*</td>
<td>0 -3.657*** 6</td>
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<td>Int.</td>
<td>-6.710***</td>
<td>2 2.038*** 3</td>
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<td>IP</td>
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<td>2 6.122*** 1</td>
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<td>M</td>
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<td>3 4.509*** 2</td>
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<td>3 0.758*** 4</td>
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<td>X</td>
<td>-1.560</td>
<td>12 -5.848*** 11</td>
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<td>M</td>
<td>-0.418</td>
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<td>Int.</td>
<td>-11.521**</td>
<td>3 0.570*** 3</td>
</tr>
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<td>IP</td>
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<td>0 20.625*** 0</td>
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<td>X</td>
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<td>0 6.316*** 1</td>
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<td>M</td>
<td>-3.073***</td>
<td>4 4.868*** 3</td>
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<tr>
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<td>CPI</td>
<td>1.378</td>
<td>3 -5.080*** 2</td>
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<tr>
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<td>Int.</td>
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<td>0 20.522*** 0</td>
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<tr>
<td></td>
<td>RER</td>
<td>-2.290</td>
<td>0 7.816*** 0</td>
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Table 2.2 (continued): Augmented Dickey-Fuller (ADF) Unit Root Test

| Country | Variable | Intercept | Intercept and Trend | | Intercept | Intercept and Trend |
|---------|----------|-----------|---------------------| | | |
| ARGENTINA | IP | -2.323 | 12 | 5.781*** | 12 | -2.245 | 12 | -5.846*** | 12 |
| X | -3.712*** | 0 | 7.470*** | 0 | -4.035*** | 0 | 17.470*** | 0 |
| M | -3.401** | 1 | 22.314*** | 0 | -4.147*** | 0 | 22.280*** | 0 |
| CPI | -1.711 | 8 | -2.390* | 7 | -1.195 | 8 | -2.390* | 7 |
| Int. | -11.971*** | 0 | 10.734*** | 7 | -11.954* | 0 | 10.734*** | 7 |
| RER | -2.053 | 0 | 18.549*** | 0 | -1.917 | 0 | 18.564*** | 0 |
| COLOMBIA | IP | -1.478 | 14 | -3.012** | 13 | -1.295 | 14 | -3.020* | 13 |
| X | -1.040 | 20 | 5.617*** | 1 | -2.580 | 20 | 5.527*** | 1 |
| M | -1.216 | 6 | 3.605*** | 1 | -3.111 | 6 | 3.605*** | 1 |
| CPI | -0.215 | 5 | -6.013*** | 5 | -0.322* | 5 | -6.013*** | 5 |
| Int. | -11.971*** | 0 | 10.734*** | 7 | -11.954*** | 0 | 10.734*** | 7 |
| RER | -1.488 | 10 | 10.123*** | 0 | -1.512 | 10 | 10.118*** | 0 |

Note: ***, **, and * indicate significance at 1%, 5% and 10% level. The maximum number of lags used is 16. Appropriate number of lags is the minimizing number for the Akaike Information Criteria (AIC). Critical values are MacKinnon's critical values. Notation of variables is as follows: Industrial Production (IP), Exports (X), Imports (M), Consumer Price Index (CPI), Interest rate (Int.), Real Exchange Rate (RER), and Federal Funds Rate (FFR). All variables are in logs, except interest rate.
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<tr>
<th>Country</th>
<th>ARCH (1) F-statistic</th>
<th>ARCH (6) F-statistic</th>
<th>ARCH (12) F-statistic</th>
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<td>TxR² Statistic</td>
<td>TxR² Statistic</td>
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<td>6.130</td>
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<td>76.979***</td>
<td>15.916***</td>
<td>8.949***</td>
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<td>10.560***</td>
<td>1.972*</td>
<td>11.614*</td>
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<td>111.231***</td>
<td>21.349***</td>
<td>10.664***</td>
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<td>0.210</td>
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<td>0.050</td>
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<td>10.498***</td>
<td>8.968***</td>
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<td>4.079***</td>
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<tr>
<td>Colombia</td>
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Notes: ***, **, and * indicate significance at 1%, 5% and 10% level. The F-statistic is an omitted variable test for the joint significance of all lagged squared residuals. The TxR² statistic is Engle's LM test statistic, estimated as the number of observations times the R². The ARCH test is a regression of the squared residuals on a constant and lagged squares residuals up to order q. The number of lags is in (). Thus, ARCH (1) indicates the estimation of ARCH test including 1 lag. Subsample corresponds to test estimation when the presence of structural break mimics the effects of volatility and the subsample is only the period after the break. Indonesia has a structural break in 1996, so the ARCH test for the subsample is for the period 1996-2003. The Mexican subsample is 1994-2003 (the structural break is in 1994). The Korea's subsample is 1997-2003 (the structural break is in 1997).
Table 2.4: GARCH Estimations for Real Exchange Rate

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<td>(0.000)</td>
<td>(0.106)</td>
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<td>(0.064)</td>
<td>(0.031)</td>
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<td>(0.000)</td>
<td>(0.066)</td>
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<td>(0.040)</td>
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<td>(0.000)</td>
<td>(0.096)</td>
<td>(0.096)</td>
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Notes: ***, **, and * indicate significance at 1%, 5% and 10% level. Standard errors are in parenthesis. The numbers on $a_1$, $a_4$, and $a_8$ denote the number of lags of the own variable (i.e. $a_1$ corresponds to lag 1, and so on). The coefficients on $\alpha$ represent ARCH terms, while $\beta$ accounts for the GARCH terms. The estimated equation controlled for seasonality with dummy variables.
Table 2.5: Summary of Impulse Response Functions due to U.S. Monetary Policy Shocks

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<th>Group</th>
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<th>Exports</th>
<th>Imports</th>
<th>CPI</th>
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<th>Money</th>
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<td>Transmission+</td>
<td>Transmission+</td>
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<td>No</td>
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</tr>
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<td>Korea</td>
<td>Transmission+</td>
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<td>No</td>
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<td>Fix-Moderate</td>
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<td>Indonesia</td>
<td>Transmission-</td>
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<td>No</td>
<td>No</td>
</tr>
<tr>
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<td>Transmission-</td>
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<td>Yes+</td>
<td>Yes+</td>
<td>Yes+</td>
<td>Yes+</td>
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<td>Yes+</td>
<td>Yes+</td>
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<td>Yes+</td>
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<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
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<tr>
<td></td>
<td>Peru</td>
<td>Transmission-</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
</tbody>
</table>

Notes: No Trans. means there is no significant response in that variable to U.S. monetary shocks. ER react shows whether the real exchange significantly reacts or not. The number of lags in each VEC model is set to minimize the Aikake Information Criterion for a maximum of eight lags and white noise residuals. The Choleski decomposition ordering is U.S. industrial production, U.S. CPI, U.S. federal funds rate, real exchange rate, conditional variance (when it applies), variable of analysis (i.e. industrial production, exports, and so on for the small open economy). Standard deviations are calculated via monte carlo simulations with 1,000 draws. A 48-month horizon is estimated. The signs indicate the pattern of the response: + for positive and - for negative.
Table 2.6: Summary of Impulse Response Functions due to U.S. Monetary Policy Shocks Including a Leading Economy

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<tbody>
<tr>
<td><strong>FIX</strong></td>
<td><strong>Augmented</strong></td>
<td></td>
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<tr>
<td><strong>FIX-No</strong></td>
<td><strong>Augmented</strong></td>
<td></td>
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</table>

Notes: No Trans. means that there is no significant response in that variable to foreign monetary shocks (U.S. or leader). ER react shows whether real exchange significantly reacts or not. The number of lags in each VEC model is set to minimize the Aikaike Information Criterion for a maximum of six lags and white noise residuals. The Cholesky decomposition ordering is U.S. industrial production, U.S. CPI, U.S. federal funds rate, leader real exchange rate, leader interest rate, real exchange rate for the small economy (with respect to U.S.), variable of analysis (i.e. industrial production, exports, and so on for the small open economy). Standard deviations are calculated via monte carlo simulations with 1,000 draws. A 48-month horizon is estimated. The signs indicate the pattern of the response: + for positive and - for negative. The first two groups of countries are economies that show evidence of augmented transmission (see text for details), while the next three groups of countries do not (although direct transmission exists).
Table 2.7: Summary of Impulse Response Functions due to U.S. Monetary Policy Shocks, Extended Model

<table>
<thead>
<tr>
<th>Group</th>
<th>Country</th>
<th>Real Exchange rate</th>
<th>CPI</th>
<th>Industrial Production</th>
<th>Exports</th>
<th>Imports</th>
<th>Interest rate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Japan</td>
<td>Transmission+</td>
<td>No Trans.</td>
<td>Transmission+</td>
<td>Transmission+</td>
<td>Transmission+</td>
<td>Transmission+</td>
</tr>
<tr>
<td>FIX-1-</td>
<td>Korea</td>
<td>No Trans.</td>
<td>Transmission+</td>
<td>No Trans.</td>
<td>Transmission+</td>
<td>Transmission+</td>
<td>Transmission+</td>
</tr>
<tr>
<td>Extended</td>
<td>Thailand</td>
<td>No Trans.</td>
<td>Transmission-</td>
<td>No Trans.</td>
<td>Transmission+</td>
<td>Transmission+</td>
<td>Transmission+</td>
</tr>
<tr>
<td></td>
<td>Philippines</td>
<td>No Trans.</td>
<td>Transmission+</td>
<td>No Trans.</td>
<td>Transmission+</td>
<td>Transmission+</td>
<td>Transmission+</td>
</tr>
</tbody>
</table>

Notes: No Trans. means there is no significant response in that variable to U.S. monetary shocks. The number of lags in each VEC model is set to minimize the Akaike Information Criterion for a maximum of eight lags and white noise residuals. The Cholesky decomposition ordering is U.S. industrial production, U.S. CPI, U.S. federal funds rate, real exchange rate, CPI, industrial production, exports, imports, interest rate. Standard deviations are calculated via monte carlo simulation with 1,000 draws. A 48-month horizon is estimated. The signs indicate the pattern of the response: + for positive and - for negative.
Figure 2.1: Real Exchange Rate Volatility Conditional Variance

Philippines

Malaysia

Thailand

Brazil

Chile
Figure 2.2. Impulse Responses to U.S. Monetary Policy Shocks (Contractionary Policy) – Korea

Notes: The number of lags in each VEC model is set to minimize the Akaike Information Criterion for a maximum of eight lags and white noise residuals. The Cholesky decomposition ordering is U.S. industrial production, U.S. CPI, U.S. federal funds rate, real exchange rate, conditional variance (when it applies), variable of analysis (i.e. industrial production, exports, and so on for the small open economy). Standard deviations are calculated via monte carlo simulations with 1,000 draws. A 48-month horizon is estimated. For each estimated VEC model, we present the significant impulse responses corresponding to the real exchange rate and the variable of interest (i.e. industrial production, exports, imports, CPI, interest rate or money). That is, for instance, the real exchange rate and the industrial production graphs correspond to a different VEC model than the real exchange rate and exports graphs that appear next in the figure and so on.
Notes: The number of lags in each VEC model is set to minimize the Aikake Information Criterion for a maximum of eight lags and white noise residuals. The Cholesky decomposition ordering is U.S. industrial production, U.S. CPI, U.S. federal funds rate, real exchange rate, conditional variance (when it applies), variable of analysis (i.e. industrial production, exports, and so on for the small open economy). Standard deviations are calculated via monte carlo simulations with 1,000 draws. A 48-month horizon is estimated. For each estimated VEC model, we present the significant impulse responses corresponding to the real exchange rate and the variable of interest (i.e. industrial production, exports, imports, CPI, interest rate or money). That is, for instance, the real exchange rate and the industrial production graphs correspond to a different VEC model than the real exchange rate and exports graphs that appear next in the figure and so on.
Figure 2.5: Impulse Responses to U.S. Monetary Policy Shocks (Contractionary Policy) – Venezuela

Notes: The number of lags in each VEC model is set to minimize the Aikake Information Criterion for a maximum of eight lags and white noise residuals. The Cholesky decomposition ordering is U.S. industrial production, U.S. CPI, U.S. federal funds rate, real exchange rate, conditional variance (when it applies), variable of analysis (i.e. industrial production, exports, and so on for the small open economy). Standard deviations are calculated via monte carlo simulations with 1,000 draws. A 48-month horizon is estimated. For each estimated VEC model, we present the significant impulse responses corresponding to the real exchange rate and the variable of interest (i.e. industrial production, exports, imports, CPI, interest rate or money). That is, for instance, the real exchange rate and the industrial production graphs correspond to a different VEC model than the real exchange rate and exports graphs that appear next in the figure and so on.
Figure 2.6: Impulse Responses to U.S. Monetary Policy Shocks (Contractionary Policy) – Brazil

Notes: The number of lags in each VEC model is set to minimize the Aikake Information Criterion for a maximum of eight lags and white noise residuals. The Cholesky decomposition ordering is U.S. industrial production, U.S. CPI, U.S. federal funds rate, real exchange rate, conditional variance (when it applies), variable of analysis (i.e. industrial production, exports, and so on for the small open economy). Standard deviations are calculated via monte carlo simulations with 1,000 draws. A 48-month horizon is estimated. For each estimated VEC model, we present the significant impulse responses corresponding to the real exchange rate and the variable of interest (i.e. industrial production, exports, imports, CPI, interest rate or money). That is, for instance, the real exchange rate and the industrial production graphs correspond to a different VEC model than the real exchange rate and exports graphs that appear next in the figure and so on.
Figure 2.7: Impulse Responses to U.S. Monetary Policy Shocks (Contractionary Policy) – Chile

Notes: The number of lags in each VEC model is set to minimize the Aikaike Information Criterion for a maximum of eight lags and white noise residuals. The Cholesky decomposition ordering is U.S. industrial production, U.S. CPI, U.S. federal funds rate, real exchange rate, conditional variance (when it applies), variable of analysis (i.e. industrial production, exports, and so on for the small open economy). Standard deviations are calculated via monte carlo simulations with 1,000 draws. A 48-month horizon is estimated. For each estimated VEC model, we present the significant impulse responses corresponding to the real exchange rate and the variable of interest (i.e. industrial production, exports, imports, CPI, interest rate or money). That is, for instance, the real exchange rate and the industrial production graphs correspond to a different VEC model than the real exchange rate and exports graphs that appear next in the figure and so on.
Figure 2.8: Impulse Responses to U.S. Monetary Policy Shocks (Contractionary Policy) – Malaysia

Notes: The number of lags in each VEC model is set to minimize the Aikake Information Criterion for a maximum of eight lags and white noise residuals. The Cholesky decomposition ordering is U.S. industrial production, U.S. CPI, U.S. federal funds rate, real exchange rate, conditional variance (when it applies), variable of analysis (i.e. industrial production, exports, and so on for the small open economy). Standard deviations are calculated via monte carlo simulations with 1,000 draws. A 48-month horizon is estimated. For each estimated VEC model, we present the significant impulse responses corresponding to the real exchange rate and the variable of interest (i.e. industrial production, exports, imports, CPI, interest rate or money). That is, for instance, the real exchange rate and the industrial production graphs correspond to a different VEC model than the real exchange rate and exports graphs that appear next in the figure and so on.
Figure 2.9: Impulse Responses to U.S. Monetary Policy Shocks (Contractionary Policy) – The Philippines

Notes: The number of lags in each VEC model is set to minimize the Aikake Information Criterion for a maximum of eight lags and white noise residuals. The Cholesky decomposition ordering is U.S. industrial production, U.S. CPI, U.S. federal funds rate, real exchange rate, conditional variance (when it applies), variable of analysis (i.e. industrial production, exports, and so on for the small open economy). Standard deviations are calculated via monte carlo simulations with 1,000 draws. A 48-month horizon is estimated. For each estimated VEC model, we present the significant impulse responses corresponding to the real exchange rate and the variable of interest (i.e. industrial production, exports, imports, CPI, interest rate or money). That is, for instance, the real exchange rate and the industrial production graphs correspond to a different VEC model than the real exchange rate and exports graphs that appear next in the figure and so on.
Figure 2.10: Impulse Responses to U.S. Monetary Policy Shocks (Contractionary Policy) – Thailand

Notes: The number of lags in each VEC model is set to minimize the Aikake Information Criterion for a maximum of eight lags and white noise residuals. The Cholesky decomposition ordering is U.S. industrial production, U.S. CPI, U.S. federal funds rate, real exchange rate, conditional variance (when it applies), variable of analysis (i.e. industrial production, exports, and so on for the small open economy). Standard deviations are calculated via monte carlo simulations with 1,000 draws. A 48-month horizon is estimated. For each estimated VEC model, we present the significant impulse responses corresponding to the real exchange rate and the variable of interest (i.e. industrial production, exports, imports, CPI, interest rate or money). That is, for instance, the real exchange rate and the industrial production graphs correspond to a different VEC model than the real exchange rate and exports graphs that appear next in the figure and so on.
Figure 2.11: Impulse Responses to U.S. Monetary Policy Shocks (Contractionary Policy) – India

Notes: The number of lags in each VEC model is set to minimize the Akaike Information Criterion for a maximum of eight lags and white noise residuals. The Cholesky decomposition ordering is U.S. industrial production, U.S. CPI, U.S. federal funds rate, real exchange rate, conditional variance (when it applies), variable of analysis (i.e. industrial production, exports, and so on for the small open economy). Standard deviations are calculated via monte carlo simulations with 1,000 draws. A 48-month horizon is estimated. For each estimated VEC model, we present the significant impulse responses corresponding to the real exchange rate and the variable of interest (i.e. industrial production, exports, imports, CPI, interest rate or money). That is, for instance, the real exchange rate and the industrial production graphs correspond to a different VEC model than the real exchange rate and exports graphs that appear next in the figure and so on.
Figure 2.12: Impulse Responses to U.S. Monetary Policy Shocks (Contractionary Policy) – Argentina

Notes: The number of lags in each VEC model is set to minimize the Aikake Information Criterion for a maximum of eight lags and white noise residuals. The Cholesky decomposition ordering is U.S. industrial production, U.S. CPI, U.S. federal funds rate, real exchange rate, conditional variance (when it applies), variable of analysis (i.e. industrial production, exports, and so on for the small open economy). Standard deviations are calculated via monte carlo simulations with 1,000 draws. A 48-month horizon is estimated. For each estimated VEC model, we present the significant impulse responses corresponding to the real exchange rate and the variable of interest (i.e. industrial production, exports, imports, CPI, interest rate or money). That is, for instance, the real exchange rate and the industrial production graphs correspond to a different VEC model than the real exchange rate and exports graphs that appear next in the figure and so on.
Figure 2.13: Impulse Responses to U.S. Monetary Policy Shocks (Contractionary Policy) Including Leading Economy – Korea

Notes: The number of lags in each VEC model is set to minimize the Akaike Information Criterion for a maximum of six lags and white noise residuals. The Choleski decomposition ordering is U.S. industrial production, U.S. CPI, U.S. federal funds rate, leader real exchange rate, leader CPI, leader industrial production, leader interest rate, real exchange rate for the small economy (with respect to U.S.), variable of analysis (i.e. industrial production, exports, and so on for the small open economy). Standard deviations are calculated via monte carlo simulations with 1,000 draws. A 48-month horizon is estimated. For each estimated VEC model, we present the significant impulse responses corresponding to the real exchange rate and the variable of interest (i.e. industrial production, exports, imports, CPI, interest rate or money). That is, for instance, the real exchange rate and the industrial production graphs correspond to a different VEC model than the real exchange rate and exports graphs that appear next in the figure and so on.
Figure 2.14: Impulse Responses to Japanese Monetary Policy Shocks (Contractionary Policy) Including Leading Economy – Korea

Notes: The number of lags in each VEC model is set to minimize the Akaike Information Criterion for a maximum of six lags and white noise residuals. The Choleski decomposition ordering is U.S. industrial production, U.S. CPI, U.S. federal funds rate, leader real exchange rate, leader CPI, leader industrial production, leader interest rate, real exchange rate for the small economy (with respect to U.S.), variable of analysis (i.e. industrial production, exports, and so on for the small open economy). Standard deviations are calculated via monte carlo simulations with 1,000 draws. A 48-month horizon is estimated. For each estimated VEC model, we present the significant impulse responses corresponding to the real exchange rate and the variable of interest (i.e. industrial production, exports, imports, CPI, interest rate or money). That is, for instance, the real exchange rate and the industrial production graphs correspond to a different VEC model than the real exchange rate and exports graphs that appear next in the figure and so on.
Figure 2.15: Impulse Responses to U.S. Monetary Policy Shocks (Contractionary Policy) Including Leading Economy – Malaysia

Notes: The number of lags in each VEC model is set to minimize the Aikaike Information Criterion for a maximum of six lags and white noise residuals. The Choleski decomposition ordering is U.S.industrial production, U.S. CPI, U.S. federal funds rate, leader real exchange rate, leader CPI, leader industrial production, leader interest rate, real exchange rate for the small economy (with respect to U.S.), variable of analysis (i.e. industrial production, exports, and so on for the small open economy). Standard deviations are calculated via monte carlo simulations with 1,000 draws. A 48-month horizon is estimated. For each estimated VEC model, we present the significant impulse responses corresponding to the real exchange rate and the variable of interest (i.e. industrial production, exports, imports, CPI, interest rate or money). That is, for instance, the real exchange rate and the industrial production graphs correspond to a different VEC model than the real exchange rate and exports graphs that appear next in the figure and so on.
Figure 2.16: Impulse Responses to Japanese Monetary Policy Shocks (Contractionary Policy) Including Leading Economy - Malaysia

Notes: The number of lags in each VEC model is set to minimize the Aikaike Information Criterion for a maximum of six lags and white noise residuals. The Choleski decomposition ordering is U.S. industrial production, U.S. CPI, U.S. federal funds rate, leader real exchange rate, leader CPI, leader industrial production, leader interest rate, real exchange rate for the small economy (with respect to U.S.), variable of analysis (i.e. industrial production, exports, and so on for the small open economy). Standard deviations are calculated via monte carlo simulations with 1,000 draws. A 48-month horizon is estimated. For each estimated VEC model, we present the significant impulse responses corresponding to the real exchange rate and the variable of interest (i.e. industrial production, exports, imports, CPI, interest rate or money). That is, for instance, the real exchange rate and the industrial production graphs correspond to a different VEC model than the real exchange rate and exports graphs that appear next in the figure and so on.
Figure 2.17: Impulse Responses to U.S. Monetary Policy Shocks (Contractionary Policy) Including Leading Economy – The Philippines

Notes: The number of lags in each VEC model is set to minimize the Aikaike Information Criterion for a maximum of six lags and white noise residuals. The Choleski decomposition ordering is U.S. industrial production, U.S. CPI, U.S. federal funds rate, leader real exchange rate, leader CPI, leader industrial production, leader interest rate, real exchange rate for the small economy (with respect to U.S.), variable of analysis (i.e. industrial production, exports, and so on for the small open economy). Standard deviations are calculated via monte carlo simulations with 1,000 draws. A 48-month horizon is estimated. For each estimated VEC model, we present the significant impulse responses corresponding to the real exchange rate and the variable of interest (i.e. industrial production, exports, imports, CPI, interest rate or money). That is, for instance, the real exchange rate and the industrial production graphs correspond to a different VEC model than the real exchange rate and exports graphs that appear next in the figure and so on.
Figure 2.18: Impulse Responses to Japanese Monetary Policy Shocks (Contractionary Policy) Including Leading Economy – The Philippines

Notes: The number of lags in each VEC model is set to minimize the Aikake Information Criterion for a maximum of six lags and white noise residuals. The Choleski decomposition ordering is U.S. industrial production, U.S. CPI, U.S. federal funds rate, leader real exchange rate, leader CPI, leader industrial production, leader interest rate, real exchange rate for the small economy (with respect to U.S.), variable of analysis (i.e. industrial production, exports, and so on for the small open economy). Standard deviations are calculated via monte carlo simulations with 1,000 draws. A 48-month horizon is estimated. For each estimated VEC model, we present the significant impulse responses corresponding to the real exchange rate and the variable of interest (i.e. industrial production, exports, imports, CPI, interest rate or money). That is, for instance, the real exchange rate and the industrial production graphs correspond to a different VEC model than the real exchange rate and exports graphs that appear next in the figure and so on.
Figure 2.19: Impulse Responses to U.S. Monetary Policy Shocks (Contractionary Policy) Including Leading Economy – Thailand

Notes: The number of lags in each VEC model is set to minimize the Aikaike Information Criterion for a maximum of six lags and white noise residuals. The Choleski decomposition ordering is U.S. industrial production, U.S. CPI, U.S. federal funds rate, leader real exchange rate, leader CPI, leader industrial production, leader interest rate, real exchange rate for the small economy (with respect to U.S.), variable of analysis (i.e. industrial production, exports, and so on for the small open economy). Standard deviations are calculated via monte carlo simulations with 1,000 draws. A 48-month horizon is estimated. For each estimated VEC model, we present the significant impulse responses corresponding to the real exchange rate and the variable of interest (i.e. industrial production, exports, imports, CPI, interest rate or money). That is, for instance, the real exchange rate and the industrial production graphs correspond to a different VEC model than the real exchange rate and exports graphs that appear next in the figure and so on.
Figure 2.20: Impulse Responses to Japanese Monetary Policy Shocks (Contractionary Policy) Including Leading Economy – Thailand

Real Exchange Rate

Industrial Production

Exports

CPI

Notes: The number of lags in each VEC model is set to minimize the Akaike Information Criterion for a maximum of six lags and white noise residuals. The Choleski decomposition ordering is U.S. industrial production, U.S. CPI, U.S. federal funds rate, leader real exchange rate, leader CPI, leader industrial production, leader interest rate, real exchange rate for the small economy (with respect to U.S.), variable of analysis (i.e. industrial production, exports, and so on for the small open economy). Standard deviations are calculated via monte carlo simulations with 1,000 draws. A 48-month horizon is estimated. For each estimated VEC model, we present the significant impulse responses corresponding to the real exchange rate and the variable of interest (i.e. industrial production, exports, imports, CPI, interest rate or money). That is, for instance, the real exchange rate and the industrial production graphs correspond to a different VEC model than the real exchange rate and exports graphs that appear next in the figure and so on.
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3.1 INTRODUCTION

The reaction of the stock market to monetary policy is a topic of deep interest not only to market participants and policymakers, but to society as a whole. Stock prices are among the most closely watched asset prices in an economy and are viewed as being highly sensitive to economic conditions. Deviations from fundamentals in stock prices lead to concerns about possible "bubbles" that may have adverse implications for the economy. As a consequence, to understand more precisely how monetary policy and the stock market are related is of great interest.

From the monetary policy point of view, since the final goal of monetary policy, promoting the health of the economy, is only possible to reach through indirect channels, the effects of monetary actions are reflected more immediately and directly in the financial markets. The stock market is one of these financial markets. As Bernanke notes, “If all goes as planned, the changes in financial asset prices and returns induced by the actions of monetary policymakers lead to the changes in economic behavior that the policy was trying to achieve.” (Bernanke’ remarks, 2003) Therefore, understanding the effects of the monetary policy actions is crucial to reaching the final goals of the monetary authorities.

It is very important for policy makers to understand how their actions affect stock market behavior and to see if the actual response corresponds to their original purposes. It is necessary to investigate what does not work as planned and what can be done to address the existing problems.
From an investor point of view, it is crucial to know variables that have an influence on stock market behavior in order to take better decisions on risk management and international portfolio diversification. Domestic investors need to know how monetary actions may affect the stock market. Foreign investors are even more interested in this impact. They have to make decisions on buying or selling stocks in foreign countries where they may have limited information.

Most of the research on the impact of monetary policy has been done for the U.S. economy. In this chapter we take a different focus. We analyze emerging economies and take the analysis one step further and investigate not only the impact of domestic monetary actions on the stock market of a particular economy, but also the impact of foreign monetary actions on that stock market. To the best of our knowledge, there are no previous studies on this topic.

Therefore, our contributions to the literature are in two areas. First, we investigate the impact of domestic monetary policy actions on the stock market returns of a specific emerging economy. Second, we investigate the impact of U.S. monetary actions on the stock market returns in emerging countries. That is, the international transmission of U.S. monetary policy shocks. We work with a group of thirteen economies, seven in Latin America and six in Asia¹, for a monthly period that starts in January 1976 and ends in November 2003.

This chapter has two main findings. First, there is, in general, a significant impact of domestic monetary shocks on stock market returns in emerging economies. Second, there is evidence of significant impact of U.S. monetary policy shocks on stock market returns in emerging economies. In both cases, contractionary monetary policy, expressed as increases in interest rates, decrease stock market returns.

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¹ These countries are Korea, Malaysia, the Philippines, Indonesia, India, Thailand, Mexico, Chile, Peru, Brazil, Venezuela, Argentina, and Colombia.
3.2. RELATED LITERATURE

The purpose of this section is to review recent findings in the empirical estimation of the relationship between monetary policy and the stock market. Most of the research in this area has been done for the U.S. economy, so a review of the literature on this topic necessarily involves talking about findings for the United States.

There is a debate whether there is significant impact of U.S. monetary actions on the stock market. Goto and Valkanov (2002) find that between 20 and 25 percent of the negative covariance between excess returns\(^2\) and inflation is explained by shocks to monetary policy variables during the 1966-2000 period. They argue that contractionary monetary policy lowers excess stock market returns, and note that asset-pricing models used to capture the observed negative correlation must incorporate monetary policy effects. Chordia and Sarkar (2001) suggest monetary conditions as one of the sources of common liquidity factor in stock markets. These authors believe that monetary expansion enhances stock market liquidity during crises.

Some authors argue that there is an endogenous response of financial markets to monetary policy shocks at the same time that policy may be reacting to stock market. The argument is that estimating the response of asset prices to changes in monetary policy is complicated by the endogeneity of policy decisions and the fact that both interest rates and asset prices react to numerous other variables. Rigobon and Sack (2003, 2002) state that, in the context of the U.S. economy, it would be difficult to understand any variable for stock prices that would affect the stock market without affecting the path of interest rates. They find that an increase in short-term interest rates results in a decline in stock prices.

Significant response of stock market prices to monetary policy changes has been found by several authors. D’Amico and Farka (2002) use changes in federal funds futures rates on the days of federal open market committee (FOMC) announcements to measure the impact of policy

\(^2\) Excess returns are the difference between current and last period stock returns.
changes on the S&P 500. They examine data around the announcement time for the period 1974-
2001. They find stock returns respond negatively and significantly to a positive monetary policy
shock. Similarly, Bernanke and Kuttner (2003) find that most of the response of the current
excess return on equities can be traced to policy’s impact on expected future excess return. Other
authors however, cast doubts about the significant response of stock market to monetary policy
(Lapp, Pearce, and Laksanasut, 2003).

Another discussion exists about which interest rate should be used as the monetary
variable. The most common interest rates are the federal funds rates (Kuttner and Krueger, 1996;
Bartolini, Bertola and Prati, 2002; Faust, Swanson, and Wright, 2002a); federal funds futures
rates (Kuttner, 2001; Bernanke and Kuttner, 2003), Eurodollar deposit rates (Cochrane and
Piazzesi, 2002) and Eurodollar futures rates (Sack, 2002).

Finally, whether the Federal Reserve should care about stock market fluctuations has
been an open controversy. Mishkin and White (2002) examine fifteen historical episodes of stock
market crashes and their aftermath and conclude that financial instability, not stock market
crashes, are the key problem that monetary authorities must focus on. On the opposite side, Bordo
and Jeanne (2002) argue that under certain circumstances, monetary policy should be used in a
proactive way to “diffuse asset price boom to prevent a credit crunch.” (p. 19)

For other countries, Durham (2001), in one of the few studies in this topic that uses cross
section data, uses the discount rate as the main policy indicator. He finds what seems to be a
robust relationship between monetary policy and stock price returns for 16 countries using panel
data from 1956 to 2000. However, he also finds that the relation has grown weaker over time.
Alternative measures of central bank policy suggest a weaker and a diminished correlation
between monetary policy changes and long-run stock market performance.

Ehrmann, Fratzscher, and Rigobon (2005) analyze stock market movements within and
between the United States and the euro area. They find that, in the United States, stock markets
are much more strongly affected by changes in short-term interest rates, which is interpreted as
expectations of monetary policy, than this is the case in the euro area. By contrast, euro area short rates and equity markets are relatively more affected by bond yields and exchange rates as compared to U.S. markets.

On the international transmission aspect, Stevenson (2002) analyzes the impact of German interest rate changes on seven other European countries. Stevenson concludes that cross-border transmission exists because non-German bank stocks and general equities significantly react to changes on the Budesbank rate. There is a major impact on countries committed to the exchange rate mechanism and a monetary union goal. Cassola and Morana (2002) support the view that stock market prices may be important for monetary policy because stock prices in Europe seem to play an important role on the transmission mechanism in the euro area and there is no significant impact of stock prices on inflation.

Whether there is an impact of monetary policy on the stock market is an open question. There is not yet conclusive evidence for the impact of monetary policy on the stock market. Our study sheds light on this area with the analysis of emerging economies. We examine the domestic impact of monetary policy actions on domestic stock markets and the international transmission of U.S. monetary shocks to foreign stock markets. Because our interest is to study the impact of monetary policy on stock market, we do not analyze in this chapter the potential impact of stock market on monetary policy decisions.

3.3. EMPIRICAL CONSIDERATIONS

3.3.1 Data

We use monthly data that starts as early as 1976:1 and ends at 2003:2 for the United States and thirteen countries. These countries are Korea, Malaysia, the Philippines, Indonesia, India, Thailand, Mexico, Chile, Peru, Brazil, Venezuela, Argentina, and Colombia. A country’s inclusion in the sample depends purely in data availability. The beginning of the estimation

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period is as follows: Brazil, India and Mexico at 1976:1; Chile at 1977:1; Argentina at 1978:1; Korea at 1980:1; Indonesia at 1984:1; Colombia, Malaysia, The Philippines and Venezuela at 1985:1; Thailand at 1987:1; and, Peru at 1993:1. The period ends at 2003:2 with the exception of Indonesia whose period finish at 2003:11.

The U.S. monetary policy instrument is the federal funds rate. We consider the interest rate as the main monetary policy variable because it is the variable targeted and consider by monetary authorities in most of central banks. Our stock market variable is the Total Return Index provided by Compustat, this index includes price and dividend changes. In this chapter we use the term stock market returns to refer to this index, not to first log difference of the index.

The variables considered for the U.S. economy are industrial production, the consumer price index, and the federal funds rate. For the thirteen countries, the variables included are industrial production, the consumer price index (CPI), a nominal interest rate, the real exchange rate, and stock market returns. All the variables, except interest rate, are in logs and in real terms. All variables are not seasonally adjusted. The data is obtained from the International Financial

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3 Bernanke and Blinder (1992) argue that the federal funds rate is the most appropriate variable to reflect U.S. monetary policy actions.

4 Interest rates are: the Colombian, Korean, Peruvian, and Venezuelan discount rate; the Brazilian overnight rate; the Indian call money rate; the Malaysian money market rate (federal funds); the Argentinean deposit rate; the Philippino treasury bill rate; the Chilean lending rate; the Indonesian three-month deposit rate; and, the Mexican average cost of funds.

5 Looking through the web pages of the central banks of the countries considered in our study, confirms that they target and closely watch interest rates. For instance, for Argentina, in its central bank webpage, Redrado describes that “Transmission takes place from interest rates ... to the rest of the economy rates, especially the time deposit rates offered by financial institutions.” (p.2) and that, “The objective of a central bank in controlling the short-term interest rate consists in affecting the economy's real interest rate through the different monetary policy transmission channels.” (p. 4). For Brazil, in its web page, the Brazilian central bank explains that “The interest rate target set by the COPOM is the target for the SELIC interest rate, the interest rate for overnight interbank loans collateralized by government bonds registered with and traded on the Sistema Especial de Liquidação e Custodia.” In the case of Colombia, its central bank webpage explains that “The Banco de la República implements monetary policy by changing interest rates, which either provide or withdraw liquidity from the economy.” Similar explanations can be found in the case of Asian countries. For example, in its web page, the Thai central bank affirms that “The Bank of Thailand Act was enacted in 1942 .... The Act specified the mandate for the Bank of Thailand to do the business of central banking, ... it gave power to the Court of Directors to set the Bank Rate which was the interest rate under the Bank's lender-of-last-resort facility.” Also, the Philippino central bank explains that “The BSP’s primary monetary policy instruments are its overnight reverse repurchase (borrowing) rate and overnight repurchase (lending) rate.”

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Statistics CD-ROM, Datastream and Compustat. We control for seasonality by including seasonal dummies in each VEC model.

For all estimation, we consider the real exchange rate instead of the nominal exchange rate. Moreover, we consider a control variable for the exchange-rate regime; we know that the choice of exchange rate regime influences the way in which foreign monetary actions affect the small open economy. Levy-Yeyati and Sturzenegger (2005) constructed a de facto classification of exchange rates based on changes in the nominal exchange rate, the volatility of these changes, and the volatility of international reserves. The de facto measures provide an alternative to the recognized inconsistencies between reported and actual policies. We use this classification for the exchange rate regime. Specifically, we use dummy variables for de facto fixed and managed exchange rate regimes. Table 3.1 presents details about the de facto exchange rate regime for the countries analyzed.6

3.3.2 Methodology

A very important aspect in the analysis of the impact of monetary policy on the stock market is the nature of the changes. According to the rational expectations theory, only unanticipated monetary policy actions will have an impact on the economic activity. In our case, unanticipated monetary policy shocks may have and impact on stock market returns.

For the U.S. economy, one option to decompose changes of the monetary policy variable, the interest rate, has been using data on federal funds futures. Kuttner (2001), and Bernanke and Kuttner (2003) use changes in federal funds futures on the days of FOMC meetings as a proxy for monetary policy shocks. This measure is based on a monthly average of the relevant month’s effective funds rate. However, because the availability of information in the U.S. case is much broader than what can be found for emerging economies, other measures must be used.

6 Data from Levy-Yeyati and Sturzenegger stops at 2000, but we follow their criteria for 2001–2003.
In this chapter we use vector auto regressive (VAR) models. Several authors use this method to investigate the relationship between monetary policy and the stock market. Faust, Swanson, and Wright (2002a) use a VAR approach and achieve identification of policy changes by exploiting additional information from the federal funds rate futures market. Their method measures the impulse response of the federal funds rate to the policy shock using federal funds future data. Their method also identifies a structural VAR model by imposing the restriction that the impulse response of the funds rate to the policy shock in the VAR matches the one measured from futures data. In successive work (Faust, Swanson, and Wright, 2002b), the authors apply this method to identify contemporaneous relations between interest rates, monetary policy rates and exchange rates.

Rigobon and Sack (2003) use a structural VAR that attempts to measure the reaction of monetary policy to an exogenous movement in stock prices controlling for the influence of macroeconomic shocks. Bernanke and Kuttner (2003) also use a VAR to calculate revisions in expectations of future interest rates.

A very important issue that a researcher using the VAR methodology must deal with is how to identify relationships in the model. Various methods have been devised for identifying VAR models. One method is the Choleski decomposition, which achieves identification by imposing contemporaneous restrictions on some of the parameters in the original system. In this chapter, identification is achieved by Choleski decomposition of the reduced-form residuals. Some authors, such as Christiano, Eichenbaum and Evans (1999) and Kim (2001), make use of the Cholesky decomposition, which assumes that the contemporaneous system is recursive. This allows identification.

Another advantage of using VAR is that VAR models allow estimation the impact of unexpected changes. According to the rational expectations theory, unexpected changes in one variable are the ones that will have significant impact on other variables. “Any monetary policy

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7 For a detailed explanation of VAR models see Chapter 5 in Enders (2004).
variable can be decomposed into a systematic and an unsystematic component. The systematic component of the variable can be estimated in a VAR. This VAR equation of the policy variable can be thought of as reflecting a central bank reaction function and any other endogenous non-policy influences on the variable. What is left over, the (orthogonalized) residuals of this equation, can be thought of as monetary policy shocks – the unsystematic component of monetary policy. The recent literature on the effects of monetary policy focuses on policy shocks, that is, the orthogonalized residuals or innovations.” (Armour, Engert and Fung, 1996, p. 13)

Estimation in a VAR model includes determining the appropriate lag length. One of the commonly used criteria is the Aikaike information criterion (AIC). This is not a test statistic, but rather a diagnostic tool, and it goes from a larger length to a smaller one to avoid misspecification problems. A very important tool for analysis extracted from a VAR is the impulse response functions (IRFs), which trace the effects of a shock to an endogenous variable on the variables in the VAR.

When the variables have unit roots and are cointegrated, a VAR model is no longer optimal. Instead, it is appropriated to estimate a vector of error correction model (VEC). A VEC model is a restricted VAR that has cointegration restrictions built into the specification, so that it is designed for use with nonstationary series that are cointegrated. To test for the presence of cointegration, a commonly used procedure is that of Johansen (1991,1995). Johansen’s test is usually employed where several variables are tested for cointegration.

In the present chapter, we work with VEC models and use the corresponding impulse response functions with two-standard-deviation confidence intervals. The VEC length is determined using the AIC for a maximum of eight lags. Each country’s VEC model contains eight variables. These variables are: U.S. industrial production, the U.S. CPI, the U.S. federal funds rate, the real exchange rate, the CPI, industrial production, interest rate and stock market.

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8 A detailed explanation of cointegration is in Chapter 19 of Hamilton (1994).
returns of the emerging economy under examination. These variables are included in our model because changes in these variables presumably reflect changes in macroeconomic conditions and they will probably affect stock markets.

3.4 EMPIRICAL RESULTS

3.4.1 Unit Roots, Cointegration, and the Stock Market

Ignoring the presence of unit roots in a conventional linear regression can lead to serious errors in inferences. We use the augmented Dickey-Fuller (1979) test with MacKinnon (1991) critical values to test the presence of unit roots in the variables. The null hypothesis of a unit root is rejected against the one-sided alternative if the t-statistic is less than (lies to the left of) the critical value.

Almost all the variables included in our estimation have one unit root, as Table 3.2 shows. However, it appears that the U.S. CPI has two unit roots. To confirm this we performed a test of structural change as in Perron (1989) and Enders (2004). Perron (1989) establishes that when there is a structural break, Dickey-Fuller and Phillips-Perron test statistics are biased toward acceptance of a unit root, even when the series can be stationary in sub periods. The idea is "to test whether $Z_t$ is an integrated process or not, i.e., to test whether the shocks $\{e_t\}$ have persistent effects that do not vanish over a long horizon" (Perron, 1989, p.1387). After performing the test, we conclude that there is a structural break in the U.S. CPI after 1982. After controlling for the structural break, the series exhibits only one unit root.

Another consideration is cointegration. The presence of cointegration can create problems in the estimation when there is no error correction term in the original model. In this study, the variables are integrated of order one. After testing for cointegration with the Johansen

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10 $Z_t$ is a variable that is being tested for unit root presence.
test for a maximum of eight lags, cointegration is found for each country's model as it is summarized in Table 3.3. Therefore, we need to use VEC models.

Figure 3.1 presents the stock market returns for all the fourteen countries in the sample. At first it is possible to observe the strong fluctuations that stock markets have faced. In particular, for Asian economies the crisis around 1997 and its aftermath produced a strong decline in the stock market as it can be observed for Indonesia, Korea, Malaysia and Thailand. For Latin American countries, strong fluctuations in stock markets are present during two periods, the debt crisis around 1984 that impacted especially Argentina, Chile, and Mexico; and the crisis of 1994 that seemed to be affected Brazil, Mexico, Peru and Venezuela. We control for these periods of crisis using dummy variables, which are 0 before the crisis starts, and 1 thereafter.

3.4.2 Evidence from Vector Error Correction Analysis: Effect of Domestic and U.S. Monetary Policy Actions

The variables in the VEC model for each country follow the ordering: U.S. industrial production, U.S. CPI, U.S. federal funds rate, the real exchange rate, consumer price index (CPI), industrial production, the nominal interest rate, and stock market returns of an emerging economy.

The model also contains dummy variables for the exchange rate regime, financial crisis and seasonality. These variables are exogenous. A VEC model is estimated for each country in the sample. The number of lags in each VEC model is set to minimize the Aikaike Information Criterion for a maximum of eight lags and white noise residuals.

The ordering of the variables used in the Choleski decomposition may have an impact on the results from impulse responses. "The key point is that the decomposition forces a potentially

11 Because of space limitations, we do not include detailed cointegration results, but they are available upon request.
12 The beginning point for these dummy variables are as follow: Chile and Mexico at 1982; Argentina at 1985; Brazil and Venezuela at 1994; Thailand at 1997; and, Indonesia, Korea, Malaysia, and Peru at 1998.
important asymmetry on the system” (Enders, 2004, p. 275). This happens because, for instance, in a two-variable model, shocks from the variable that is put first in the ordering contemporaneously affect both variables, while shocks from the second variable will not contemporaneously affect the first one. “Unfortunately . . . identification necessitates imposing some structure on the system. The Choleski decomposition provides a minimal set of assumptions that can be used to identify the structural model” (Enders, 2004, p.276).

Changing the order may alter results, but the researcher must decide on the ordering using any “theoretical reason to suppose that one variable has no contemporaneous effect on the other” (Enders, 2004, p.275). In our case, we order U.S. variables first because, presumably, they may have an impact on the small (emerging) economy variables. But contemporaneous changes in emerging-economy variables will not have a contemporaneous impact on U.S. variables. It would be hard to argue that a small economy may have an impact on U.S. variables, so the order seems the most appropriate. With respect to the ordering of domestic variables, we assume that changes in macroeconomic variables contemporaneously affect stock market returns, but changes in stock market returns do not contemporaneously affect these variables. This ordering corresponds with our idea of measuring how the stock market is being affected by domestic monetary policy, and we also include other macroeconomic variables that presumably may also have an influence on stock market returns.

IRFs with forecast horizons of 48 periods (four years) are constructed, and 1,000 Monte Carlo simulations are used to derive the two standard deviation confidence bands. A response is considered significant when the confidence bands do not contain zero. Innovations are to U.S. federal funds rate for U.S. monetary policy, while innovations to the domestic interest rate are used as a measure for domestic monetary policy. Because of space limitation, only significant responses will be presented.

The expected effect from positive shocks to the domestic interest rate, or contractionary shocks, is that equity prices will decline. A decline in equity prices may have strong effects in
two areas. First, they may affect spending because the change in the ratio of debt-to-assets will prevent households and firms from meeting their repayment obligations. Second, it may also increase fears about the ability to repay debts in the future because the decline in stock prices reduces the value of liquid assets available to repay loans. (Kamin, Turner and Van't dack, 1998).

On the opposite case, with “an easier monetary policy stance, equity prices may rise, increasing the market price of firms relative to the replacement cost of their capital. This will lower the effective cost of capital, as newly issued equity can command a higher price relative to the cost of real plant and equipment. Hence, even if bank loan rates react little to the policy easing, monetary policy can still affect the cost of capital and hence investment spending. Policy-induced changes in asset prices may also affect demand by altering the net worth of households and enterprises. Such changes may trigger a revision in income expectations and cause households to adjust consumption.” (Kamin, Turner and Van’t dack, 1998. p.11)

Figure 3.2 presents the significant impulse responses of stock market of emerging economies to domestic monetary shocks. For a group of thirteen emerging economies, domestic monetary policy shocks cause significant impacts on the stock market returns of nine countries. Five of these countries are in Asia and four in Latin America. These countries are Brazil, Colombia, India, Indonesia, Korea, Malaysia, Mexico, Peru, and Thailand.

In seven of these nine economies, a contractionary monetary policy decreases stock market returns, which is consistent with empirical studies for developed economies including the U.S. economy. The results are also consistent with the theoretical notion that contractionary (expansionary) monetary policy leads to lower (higher) stock prices because changes in monetary policy influence forecasts of market-determined interest rates, the equity cost of capital, and expectations of corporate profitability (Waud, 1970; Durham, 2003). The results are evidence that monetary policy actions are relevant for stock markets in emerging economies and therefore, they need to be considered by investors, monetary authorities and other economic agents when decisions are taken.
What can explain the significant response of these economies to domestic monetary shocks? Perhaps the main reason is the increasing importance of the stock market for these economies and the efforts of monetary authorities to control excessive fluctuations. Although emerging stock markets share about 12% of the global stock market capitalization and value traded, they have over 50% of number of listed companies. In addition, the size of the market measured by the ratio of the market capitalization to GDP, show some emerging markets are larger than the developed markets (Green, Murinde, and Ngugi, 2000).

It is precisely this increasing importance that may signal opportunities to raise capital through stock markets and the possibility to diversify risk (Bonser-Neal and Dewenter, 1999). There is also evidence that stock markets in emerging economies are more liquid than they are in developed economies (Green, Murinde, and Ngugi, 2000), so that could explain the impact in response to changing conditions in the economy, in particular monetary policy actions.

In addition, monetary authorities, especially in Asia, seem to care about controlling excessive fluctuations in stock markets. For Indonesian monetary authorities, control of capital inflows and stock markets fluctuations has become a major monetary policy concern because of high capital mobility with large inflows of short-term capital seeking speculative gains (Iljas, 1998). Equal concern is shared by Thailand, where monetary authorities believed inflows in the equity markets represented a key driving force for continual economic expansion, but also a source of speculation that can exacerbate fluctuations (Siamwalla, Vajragupta, and Vichyanond, 1999). Similarly, the Malaysian Central Bank has designed monetary policy with the goal of controlling domestic interest rates, the volatile short-term capital flows, and the excessive volatility of the ringgit. (Cheong, 2005) For Malaysia, monetary uncertainty has significant long-run dynamics with the uncertainty in stock prices (Yakov, 2001).

In India, following the adoption of structural reforms and external liberalisation in the early 1990s, the Indian economy experienced surges of capital inflows and although they eased the external financing constraint, they also posed dilemmas for the conduct of monetary policy.
“Monetary policy action was needed to ensure that the pursuit of the final target of growth with price stability was not endangered.” (Mohan, 2005, p. 165) Indian monetary authorities have implemented actions to ensure that excessive fluctuations on the stock market can be neutralized Mohan (2005).

Lim (2003) shows that asset prices and inflation in Korea are closely related. Therefore, monetary actions oriented to control inflationary pressures are also going to affect asset prices.

For the case of Latin American countries whose stock markets respond significantly to domestic monetary actions, our results are consistent with studies by Lopes (1998) for Brazil and Kamin, Turner and Van’t dack (1998) for Colombia. Lopes (1998) argues that in Brazil, “A lower real rate of interest implies a higher present value of existing durable (capital and consumption) goods and an increase in the ratio between the prices of existing stocks.” (p. 66) In Colombia, Kamin, Turner and Van’t dack (1998) find a positive response of asset prices to monetary policy easing (which corresponds to expansionary monetary policy).

However, there are two Latin American countries where there is a significant response of stock market to domestic monetary shocks, but the sign is not as expected. These countries are Mexico and Peru, where after a contractionary monetary policy shock, stock market returns increase.

The results for those two countries are a puzzle, especially considering that they share some common experiences with the other countries in the sample whose responses have the expected sign. Mexico had, as the Asian economies in our sample, a large flow of international capital flows. Sidaoui (2005) explains that the Bank of Mexico has been actively using open market operations to prevent additional uncertainty in the financial markets. In Peru, Velarde (2005) and Choy (2002) argue that institutional investors (banks and pension funds) are the most active participants in the stock market in Peru. More research is needed to explain these results.

Figures 3.3 presents the significant impulse responses of stock market of emerging economies to U.S. monetary policy shocks. There is evidence of international transmission of
U.S. monetary shocks to the stock market in emerging economies. U.S. monetary policy shocks affect the stock market returns in five emerging economies in our sample, two in Asia (the Philippines and Thailand) and three in Latin America (Chile, Colombia, and Venezuela).

It can be observed that increases in U.S. federal funds rate, which correspond to contractionary monetary policy, decrease stock market returns in emerging economies. Only in Chile, U.S. contractionary monetary shocks seem to have a positive effect on its stock market.

What can explain the significant effect of U.S. monetary shocks on those stock markets? The factor behind the significant response of emerging stock markets to U.S. monetary shocks may be the increasing capital inflows these economies have received in their equity markets. Uribe (2005) explains that in the 1990s, Colombian reforms to open access to foreign funds helped to greatly increase capital inflows. Foreign participation in stock markets is equally important in the Philippines, which experienced a surge of inflows in the 1990s because of the financial liberalization (Tetangco, 2005). Similarly, in Thailand, according to Siamwalla, Vajragupta, and Vichyanond (1999), in the late 1980s and early 1990s, “relatively low yields in industrial countries together with impressive economic growth and attractive returns in developing economies motivated western investors to relocate their funds to money and capital markets in the east.” (p. 1)

But what can explain the negative reaction of stock markets in emerging economies to U.S. contractionary monetary policy? Contractionary monetary policy in the U.S. economy will decrease U.S. stock market returns. Why would that also decrease stock market returns in emerging economies?

We offer two complementary explanations for that reaction. First, funds to invest in emerging economies may mostly come from excess funds from developed economies, either excess funds from productive sectors or excess funds from household savings. In both cases, a U.S. contractionary monetary policy causes increases in interest rates, which deteriorates economic conditions inside these developed economies, and then reduces the ability to raise
funds, decreases the demand for stocks in emerging countries and therefore decreases stock prices and stock market returns. Kim (2001) has shown that U.S. monetary shocks affect the U.S. economy and the G-7 economies in the same way. That is, contractionary monetary policy will deter economic conditions in the U.S. and in the G-7 economies, which we may suspect are the biggest sources of capital inflows to stock markets in emerging economies.

Second, with lower excess funds available, but raising interest rates in their home countries, foreign investors have less incentive to buy stocks in emerging economies because they could invest in other short-term financial securities in their own countries and obtain higher returns without facing the higher risk of investing overseas.

Because of the evidence about international transmission, investors, monetary authorities and other economic agents need to consider that not only does domestic monetary policy have an impact on the stock market returns, but also U.S. monetary policy influences the stock market.

For checking the robustness of the results, two alternatives estimations were performed for each country. The first is a change in the ordering. The original ordering is: U.S. industrial production, U.S. CPI, U.S. federal funds rate, the real exchange rate, consumer price index (CPI), industrial production, the nominal interest rate, and stock market returns of an emerging economy. The alternative ordering is U.S. industrial production, U.S. CPI, U.S. federal funds rate, industrial production, consumer price index (CPI), the nominal interest rate, the real exchange rate, and stock market returns of an emerging economy. That means that now, industrial production precedes the real exchange rate and CPI, while the real exchange rate is placed almost at the end of the ordering. According to the new ordering, industrial production contemporaneously impact the real exchange rate and CPI while those two variables do not contemporaneously impact industrial production. This new ordering corresponds to the idea that changes in industrial production (a measure of output) may contemporaneously impact other macroeconomic variables, while changes in those variables do not contemporaneously impact
output. The results that appear in Figures 3.4 and 3.5 show that there are consistent with the original ordering, that is, the same countries that in Figures 3.2 and 3.3 exhibit significant responses to monetary shocks, show significant responses under the new ordering and also with the same sign in their response. With this new ordering, stock returns in one additional country appear to significantly respond to domestic monetary changes (Chile) while stock market returns in four more show significant response to U.S. monetary shocks (Brazil, Korea, Malaysia, and Peru).

The second alternative model tested was to replace U.S. industrial production and U.S. CPI by U.S. stock market index under the presumption that changes in U.S. macroeconomic conditions will be incorporated in U.S. stock markets and that that variable may impact emerging stock markets. The results are shown in Figures 3.6 and 3.7. In general, the results are consistent with our original estimation. In the case of domestic monetary policy, two additional countries significantly respond to domestic monetary shocks (Argentina and Chile), while only three countries (Colombia, Korea, and the Philippines) instead of five significantly respond to U.S. monetary shocks.

From the analysis in this section, there is strong evidence of the significant impact of domestic monetary policy on stock markets in emerging economies. There is also evidence of the impact of U.S. monetary policy in five emerging economies of the thirteen considered in this study. Therefore, in light of the results, it is possible to affirm that monetary actions are relevant for stock markets in emerging economies, and therefore should be carefully considered by economic agents and monetary authorities in these economies, and by foreign investors.

3.5. CONCLUSIONS

This chapter examines the impact of domestic and U.S. monetary policy actions on the stock market of thirteen emerging economies. There are two contributions from this research.
First, this research investigates the impact of domestic monetary policy actions on the stock market returns of specific emerging economies. Second, this research investigates the impact of U.S. monetary actions on the stock market returns of specific economies. That is, we examine the international transmission of U.S. monetary policy shocks.

We work with monthly data for a group of thirteen economies, seven in Latin America and six in Asia. To estimate the impact of monetary policy shocks on stock markets VEC models are used.

In the analysis of whether domestic monetary policy impacts the stock market, monetary policy shocks cause significant impacts on the stock market returns of nine countries in both Asian and Latin America. These countries are: Brazil, Colombia, India, Indonesia, Korea, Malaysia, Mexico, Peru, and Thailand. In general, a contractionary monetary policy decreases stock market returns.

In the analysis of whether U.S. monetary policy has an impact on the stock market of emerging economies, there is some evidence of international transmission of U.S. monetary shocks. U.S. monetary policy shocks affect the stock market returns in five of the emerging economies in our sample: Chile, Colombia, The Philippines, Thailand, and Venezuela. For these economies, increases in U.S. federal funds rate, which correspond to contractionary monetary policy, decreases stock market returns in emerging economies.

Because of the evidence that both domestic and U.S. monetary policy shocks significantly affect stock market returns in emerging economies, investors, monetary authorities and other economic agents need to incorporate monetary policy shocks among the variables considered when decisions about stock markets are made.

Future work will consider whether the impact of monetary policy on stock market has been changing over time and the potential role of exchange rate in that change.
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### Table 3.2: Augmented Dickey-Fuller (ADF) Unit Root Test

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<td>-1.693</td>
<td>1</td>
<td>-8.861***</td>
<td>0</td>
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<td></td>
</tr>
<tr>
<td></td>
<td>Stock</td>
<td>-2.445</td>
<td>1</td>
<td>-10.005***</td>
<td>0</td>
<td>-1.652</td>
<td>1</td>
<td>-10.214***</td>
<td>0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: ***, **, and * indicate significance at 1%, 5% and 10% level. The maximum number of lags used is 16. The appropriate number of lags is the number of lags that minimizes the Akaike Information Criteria (AIC). Critical values are MacKinnon's (critical) values. Notation for variables is as follows: Industrial Production (IP), Consumer Price Index (CPI), Interest rate (Int.), Real Exchange Rate (RER), Stock market returns (Stock) and Federal Funds Rate (FFR). All variables are in logs, except the interest rate.
Table 3.3: Cointegration Tests Summary

<table>
<thead>
<tr>
<th>Country</th>
<th>No. of Variables in the test</th>
<th>None No Intercept None No Trend</th>
<th>None Intercept No Trend</th>
<th>Linear Intercept No Trend</th>
<th>Linear Intercept Trend</th>
<th>Quadratic Intercept Trend</th>
</tr>
</thead>
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<td>Argentina</td>
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<td>4</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
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<td>4</td>
<td>4</td>
<td>4</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Chile</td>
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<td>3</td>
<td>3</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
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<td>5</td>
<td>5</td>
<td>6</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
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<td>2</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Indonesia</td>
<td>8</td>
<td>4</td>
<td>4</td>
<td>3</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Korea</td>
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<td>6</td>
<td>5</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>Malaysia</td>
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<td>4</td>
<td>4</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
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</tr>
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<tr>
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</tr>
<tr>
<td>Thailandia</td>
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<td>3</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Venezuela</td>
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<td>4</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
</tr>
</tbody>
</table>

Notes: This table presents the results of Johansen's (1995) cointegration test. Rank refers to the number of cointegrating vectors. The number of lags was determined from a VAR specification in levels with white noise residuals. The number of lags selected is the one that minimizes the AIC criterion. Each test also includes exogenous variables that control for the exchange rate regime, financial crisis and seasonality. The five options presented in the table provide particular alternatives for whether an intercept or trend term should be included in the specification of the cointegrating equations. Critical values for this statistic are taken from Osterwald-Lenum (1992).
Figure 3.1: Stock Market Returns

Argentina

Brazil

Chile

Colombia

India

Indonesia

Korea

Malaysia

Mexico

ARGLOGSTOCK

BRLLOGSTOCK

CHILOGSTOCK

ARGLOGSTOCK

BRLLOGSTOCK

CHILOGSTOCK

ARGLOGSTOCK

BRLLOGSTOCK

CHILOGSTOCK

ARGLOGSTOCK

BRLLOGSTOCK

CHILOGSTOCK

ARGLOGSTOCK

BRLLOGSTOCK

CHILOGSTOCK
Figure 3.1 (continued): Stock Market Returns

Peru

Philippines

Thailand

Venezuela
Figure 3.2: Impulse Responses of Stock Market Returns to Shocks in the Domestic Interest Rate, by Country. Ordering: U.S. Industrial Production, U.S. CPI, U.S. Federal Funds Rate, Real Exchange Rate, Consumer Prices, Industrial Production, Interest Rate, and Stock Market Returns.

Notes: The number of lags in the VEC model is set to minimize the Aikaike Information Criterion for a maximum of eight lags and white noise residuals. The Cholesky decomposition ordering is U.S. industrial production, U.S. CPI, U.S. federal funds rate, real exchange rate, consumer prices, industrial production, interest rate, and stock market returns for the emerging economy. Only significant responses are presented. Two standard deviation confidence bands are calculated via monte carlo simulations with 1,000 draws. A 48-month horizon is estimated.
Figure 3.3: Impulse Responses of Stock Market Returns to Shocks in U.S. Federal Funds Rate, by Country. Ordering: U.S. Industrial Production, U.S. CPI, U.S. Federal Funds Rate, Real Exchange Rate, Consumer Prices, Industrial Production, Interest Rate, and Stock Market Returns.

Notes: The number of lags in the VEC model is set to minimize the Aikake Information Criterion for a maximum of eight lags and white noise residuals. The Cholesky decomposition ordering is U.S. industrial production, U.S. CPI, U.S. federal funds rate, real exchange rate, consumer prices, industrial production, interest rate, and stock market returns for the emerging economy. Only significant responses are presented. Two standard deviation confidence bands are calculated via monte carlo simulations with 1,000 draws. A 48-month horizon is estimated.
Figure 3.4: Impulse Responses of Stock Market Returns to Shocks in the Domestic Interest Rate, by Country. Ordering: U.S. Industrial Production, U.S. CPI, U.S. Federal Funds Rate, Industrial Production, Consumer Price Index, Interest Rate, Real Exchange Rate, and Stock Market Returns.
Figure 3.4 (continued): Impulse Responses of Stock Market Returns to Shocks in the Domestic Interest Rate, by Country. Ordering: U.S. Industrial Production, U.S. CPI, U.S. Federal Funds Rate, Industrial Production, Consumer Price Index, Interest Rate, Real Exchange Rate, and Stock Market Returns.

Notes: The number of lags in the VEC model is set to minimize the Aikake Information Criterion for a maximum of eight lags and white noise residuals. The Cholesky decomposition ordering is U.S. industrial production, U.S. CPI, U.S. federal funds rate, industrial production, consumer price index, interest rate, real exchange rate, and stock market returns for the emerging economy. Only significant responses are presented. Two standard deviation confidence bands are calculated via monte carlo simulations with 1,000 draws. A 48-month horizon is estimated.
Figure 3.5: Impulse Responses of Stock Market Returns to Shocks in U.S. Federal Funds Rate, by Country. Ordering: U.S. Industrial Production, U.S. CPI, U.S. Federal Funds Rate, Industrial Production, Consumer Price Index, Interest Rate, Real Exchange Rate, and Stock Market Returns.

Notes: The number of lags in the VEC model is set to minimize the Akaike Information Criterion for a maximum of eight lags and white noise residuals. The Cholesky decomposition ordering is U.S. industrial production, U.S. CPI, U.S. federal funds rate, industrial production, consumer price index, interest rate, real exchange rate, and stock market returns for the emerging economy. Only significant responses are presented. Two standard deviation confidence bands are calculated via Monte Carlo simulations with 1,000 draws. A 48-month horizon is estimated.
Figure 3.6: Impulse Responses of Stock Market Returns to Shocks in the Domestic Interest Rate, by Country. Ordering: U.S. Stock Market Index, U.S. Federal Funds Rate, Real Exchange Rate, Consumer Prices, Industrial Production, Interest Rate, and Stock Market Returns (U.S. Stock Market Index Used Instead of U.S. Industrial Production and U.S. CPI).
Figure 3.6 (continued): Impulse Responses of Stock Market Returns to Shocks in the Domestic Interest Rate, by Country. Ordering: U.S. Stock Market Index, U.S. Federal Funds Rate, Real Exchange Rate, Consumer Prices, Industrial Production, Interest Rate, and Stock Market Returns (U.S. Stock Market Index Used Instead of U.S. Industrial Production and U.S. CPI).

Notes: The number of lags in the VEC model is set to minimize the Aikake Information Criterion for a maximum of eight lags and white noise residuals. The Cholesky decomposition ordering is U.S. stock market index, U.S. federal funds rate, real exchange rate, consumer prices, industrial production, interest rate, and stock market returns for the emerging economy. Only significant responses are presented. Two standard deviation confidence bands are calculated via monte carlo simulations with 1,000 draws. A 48-month horizon is estimated.
Figure 3.7: Impulse Responses of Stock Market Returns to Shocks in U.S. Federal Funds Rate, by Country. Ordering: U.S. Stock Market Index, U.S. Federal Funds Rate, Real Exchange Rate, Consumer Prices, Industrial Production, Interest Rate, and Stock Market Returns (U.S. Stock Market Index Used Instead of U.S. Industrial Production and U.S. CPI).

Notes: The number of lags in the VEC model is set to minimize the Aikake Information Criterion for a maximum of eight lags and white noise residuals. The Cholesky decomposition ordering is U.S. stock market index, U.S. federal funds rate, real exchange rate, consumer prices, industrial production, interest rate, and stock market returns for the emerging economy. Only significant responses are presented. Two standard deviation confidence bands are calculated via monte carlo simulations with 1,000 draws. A 48-month horizon is estimated.
CHAPTER 4

MONEY AND REMITTANCES

4.1 INTRODUCTION

Worker's remittances characterize today's globalization. Remittances are money flows typically going from developed countries to developing economies. "Call it the case of the missing billions. For decades, millions of migrant workers have been sending billions of dollars back to their home countries to support their families. Yet the impact of these huge international flows of both money and workers is only beginning to be understood" (Terry, 2005). Ratha (2003) affirms that remittances are an important and stable source for development finance. Ratha also notes that workers' remittances worldwide reached $72.3 billion in 2001 and exceeded official development assistance.

According to the Inter-American Development Bank (2005, 2004), Latin American and Caribbean migrants working in developed nations sent back home $45 billion in 2004, up from $38 billion sent in 2003, and up from $32 billion in 2002. For this region, remittances surpassed foreign direct investment (FDI) and official development assistance (ODA) combined as a source of financing. Furthermore, remittances are likely to continue to flow due to the increased demand for labor in industrialized countries and the scarce job opportunities available in most Latin American and Caribbean countries.

Another characteristic of remittance flows is that they are highly concentrated in a group of 20 developing countries that capture around 80 percent of all remittances (Solimano, 2003).
Latin American countries are part of this group. Mexico is the second largest recipient of worker's remittances in the world, slightly surpassed by India. Solimano (2003) estimates that Mexico receives 9.9 billion dollars annually, the Dominican Republic is in 10th place with 2 billion dollars, El Salvador is in 11th place with 1.9 billion dollars, Colombia is in 12th place with 1.8 billion dollars, and Ecuador is in 16th place with 1.4 billion dollars.

As a percentage of GDP, Latin American countries belong to the top-20 developing countries with the highest remittances when measured as a percentage of GDP. Remittances amount to 16.2% of the GDP in Nicaragua in the year 2003, 13.8% in El Salvador, 9.3% in the Dominican Republic, 8.5% in Honduras, and 7.9% in Ecuador.

To have a sense of the importance of remittances for the countries in our study, Figure 4.1 presents the pattern of remittances, FDI and the trade balance for each country in the sample. Figure 4.1 indicates that remittances have been steadily growing over time for each of the seven economies considered. It is also evident that remittances have surpassed FDI and trade balance flows in each of these economies, with the exception of Mexico. Clearly remittances are an important source of external finance. Looking at the graphs, one can have an idea of the increasing importance of remittances for developing economies and wonder how they could have been ignored in economic research.¹

In spite of the obvious importance of remittances, only recently have economic researchers started to pay attention to them. Most of the previous literature deals with issues such as the motives to remit, the mechanisms for transfer, and the uses of remittances by its recipients. One of the unexplored areas, and focus of the present study, is the impact of remittances on money in developing economies. Because of the increasing inflow of remittances, we presume they have an impact on this variable.

It is important to understand the impact of remittances on money because remittances may impact this variable even if domestic factors are controlled for. As we mentioned, there is a

¹ Lack of data could be one of the reasons behind the lack of research.
lack of research on this topic. Therefore, this study makes two contributions to the literature. First, it investigates the impact of remittances on the demand for money in developing economies. Second, it investigates the impact of remittances on the money supply in these developing economies. We work with a panel of seven Latin American economies\(^2\) using quarterly data beginning with 1981:1 and ending with 2003:4.

This chapter has two main findings. First, remittances do significantly impact the demand for money. Increases in remittances reduce the demand for domestic money. That is, increased remittances lead to currency substitution and a reduction in money demand. Second, remittances do not have a significant influence on the interest rate. The volatility of remittances does not have a significant impact on money demand or the interest rate.

4.2 RELATED LITERATURE

The increasing importance of remittances has prompted some attention from economic researchers. Issues such as the motives to remit, the mechanisms for transfer, and the uses of remittances have been the objects of academic studies.

There are various explanations for remittances. Remittances may be sent for an altruistic purpose to satisfy economic needs of families left back home (Becker 1974). Remittances may be sent in "exchange" or as a payment to family and relatives for investments in the education or travel of the migrant (Cox, 1987). Finally, remittances may constitute "co-insurance", where the migrant and the family engage in transfers that insure each other against temporary shocks (Lucas and Stark, 1985).

Transfer mechanisms, the methods immigrants use to remit, have recently received more attention, often due to political considerations. The Under Secretary of Treasury for International

\(^2\) The countries are Colombia, the Dominican Republic, Ecuador, El Salvador, Guatemala, Mexico, and Nicaragua. The selection is based on the availability of data.
Affairs for the United States, John Taylor (October, 2004) stated that a top priority of the U.S. government is the “efficient and secure flow of remittances” (p.1). Fears that the informal system is used as a channel for money laundering or to fund terrorist groups has induced the development of more formal and regulated channels to send remittances.

Lastly, the remittance literature has also examined their uses, focusing on “productive” versus “unproductive” uses of remittances in the home communities. Whether remittances are consumed or invested to promote economic growth (Mishra, 2006) has been a question of great concern.

The topic of our analysis deals with a new area in remittances’ research. We are interested in investigating how worker’s remittances impact money demand and money supply because we presume that the increasing large inflows of remittances entering developing countries have an impact on these variables.

4.2.1 Money Demand

In a domestic economy, individuals can hold their monetary wealth in two forms, money and interest-earning assets. Money demand is related to three motives that lead an individual to hold money: transactions, precaution, and speculation. First, the transactions motive operates when people demand money to meet day-to-day needs, in which case, the demand for money is proportional to income and the interest rate lost because of holding money instead of interest-earning assets. Second, the precautionary motive arises when people need money to meet unexpected expenditures. Hence, money demand is a function of income and also of the interest rate forgone by holding money instead of interest-earning assets. Third, the speculation motive occurs when people anticipate a price change for their assets. Hence, the demand for money depends on the interest rate.
Based on the above explanation, money demand in a domestic economy depends on both income and the interest rate (Bordo and Schwartz, 2003). Income exerts a positive effect on the demand for money, while the interest rate affects money demand inversely. According to McCallum (1989), a familiar demand function for money is expressed as:

\[ M/P = aY_i \]

where \( M/P \) represents real money balances, \( Y \) denotes income, while \( i \) corresponds to the interest rate. An example of the empirical estimation of money demand for a closed economy can be found in a study by Mehra (1993). Mehra uses U. S. data for the period 1953–1991 to estimate a money demand function and finds a positive relation between the demand for money and income and a negative relation between money demand and the interest rate.

People in open economies may choose to hold their monetary wealth in the form of four basic assets: domestic money, foreign money, domestic-currency denominated interest-earning assets and foreign denominated interest-earning assets. They can hold both domestic and foreign money for performing transactions. The possibility of holding foreign money is linked with the idea of currency substitution.

Currency substitution affects the demand for domestic money. Savastano (1992) defines currency substitution as the demand for foreign money beyond the requirements of international trade and tourism by a country’s domestic residents who travel abroad. International traders may acquire and use foreign money to effectuate their transactions of goods across countries, while tourists demand foreign money to undertake spending while they travel abroad. There is no unique motive that leads to currency substitution. Currency substitution could be caused by the fear of exchange rate depreciation (Canto, 1985), the fear of high domestic inflation that erodes the purchasing power of domestic money (Calvo and Végh, 1992), capital flight speculation (Agenor and Khan, 1996), or general use of foreign currency in domestic transactions (Krueger and Ha, 1996).
Models of currency substitution typically specify a money demand function for domestic money that incorporates variables such as the exchange rate and foreign interest rate. A common money demand function under currency substitution (Adam, Goujon and Jeanneney, 2004; Tsang and Ma, 2002) is given by:

\[
M/P = m(y, \pi, i, i^*, s)
\]

where \( M/P \) is money in real terms, \( y \) is real domestic income, \( \pi \) is inflation, \( i \) denotes domestic nominal interest rate, \( i^* \) corresponds to nominal interest rate on foreign deposits, and \( s \) denotes the real exchange rate.

Explanations of currency substitution attribute this phenomenon to economic agents who are concerned about domestic economic conditions. Empirical studies of currency substitution have found different results about the reasons that people use foreign currency as a substitute for their national currency. For instance, in Latin American countries, although Ize and Levy-Yeyati (2003) and Keskinel (2002) affirm that the process of currency substitution is mostly related to hedging against inflation, Gomis-Porqueras, Serrano, and Somuano (2000), using data from Latin American countries, emphasizes that currency substitution is strongly influenced by depreciation fears.

Our contribution to the literature is to use the currency substitution framework to include an omitted contributing factor, workers' remittances, in the money demand function. In the presence of currency substitution in the recipient country, and given that remittances can be sent in foreign currency, the remittance’s recipient may decide to keep this money in its original (foreign) form. In this case, remittances may accelerate currency substitution and reduce money demand.

Taking into account remittances, our open economy money demand function is:

\[
M/P = m(Y, \text{Remit}, \pi, i, i^*, s)
\]

where \( \text{Remit} \) denotes workers' remittances.
Because our research explores how remittances impact the demand of money, we also include the volatility of this variable (remittances). Although remittances have been said to be a stable source of development and external finance, some authors, including Chami, Fullenkamp and Jahjah (2003), have questioned their stability over time. According to this argument, remittances are not as stable as they are thought to be and their volatility could have an impact on other variables.

In our study, we are concerned with the volatility of remittances. Volatility of remittances can occur for several reasons. One of the reasons the recipient of remittances experience volatility in the remittances received is related to the working conditions in the sending countries. These working conditions are related with the legal status attained by immigrants. In the case of the United States, the main destination for Latin American migrants who send remittances, Passel (2005) estimates that in 2004 a substantial share (29%) of the foreign-born population was unauthorized, and from those unauthorized, 81% are from Latin America. An unauthorized immigrant faces higher volatility about her income than an authorized migrant, and that volatility may be reflected in the remittances she sends.

We suggest that because of the volatility in the income that immigrants earn in the sending countries, remittances are volatile. Our argument is as follows: An immigrant, as other economic agents, uses her income for consumption and saving. However, different from other economic agents, an immigrant devotes part of what is left after her consumption for sending remittances to her home country. That is, for an immigrant: Income - Consumption = Savings + Remittances. We suggest that for an immigrant, her consumption is fairly stable (i.e. rent, food and other expenses). However, her income is not stable because of the special working conditions previously mentioned. Thus, we suggest that a volatile income for immigrants in the sending country results in volatility in remittances. Savings are used to smooth both consumptions and

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3 In this chapter we use volatility and uncertainty synonymously.
4 Unauthorized means people that do not hold a specific authorization to work.
remittances, so because we assume consumption to be stable, it is remittances the variable that may exhibit volatility.

We have stated that the demand for domestic money can be affected by remittances. That is, the demand for domestic money is a function of remittances. Nevertheless, the way in which remittances impact the money demand will depend on whether remittances are kept in foreign currency. In addition to the impact of remittances, we also analyze the impact that the volatility of remittances could have on the demand for domestic money. The presence of volatility in remittances can affect the behavior of a remittances’ recipient. Because of underdeveloped credit markets in developing countries, the volatility of remittances, as well as the volatility of domestic income\(^5\), cannot be smoothed, as it can be in countries with more developed credit markets. In a developed credit markets, credit lines help to smooth volatile income flows. Because of underdeveloped credit markets in developing countries, the volatility of remittances may have an impact on money demand.

As a result of including remittances volatility, the demand for domestic money may be written as:

\[
\frac{M}{P} = m(Y, \text{Remit}, \pi, i, i^*, s, \text{VolRemit})
\]

where \(M/P\) is money in real terms, \(Y\) denotes real domestic income, \(\text{Remit}\) indicates real remittances, \(\pi\) represents inflation, \(i\) domestic nominal interest rate, \(i^*\) is foreign nominal interest rate, \(s\) is the real exchange rate, and \(\text{VolRemit}\) denotes the volatility of remittances. Further explanation about our money demand function is provided in Section 4.3.

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\(^5\) With the exception of one country (Ecuador), we did not find evidence of volatility in the domestic income for the countries in our sample. Therefore, we do not include the volatility of domestic income as a variable in our estimations.
4.2.2 Money Supply

A central bank has the ability to determine the amount of money supply in circulation. With the use of reserve credit in open market operations and lending at the discount window, the central bank determines the monetary base or high-powered money (H). For a domestic economy, H is made of domestic credit, which corresponds to currency in circulation and bank reserves. Through reserve requirements, the central bank also determines the amount of loans banks can make to expand the monetary base. Because banks are penalized if their reserves fall below their reserve requirements, they keep some excess reserves. By holding excess reserves, banks face an opportunity cost of not lending out reserves, but they avoid the interest rate cost of borrow reserves.

The money supply is a function of domestic credit (assets of the central bank) and the interest rate (Bordo, Choudhri and Schwartz, 1984). A standard money supply is (McCallum, 1989):

\[ M = bHi \]

where M is money, H is high-powered money, and i denotes interest rate. The money supply function is increasing in both i and H (McCallum, 1989). An example of the empirical studies of domestic money supply is Cover (1992). Cover runs a number of different specifications for the money supply of the United States in order to ensure that the results are robust with respect to what theoretical studies assume determines the money supply. With respect to the monetary base, Cover (1992) finds that the growth rate of monetary base positively impacts the growth rate of money supply. With regard to interest rate, Cover’s (1992) results indicate that the interest rate positively impacts the money supply.

Money supply in an open economy context is discussed in the monetary approach to the balance of payments literature. Early developments in this literature were done in the 1950s and 1960s, but it was really in the 1970s when this area received more attention among economic...
scholars due to the research led by the International Monetary Fund, the University of Chicago, and the London School of Economics (Polak, 2001). Frenkel and Johnson (1976, p.21) affirm that, “The main characteristic of the monetary approach to the balance of payments can be summarized in the proposition that the balance of payments is essentially a monetary phenomenon.”

Money supply in the monetary approach to the balance of payments includes a foreign component, because a central bank’s balance sheet has two components on the asset side, domestic credit (DC) and international reserves (R). Thus, H is made of a domestic (DC) and a foreign component (R). Then, the money supply is given by:

$$M = b(R, DC, i)$$

Empirical studies show that the money supply is significantly influenced by international reserves. However, contradictory results with respect to the sign of international reserves exist. Two studies serve as examples. Elbadawi (1990), in a study for Sudan, finds that international reserves negatively impact money, while Akikina and Al-Hoshan (2003), in an analysis for Saudi Arabia, find this variable positively impacts money.

According to the monetary approach, money is influenced by the factors that are part of international reserves, by domestic credit and by the interest rate. Our contribution is to explicitly explore the impact of remittances on the money supply. For this purpose, instead of international reserves, we use a detailed decomposition of this variable. That is, we consider that international reserves accumulate by resources coming from the trade balance for goods (TB), foreign direct investment (FDI), workers’ remittances (Remit), the balance of services (BceSer), and Net Income$^6$ (NetInc). Our money supply function is thus given by:

$$M = b(TB, FDI, Remit, BceSer, NetInc, DC, i)$$

$^6$ As defined in the data section, net income corresponds to the net value of income credit (inflows) minus debit (outflows). This last series includes payments of interest on loans, or payments on interest for external debt.
In addition to these variables, we also include the volatility of remittances in the money supply function. The volatility of remittances may affect the money supply because it may alter the design of domestic monetary policy made by a central bank. Tucker (2006) indicates that problems in the money supply area can arrive when a central bank does not provide the accurate amount of liquidity the system as a whole needs. At the same time, it is recognized by the literature that excess money supply can cause inflation so money supply must be carefully managed. In a country where remittances are important flows of resources, the presence of volatility in these flows causes a central bank to face problems in properly forecasting remittances. As a consequence, a central bank finds it difficult to establish an accurate amount of money supply to provide to the system. Therefore, it is important to analyze the impact of remittances volatility on the money supply.

After including the volatility of remittances, our money supply function is given by:

\[(8) \quad M = b(TB, FDI, Remit, BceSer, NetInc, DC, i, VolRemit)\]

By means of equation (8), we can explicitly explore the role of remittances in the money supply, whereas equation (4) explores remittances' role in money demand.

4.3 MONEY DEMAND AND MONEY SUPPLY FUNCTIONS WITH REMITTANCES

As developed in the previous section, we introduce remittances in the money demand (equation (4)) and the money supply (equation (8)) functions. The literature on currency substitution allows us to introduce remittances into the demand for money, and literature on the

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7 Although the other variables included in our specification can also be volatile, using the ARCH test to test for the presence of volatility (this test is an LM test for ARCH models developed by Engle (1982) where the null hypothesis is that there is "no ARCH" up to order q in the residuals obtained from a regression of the square residuals on a constant and on the lagged squared residuals up to order q) on each variable, we did not find evidence of volatility in the trade balance, domestic credit, FDI (except in Guatemala and Nicaragua), balance of services and net income (except in Mexico). Therefore, we do not include the volatility of those variables in our estimations.
monetary approach to the balance of payments provided the framework to introduce remittances into the money supply. Here we provide further explanation about our money functions.

We start with the money demand. While explanations of currency substitution cite fears of economic agents with respect to domestic economic conditions, an additional factor that has not been considered by the existing literature may accelerate the process of currency substitution. This is the issue of workers' remittances. In the presence of currency substitution in the recipient country, and given that remittances are sent in foreign currency, the remittance's recipient may decide to keep this money in its original foreign form. In this case, remittances may accelerate currency substitution and may have a negative impact on the demand for domestic money.

Thus, the demand for domestic money may be written as:

\[ \frac{M}{P} = m(Y, \text{Remit}, \pi, i, i^*, s, \text{VolRemit}) \]

where \( \frac{M}{P} \) is money in real terms, \( Y \) denotes real income, \( \text{Remit} \) indicates real remittances, \( \pi \) represents domestic inflation, \( i \) domestic nominal interest rate, \( i^* \) is foreign interest rate, \( s \) is the real exchange rate, and \( \text{VolRemit} \) denotes the volatility of remittances.

Two elements in this money demand function differ from standard money demand functions under currency substitution. These elements are remittances and the volatility of remittances. Our money demand function incorporates the fact that people receive income from abroad in the form of remittances. Remittances are not part of domestic income because they are not earned by domestic residents. Remittances are sent by immigrants from abroad to people in their home countries. A particular characteristic of remittances, which makes them different from foreign aid, is that remittances are received directly by private agents, not by the government or non-profit organizations. In this regard, remittances are international transfers that may affect the demand of domestic money.

We define money in real terms, \( \frac{M}{P} \), as \( M1 \) divided by the consumer price index. This is a narrow definition of money. We choose this definition of money because we are more interested in the impact of remittances on the transactions demand for domestic money. Then, if remittances
are converted into domestic currency, they will have a positive effect on money demand. If they are kept in foreign currency, they will decrease the demand for domestic money. In the later case, remittances may be facilitating the currency substitution process that takes place in a particular country.

Also included in the model specification is real income. Given that domestic money serves as a medium of exchange, we expect that increases in income will result in higher money demand. With respect to inflation, this variable can impact the demand for money on two accounts. First, higher inflation induces people to hold less money because high inflation reduces the real rate of interest and therefore reduce money demand. Second, higher inflation has been shown to induce switching from domestic to foreign money as a way to avoid losing purchasing power (Calvo and Végh, 1992). Both domestic (i) and foreign (i*) interest rates are included in the specification because they represent the opportunity cost of holding money in two different forms. The exchange rate is part of the specification because, in moving from domestic toward foreign money, the value of one currency in terms of another (given by the exchange rate) is important. In fact, fear of depreciation has been cited as a significant motive for currency substitution (Gomis-Porqueras, Serrano, and Somuano, 2000).

Now, we turn our attention to the money supply. As mentioned in the related literature section, in the monetary approach to the balance of payments, money is influenced by the factors that are part of international reserves, by domestic credit and by interest rate. Because our purpose is to investigate the impact of remittances on money, instead of international reserves we use a detailed decomposition of international reserves. International reserves are accumulated with the net flows (inflows – outflows) that enter an economy. Then, our money supply function is given by:

$$M = b(TB, FDI, Remit, BceSer, NetInc, DC, i, VolRemit)$$

Thus, international reserves accumulate by resources coming from the trade balance from goods (TB), foreign direct investment (FDI), workers' remittances (Remit), the balance of
services (BceSer), and Net Income⁸ (NetInc). Following Arida and Bacha (1987) and Vera (2005), we consider these flows to be driven by factors outside the control of governments who accumulate international reserves. Because, as we said before, remittances can be volatile, we also consider the potential role that the volatility of remittances can have in money supply.

In principle, we would expect that the more external resources entering an economy, the higher the money supply. A positive relation is expected between money and interest rate, while the sign of the volatility of remittances is unknown.

Our objective is to estimate the money demand function given by equation (4) and the money supply function given by equation (8). For empirically estimating these equations, we put them in log linear form and control for seasonality and official dollarization (Ecuador adopted the dollar as its currency in 2000, while El Salvador dollarized in 2001) with dummy variables. Therefore, for the money demand we estimate:

\[
\log \left( \frac{M}{P} \right)_t = \beta_0 + \beta_1 \log Y_t + \beta_2 \log \text{Remit}_t + \beta_3 \log \pi_t + \beta_4 \log s_t + \beta_5 \log R_t + \beta_6 \log \text{VolRemit}_t + \beta_7 \text{Season}_1 + \beta_8 \text{Season}_2 + \beta_9 \text{Dollar} + u_t
\]

where the subscripts denote country i at time t, and Season and Dollar denotes the dummy variables.

The money supply equation is:

\[
\log M_t = a_0 + a_1 \log TB_t + a_2 \log FDI_t + a_3 \log \text{Remit}_t + a_4 \text{BceSer}_t + a_5 \text{NetInc}_t + a_6 \log DC_t + a_7 \text{Season} + a_8 \text{Dollar} + \eta_t
\]

but we estimate an inverse money supply function (because money is already a dependent variable in the money demand equation) given by:

\[
\eta_t = (a_0/a_7) + (a_1/a_7) \log TB_t + (a_2/a_7) \log FDI_t + (a_3/a_7) \log \text{Remit}_t + (a_4/a_7) \log \text{BceSer}_t + (a_5/a_7) \log \text{NetInc}_t + (a_6/a_7) \log DC_t - (1/a_7) \log M_t + (a_8/a_7) \log \text{VolRemit}_t + \alpha \text{Season} + \alpha \text{Dollar} + \eta_t
\]

⁸ As defined in the data section, net income corresponds to the net value of income credit (inflows) minus debit (outflows). This last series includes payments of interest on loans, which are basically payments on interest for external debt.
where the subscripts denote country i at time t.

In conclusion, whether remittances impact on the money demand and money supply are open questions. Because these topics have not been previously studied, this research is even more relevant. Our study sheds light on this area by analyzing the impact of remittances for Latin American countries.

4.4 EMPIRICAL CONSIDERATIONS

4.4.1 Data

We use quarterly data that runs from 1981:1 to 2003:4 for seven Latin American economies. These countries are Colombia, the Dominican Republic, Ecuador, El Salvador, Guatemala, Mexico, and Nicaragua. A country's inclusion in the sample depends purely on data availability.


The variables included in our analysis are international reserves, the real exchange rate, money, U.S. 90-day T-bill rate (used as a proxy for foreign interest rate), foreign direct investment, worker's remittances, the trade balance, the balance of services, net income, and inflation.

The real exchange rate is computed using the nominal exchange rate, the domestic and foreign consumer price index. The U.S. CPI is used as a proxy for the foreign consumer price index. The nominal exchange rate is defined as the domestic currency units per U.S. dollar. Money and domestic credit are the variables defined as such in the International Financial
Statistics (IFS). “Money (line 34) equals the sum of currency outside deposit money banks (line 14a) and demand deposits other than those of the central government ... The data in line 34 are frequently referred to as M1.” (IMF, 2005, pp. xiv-xv) M1 does not include foreign denominated deposits.

The trade balance is defined as exports minus imports of goods. The balance of services is defined as the net value of credit (service exports) minus debit (service imports). Net income corresponds to the net value of income credit (inflows) minus debit (outflows). This last series includes payments of interest on loans, or payments on interest for external debt, which are significant for some Latin American countries.

The data are taken from the International Financial Statistics (IFS), except for worker’s remittances, which come from each country’s Central Bank. All variables are in real terms and in logs, with the exception of the nominal interest rate that appears in its original form, inflation is the first difference of the log of the CPI, and the trade balance, balance of services and net income that are a ratio to GDP. The estimated model also includes seasonal dummies to control for seasonality and a dummy for dollarization.

4.4.2 Methodology

Because of data availability, the analysis is conducted with a limited number of observations for each country. For that reason, we use panel data models. Because we have a system of equations, we need to use a simultaneous equations model.

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9 Because the trade balance, the balance of services and net income are sometimes negative, the log of the series is not possible to obtain, so we use a ratio. Using ratios also smooths the data.

10 The nominal rate of interest and the inflation rate are included in the model instead of the real interest rate. The real rate of interest is equal to the nominal rate of interest minus expected inflation. We proxy the expected rate of inflation with the actual inflation rate.

11 Ecuador adopted the dollar as its currency in 2000, while El Salvador dollarized in 2001.
We explain simultaneous equations models and estimation techniques following Greene (2003). Consider a two-equation structural model:

\begin{align*}
    y_1 &= a_1 y_2 + a_2 x_1 + u_1 \\
    y_2 &= a_3 y_1 + a_4 x_2 + u_2
\end{align*}

these two equations are structural equations because each equation is a behavioral equation based on economic theory. Both equations contain an endogenous variable as a regressor. They are called a simultaneous equations model (SEM) because these two equations simultaneously determine both $y_1$ and $y_2$. $y_1$ and $y_2$ are endogenous variables, and $x_1$ and $x_2$ are exogenous variables. $u_1$ and $u_2$ are structural errors.

Because the endogenous variables are correlated with the disturbances, least squares estimation provides biased and inconsistent parameter estimates. It is possible to use an instrumental variable estimator taking the exogenous variables as the instruments. Among the methods to estimate SEM models, we chose iterative three-stage least squares (3SLS). 3SLS take into account error covariances across equations and is asymptotically efficient.

In order to have a solution to the system formed by equations (9) and (11), we assume that real money and interest rate are endogenous. The rest of the variables are treated as exogenous. For the estimation, time and population are used as additional instruments in the first stage.

4.5 EMPIRICAL RESULTS

Before proceeding with the estimation, we explain two issues we consider in our estimation: the presence of unit roots and the volatility of remittances. Ignoring the presence of unit roots in a conventional linear regression can lead to serious inference errors. Therefore, we test for the presence of unit roots using the Im, Pesaran and Shin (2003) panel unit root test. This test proposes a "standardized t-bar test statistic based on the (augmented) Dickey-Fuller statistics
averaged across the groups." (Im, Pesaran, and Shin, 2003, p.53) These authors provide critical values computed via stochastic simulation. To carry out the test, a separate augmented Dickey-Fuller test statistic is estimated for each variable in each country. The number of lags selected is based on the Schwarz information criterion for a maximum of eight lags. Because there may be a problem of correlation with the residuals from the individual equations (from each country), a common strategy is to subtract a common time effect from each observation and to estimate the test using the values of \( y_{it}^* \) (the difference between the original value of a variable and its mean). Table 4.1 displays the results from the panel unit root tests. With the exception of FDI and inflation, all the variables exhibit one panel unit root. Therefore, we first difference the variables that exhibit one unit root.

Another consideration is volatility. We test for the presence of volatility in workers’ remittances for each country using the LM test for ARCH models developed by Engle (1982). The null hypothesis is that there is “no ARCH” up to order \( q \) in the residuals obtained from a regression of the square residuals on a constant and on the lagged squared residuals up to order \( q \). Table 4.2 presents the results of these tests, which are performed on the remittances series of each country. The null hypothesis of “no ARCH” is rejected for five of the seven countries in our sample: Colombia, the Dominican Republic, El Salvador, Mexico, and Nicaragua. The null hypothesis cannot be rejected for Ecuador and Guatemala. As such, we estimate the volatility of remittances for the remittances series of each country. Volatility is proxied using generalized autoregressive conditional heteroskedastic (GARCH) models.

GARCH specifically estimates a model of the volatility of innovations, rather than simply estimating a volatility measure from past outcomes (moving standard deviation). It is argued that volatility of an economic variable can be seen as a stochastic process that evolves over time and

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12 “The method is to subtract this common mean from each observation (i.e., form \( y_{it}^* = y_{it} - \bar{y}_t \)” (Enders, 2004, p. 227).

13 The mean is estimated for each country.

14 The variables that exhibit one unit root and are stationary after the first difference.
at least part of it is random (unpredictable component), while the other part is deterministic (predictable component). The advantage of using GARCH models is that they capture the unexpected volatility (Elsayed, 2003). It is the unexpected volatility that may have an impact on the behavior of economic agents because the predictable part can be anticipated and incorporated a priori so that no surprise would come from that. Because of the advantages of using GARCH models, there has been a shift in the literature towards the use of these models as a proxy for volatility. For the purpose of our paper, which is to investigate the impact that the volatility of remittances may have on the demand and the supply of money, GARCH models allow us to capture that unpredictable volatility that is present in remittances given that this variable (remittances) are not completely forecastable.

Table 4.3 presents the results of estimating GARCH models for the countries in our sample. We choose the GARCH model that minimizes the AIC criterion. That is, for instance, the while for Nicaragua, a GARCH (1,1) is the specification that minimizes the AIC criterion, for Colombia it is an ARCH (2) specification that does it. The estimation includes one lag of the own variable and controls for seasonally using dummy variables. From these estimations we extract the conditional volatility measure that is used in our estimations for money demand and supply. Estimation of volatility through GARCH models under a panel data framework has been done by, among others, Guang-Zhong and Voon (2004).

With the series properly transformed, we jointly estimate equations (9) and (11). We start our analysis with the results for equation (9), the money demand equation. Table 4.4 presents the results of using 3SLS.\textsuperscript{15} From the results, the coefficient on remittances is significant in the money demand function at the 1% level. That is, an increase in remittances reduces the demand for domestic money. This result supports the idea that remittances work in favor of currency

\textsuperscript{15} No autocorrelation is found using Q-statistics calculated for up to eight lags. The estimation also produces White's heteroskedasticity consistent covariance estimates.
substitution. It is also consistent with the notion that foreign shocks can impact developing economies.

How can this be explained? This result makes sense under the currency substitution analysis. Perhaps families receiving remittances keep part of those inflows as dollars or deposit them in dollar accounts. Our measure of money, M1, does not include foreign currency deposits. Some evidence supports the explanation that remittances are kept in foreign currency form. Taylor (2000) affirms that there has been an increasing dollarization of Latin American economies. This has been reflected in the acceptance of U.S. dollars as currency in transactions in Latin American economies. Rennhack and Nozaki (2006) explain that, during the 1990s, foreign currency deposits as a share of total deposits picked up in countries with initially lower levels of dollarization, such as the Dominican Republic and Nicaragua.

Even countries such as Colombia and Mexico, which have avoided significant dollarization, still have observed an increased in financial dollarization. In fact, some economies have legally accepted the use of U.S. dollars as official currency. For instance, from the countries in our sample, since the year 2000, Guatemala has legalized the dollar as a domestic currency along with the quetzal\textsuperscript{16} (The Economist, September 2002). Similarly, Ecuador and El Salvador were heavily dollarized even before officially adopting the U.S. dollar as their currency (Kyle, 2005; Rennhack and Nozaki, 2006).

Some evidence about the use of U.S. dollars by remittances' recipients can help explain that currency substitution may be behind the negative impact of remittances on money. Suki (2004) describes that in the Dominican Republic, because the full convertibility of the Dominican peso, remittances are received either in pesos or U.S. dollars. This process of currency substitution is increasing in the Dominican Republic. In 2002 and 2003, the predominant currency of delivery\textsuperscript{17} was the peso, with 78\% and 71\% respectively, but the “dramatic

\textsuperscript{16} The quetzal is the currency of Guatemala.
\textsuperscript{17} Currency of delivery means the currency in which remittances are received by the remittances' recipient.
Depreciation of the currency in 2004 caused substantial switching to receipts in US dollars. The proportion of delivery in US dollars now varies from company to company but appears to be in the range of 50% US dollar receipts.\textsuperscript{18} (Suki, 2004, p. 12) This large switch shows that remittance recipients may choose to retain their dollars waiting for the peso to stabilize and to avoid inflationary fears. For Mexico, Hernandez-Coss (2005) explains that when this country experienced a financial crisis in the mid-1990's, “informal transfer systems boosted their popularity by offering remittances in U.S. dollars. They appear particularly active in rural isolated regions, where big banks and money transfer offices are not established, and around U.S. border towns where border-crossing is commonplace.” (Hernandez-Coss, 2005, p. 64) In Nicaragua, Falla (2000) explains that the use of U.S. dollars among remittances’ recipients is common. For instance, Falla cites the example of a small rural community of 30,000 people where about 22% of them receive remittances where they use dollars to purchase assets.

There is an additional possibility that may explain the negative impact of remittances on money. It is the increasingly popular approach for banks to build remittance services on the existing networks of automatic teller machines (ATMs) (Bernanke, 2004). For instance, “Bank of America's SafeSend program and Citibank's Money Card program issue debit cards to a person in Mexico designated by the U.S. remitter, allowing the recipient to gain access to funds transmitted from any ATM... Second Federal Savings in Chicago offers account holders an "amigo card," a second ATM card that can be sent to a family member in Mexico.” (Bernanke’s remarks, 2004)

These debit cards can be used “to withdraw money from ATMs or make purchases at any retail location that accepts Visa cards.” (Pena, 2004) Thus, a remittance’s recipient can perform different transactions without even physically withdrawing money. In this case, remittances may never enter the recipient country, but their presence decreases the demand for domestic money. The impact of remittances on money demand could be even higher because it is possible that remittances are not completely accounted for by official statistics because of the use of informal

\textsuperscript{18} Companies are agencies where people can send remittances.
channels. Feige (2003) points out that in an economy with unofficial dollarization, measures of money fall short of the effective money due to the omission of foreign cash in circulation outside the banking system, which is typically unknown. In short, Feige suggest that the definition of money should include foreign currency and foreign denominated deposits. Feige goes on to argue that because of those shortcomings in the data, it is not possible to exactly measure the effective degree of currency substitution in an economy.

In addition to the significant impact of remittances on real money demand, inflation and real income are also relevant. The coefficient on real income is statistically significant at the 10%, while the coefficient on inflation is significant at the 1% level. Higher inflation rates increase money demand. This is expected result because according with standard monetary theory higher inflation should result in higher money demand because increases in inflation reduce the real rate of interest. Although significant only at the 10% level, the positive impact of income is consistent with theoretical expectations that higher income raises the demand for money. There is no significant impact of remittances volatility in the money demand.

With respect to the money supply, Table 4.5 presents the results of estimating equation (11), the inverse money supply equation, with iterative 3SLS. Remittances, although positive for the interest rate, are not statistically significant. From the results, no variable shows statistical significance on the interest rate. Other factors may have an influence on monetary authorities when they decide about changes to impact the interest rate.

The results presented in this section indicate that remittances have a significant impact on the money demand, but not on the money supply. Because remittances are received by private agents, these results indicate that remittances affect the recipient's decisions in the demand for domestic money. However, remittances do not significantly impact the interest rate. The currency substitution notion helps to explain the results for the demand for money.

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19 No autocorrelation is found using Q-statistics calculated for up to eight lags. The estimation also produces White's heteroskedasticity consistent covariance estimates.
4.6 CONCLUSIONS

This chapter contributes to the remittance literature by examining the impact of workers' remittances on the money demand and supply for a group of seven Latin American economies. These countries are Colombia, Dominican Republic, Ecuador, El Salvador, Guatemala, Mexico and Nicaragua. Panel three-stage least squares regressions are estimated using quarterly data running from 1981:1 to 2003:4.

Using the monetary approach to the balance of payments and the currency substitution framework, we estimate separate equations for money supply and for money demand. In the case of the demand for money, remittances do have a significant impact in the money demand for Latin American economies. An increase in remittances reduces the demand for domestic money. Then, remittances can be a factor that may accelerate the currency substitution process in these countries.

In the estimation of the impact of remittances on the money supply, workers' remittances do not have a significant impact on the inverse supply of money, where interest rate is the dependent variable. Apparently, remittances flows do not have a significant influence on monetary authorities' decisions about money supply.
Figure 4.1: FDI, Remittances and Trade Balance Flows

Colombia

Dominican Republic

Ecuador

El Salvador
Figure 4.1 (continued): FDI, Remittances and Trade Balance Flows

Notes: Data is in millions of U.S. dollars
Table 4.1: Panel Unit Root Test

<table>
<thead>
<tr>
<th>Variables</th>
<th>Level</th>
<th>1st Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Intercept</td>
<td>Intercept and Trend</td>
</tr>
<tr>
<td>Real Exchange Rate (RER)</td>
<td>-1.928</td>
<td>-1.982</td>
</tr>
<tr>
<td>Money (M)</td>
<td>-1.674</td>
<td>-2.075</td>
</tr>
<tr>
<td>Remittances (Remit)</td>
<td>-1.219</td>
<td>-2.108</td>
</tr>
<tr>
<td>Trade Balance (TB)</td>
<td>-1.126</td>
<td>-1.713</td>
</tr>
<tr>
<td>FDI</td>
<td>-3.462**</td>
<td>-3.318**</td>
</tr>
<tr>
<td>Balance of Services (BceSer)</td>
<td>-1.453</td>
<td>-2.44</td>
</tr>
<tr>
<td>Net Income (NetlnC)</td>
<td>-1.089</td>
<td>-2.15</td>
</tr>
<tr>
<td>Domestic Credit (DC)</td>
<td>-1.787</td>
<td>-2.09</td>
</tr>
<tr>
<td>GDP</td>
<td>-1.834</td>
<td>-2.46</td>
</tr>
<tr>
<td>Inflation</td>
<td>-3.373**</td>
<td>-4.940**</td>
</tr>
<tr>
<td>Interest Rate (i)</td>
<td>-1.663</td>
<td>-2.951**</td>
</tr>
<tr>
<td>U.S. t-bill 3-months (i*)</td>
<td>-1.344</td>
<td>-2.629</td>
</tr>
</tbody>
</table>

Notes: At the 5% level of significance, the critical value for the test without trend is -2.17. The critical value for the test with a trend is -2.85. These critical values are taken from Table 2 in Im, Pesaran, and Shin (2003).
Table 4.2: ARCH Test for Remittances

<table>
<thead>
<tr>
<th>Country</th>
<th>ARCH (1) F-statistic</th>
<th>ARCH (1) TxR² Statistic</th>
<th>ARCH (2) F-statistic</th>
<th>ARCH (2) TxR² Statistic</th>
<th>ARCH (4) F-statistic</th>
<th>ARCH (4) TxR² Statistic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colombia</td>
<td>0.356</td>
<td>0.377</td>
<td>3.739**</td>
<td>6.478**</td>
<td>4.608***</td>
<td>12.309***</td>
</tr>
<tr>
<td>Dominican Republic</td>
<td>0.284</td>
<td>0.308</td>
<td>2.223</td>
<td>4.160</td>
<td>3.115**</td>
<td>8.947***</td>
</tr>
<tr>
<td>Ecuador</td>
<td>0.511</td>
<td>0.532</td>
<td>0.739</td>
<td>1.542</td>
<td>1.055</td>
<td>4.319</td>
</tr>
<tr>
<td>El Salvador</td>
<td>0.026</td>
<td>0.027</td>
<td>5.713***</td>
<td>9.749***</td>
<td>2.375*</td>
<td>8.672*</td>
</tr>
<tr>
<td>Guatemala</td>
<td>0.134</td>
<td>0.141</td>
<td>0.076</td>
<td>0.164</td>
<td>0.146</td>
<td>0.668</td>
</tr>
<tr>
<td>Mexico</td>
<td>1.393</td>
<td>1.403</td>
<td>11.098***</td>
<td>18.258***</td>
<td>2.599**</td>
<td>9.789**</td>
</tr>
<tr>
<td>Nicaragua</td>
<td>0.047</td>
<td>0.050</td>
<td>0.088</td>
<td>0.189</td>
<td>6.723***</td>
<td>17.224***</td>
</tr>
</tbody>
</table>

Notes: ***, **, and * indicate significance at 1%, 5% and 10% level. The F-statistic is an omitted variable test for the joint significance of all lagged squared residuals. The TxR² statistic is Engle's LM test statistic, estimated as the number of observations times the R². The ARCH test is a regression of the squared residuals on a constant and lagged squares residuals up to order q. The number of lags is in ( ). Thus, ARCH (1) indicates the estimation of ARCH test including 1 lag.
Table 4.3: GARCH Estimations for Remittances

<table>
<thead>
<tr>
<th>Country</th>
<th>$a_1$</th>
<th>$\omega$</th>
<th>$\alpha_1$</th>
<th>$\alpha_2$</th>
<th>$\beta_i$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colombia</td>
<td>-0.001</td>
<td>0.004</td>
<td>0.591*</td>
<td>0.269*</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.008)</td>
<td></td>
<td>(0.256)</td>
<td>(0.125)</td>
<td></td>
</tr>
<tr>
<td>Dominican Republic</td>
<td>0.047</td>
<td>0.055*</td>
<td>0.039*</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.023)</td>
<td></td>
<td>(0.015)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ecuador</td>
<td>0.141***</td>
<td>0.006**</td>
<td>0.839</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.002)</td>
<td></td>
<td>(0.672)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>El Salvador</td>
<td>0.044***</td>
<td>0.0001*</td>
<td>0.222</td>
<td>0.559***</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.000)</td>
<td></td>
<td>(0.271)</td>
<td>(0.203)</td>
<td></td>
</tr>
<tr>
<td>Guatemala</td>
<td>0.086</td>
<td>0.036***</td>
<td>-0.041</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.008)</td>
<td></td>
<td>(0.229)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mexico</td>
<td>-0.085***</td>
<td>0.006***</td>
<td>0.047</td>
<td>0.523**</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.002)</td>
<td></td>
<td>(0.130)</td>
<td>(0.266)</td>
<td></td>
</tr>
<tr>
<td>Nicaragua</td>
<td>0.136***</td>
<td>0.0001***</td>
<td>0.047***</td>
<td>0.953***</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.000)</td>
<td></td>
<td>(0.006)</td>
<td>(0.019)</td>
<td></td>
</tr>
</tbody>
</table>

Notes: ***, **, and * indicate significance at 1%, 5% and 10% level. Standard errors are in parenthesis. The numbers on $a_1$ correspond to one lag of the own variable. The coefficients on $\omega$ represent the mean term of the GARCH model, $\alpha$ represent ARCH terms, while $\beta$ accounts for the GARCH terms. The equation estimated controlled for seasonality using dummy variables.
Table 4.4: Panel Simultaneous Equations: Three-Stage Least Squares Regression Estimates - Money Demand

<table>
<thead>
<tr>
<th>Variables</th>
<th>Coefficient</th>
<th>S.E.</th>
</tr>
</thead>
<tbody>
<tr>
<td>GDP (Y)</td>
<td>0.035*</td>
<td>0.019</td>
</tr>
<tr>
<td>Remittances (Remit)</td>
<td>-0.094***</td>
<td>0.032</td>
</tr>
<tr>
<td>Inflation</td>
<td>0.003***</td>
<td>0.001</td>
</tr>
<tr>
<td>Interest rate (i)</td>
<td>-0.005</td>
<td>0.005</td>
</tr>
<tr>
<td>Foreign interest rate (i*)</td>
<td>-0.011</td>
<td>0.010</td>
</tr>
<tr>
<td>Real Exchange Rate (s)</td>
<td>0.066</td>
<td>0.083</td>
</tr>
<tr>
<td>Volatility of Remittances (VolRemit)</td>
<td>0.161</td>
<td>0.224</td>
</tr>
</tbody>
</table>

Number of observations: 317
Number of countries: 7
Q-statistic: 8.421

Notes: *** and * indicate significance at 1%, and 10% level respectively. The regression includes also a constant and controls for seasonality and dollarization. All variables, except remittances volatility and inflation, are in 1st difference. Q-statistic is the Ljung-Box Q-statistic at eight lags of the residuals under the null hypothesis of white noise.
Table 4.5: Panel Simultaneous Equations: Three-Stage Least Squares Regression Estimates – Inverse Money Supply

<table>
<thead>
<tr>
<th>Variables</th>
<th>Coefficient</th>
<th>S.E.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trade Balance (TB)</td>
<td>-9.040</td>
<td>9.588</td>
</tr>
<tr>
<td>FDI</td>
<td>0.011</td>
<td>0.052</td>
</tr>
<tr>
<td>Remittances (Remit)</td>
<td>3.432</td>
<td>3.103</td>
</tr>
<tr>
<td>Balance-Service (Bce.Serv)</td>
<td>12.883</td>
<td>31.808</td>
</tr>
<tr>
<td>Net Income (NetInc)</td>
<td>11.972</td>
<td>12.991</td>
</tr>
<tr>
<td>Domestic Credit (DC)</td>
<td>-4.281</td>
<td>3.467</td>
</tr>
<tr>
<td>Money (M)</td>
<td>2.866</td>
<td>15.406</td>
</tr>
<tr>
<td>Volatility of Remittances (VolRemit)</td>
<td>2.983</td>
<td>19.842</td>
</tr>
</tbody>
</table>

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of observations</td>
<td>317</td>
</tr>
<tr>
<td>Number of countries</td>
<td>7</td>
</tr>
<tr>
<td>Q-statistic</td>
<td>15.080</td>
</tr>
</tbody>
</table>

Notes: The regression includes also a constant and controls for seasonality and dollarization. All variables, except remittances volatility and FDI, are in 1st difference. Q-statistic is the Ljung-Box Q-statistic at eight lags of the residuals under the null hypothesis of white noise.
CHAPTER 5

CONCLUSIONS

The increasing globalization process has created new concerns. For an open economy, not only do domestic actions have an impact on its economic conditions, but foreign actions also may affect a country. This may be the case even though stable domestic conditions may exist. Foreign shocks can impact a small open economy. In this dissertation, we analyze the impact of two specific foreign shocks, U.S. monetary policy actions and workers’ remittances.

The empirical investigation of the international transmission process has mainly focused on the analysis of international transmission to developed economies. Although not extensive, this literature indicates deterioration in the general economic conditions in a country, such as a European Union member or Japan, after a contractionary monetary policy shock from the U.S. Federal Reserve takes place.

This literature indicates that a contractionary monetary policy in a large economy, such as the United States, deteriorates not only the large country economic conditions, but also the conditions of other economies. Because of the increasing process of globalization, it can be expected that the process of international transmission will deepen. Thus, one can expect that U.S. monetary policy actions will acquire even more importance for economies worldwide.

The analysis of the U.S. international transmission of monetary policy actions ignores the examination of the transmission to emerging economies. This absence in the international transmission research could be puzzling for policy authorities, analysts, and economic agents. In the absence of specific studies about emerging economies, policy authorities, analysts and economic agents may assume that the impact of international transmission operates in the same
way it does for developed countries. The focus of the two first essays in this dissertation is to explain how the international transmission of U.S. monetary policy takes place for emerging economies. Our intention is to provide an extensive and complete analysis of emerging countries. In this regard, we work with a sample that includes countries from two different regions, Asia and Latin America.¹

In the first essay (Chapter 2) of this dissertation, the international transmission of monetary policy is examined by focusing on the impact on emerging economies. The analysis of the international transmission of U.S. monetary policy has indicated that after a contractionary monetary shock from the United States, there is a negative impact on developed economies. We ask whether the same reaction can be found in emerging economies.

In addition to the impact on output, we also analyze the international transmission in other variables, such as exports, imports, money, prices and interest rates. We distinguish the exchange rate regime in our analysis and also include the volatility of the exchange rate. It has been suggested in the literature that the exchange rate regime can affect the international transmission process. Because of that concern, in the estimation, we include a dummy variable indicative of the *de facto* exchange-rate regime extracted from Levy-Yeyati and Sturzenegger (2005). These authors constructed a *de facto* classification of exchange rates based on changes in the nominal exchange rate, the volatility of these changes, and the volatility of international reserves. The *de facto* measure provides an alternative to the recognized inconsistencies between reported and actual policies. With regard to volatility, interest in analyzing exchange rate volatility and its effects has gained ground in the economic discussion following the financial crisis of the 1990s. We include volatility of the real exchange rate in the VECs. Volatility is proxied using generalized autoregressive conditional heteroskedastic (GARCH) models. The method of estimation in this chapter, which is the use of vector error correction (VEC) models,

¹ These countries are Japan, Korea, Malaysia, the Philippines, Indonesia, India, Thailand, Mexico, Chile, Peru, Brazil, Venezuela, Argentina, and Colombia. Although Japan is not an emerging country, it is included in our estimation because it is used as a leader for Asian countries.
enable us to detect the pattern of response of a particular variable after a U.S. monetary shock takes place.

Our analysis of the transmission to emerging economies shows that these countries are impacted in a different way. In general, economic conditions in emerging countries do not deteriorate following a contractionary monetary policy shock coming from the United States. In fact, the analysis of output indicates that this variable does significantly increase in some economies after a raise in the federal funds rate, the measure of U.S. monetary policy. The difference in the response of emerging and developed economies can be attributed to structural differences among these countries.

The results also indicate that after a U.S. contractionary monetary policy action is taken, there is an increase in prices and interest rates. Mixed reactions are found for exports, imports and money. By mixed reactions we mean that these variables significantly increase in one country, while for another economy they may significantly reduce, so no generalization is possible. With regard to the inclusion of exchange rate volatility, we find evidence that this tends to enhance the international transmission of monetary policy because it makes the significant response of a variable last more periods.

We then analyze a new possibility of international transmission. This is whether there is a process of "augmented transmission", defined as a process where, after a U.S. monetary policy shock, there is a reaction in a leading economy in a particular region, and that reaction affects the small open economies in that particular region. Is there such process observed across emerging economies? Interestingly, our results indicate that there is a process of augmented transmission taking place in Asia where Japan acts as the leader. For Asian economies, the international transmission of U.S. monetary policy is augmented by the Japanese reaction to such actions.

After this analysis, in the next essay (Chapter 3) we explore a different aspect of monetary transmission, the transmission of monetary actions to stock markets in emerging economies. The existing research of this transmission is relatively scarce. Most of the studies
analyze the impact of U.S. monetary policy actions on the U.S. stock market. That is, most of the current literature in this area is for the United States, and the analysis is at domestic level.

However, we take a different approach. We investigate how monetary policy affects stock markets in emerging economies. We consider how domestic monetary transmission takes place, that is, we test how domestic monetary actions affect stock markets in these countries. But we go one step further and also analyze the international transmission of monetary policy. Therefore, we test whether there is an international transmission of U.S. monetary policy to stock markets in emerging economies. As these markets become more financially integrated, we would expect to see significant reactions to U.S. monetary policy actions. Therefore, while in the second chapter we considered the international transmission of U.S. monetary policy to the economy in general and attempted to understand the significance of foreign monetary actions by analyzing the impact on output and other macro variables, in the third chapter we asked, what is the impact of monetary policy on stock markets?

Similar to the method used in chapter 2, vector error correction (VEC) models are used to test whether monetary policy actions, domestic and foreign, have an impact on stock markets. This complements the analysis presented earlier when we analyzed the international transmission of monetary policy for the economy as a whole, while now we focus on the financial side, the stock market. The VEC models estimated contain: U.S. industrial production, U.S. CPI, U.S. federal funds rate, the real exchange rate, consumer price index (CPI), industrial production, the nominal interest rate, and stock market returns of an emerging economy. The models control for exchange rate regime using the de facto classification provided by Levy-Yeyati and Sturzenegger (2005), and control for financial crisis in stock markets using dummy variables, which are 0 before the crisis starts, and 1 thereafter. Impulse response functions, derived from VEC models, allow us to analyze the effect of monetary policy in this chapter.

---

2 These countries are Korea, Malaysia, the Philippines, Indonesia, India, Thailand, Mexico, Chile, Peru, Brazil, Venezuela, Argentina, and Colombia.
We find that domestic monetary policy actions have a significant impact on nine of the thirteen stock markets considered in our sample. After a contractionary monetary policy action, stock markets returns decrease, which is a reaction consistent with previous findings for the United States and other economies. When the possibility of international transmission is tested, we find some support for this process when the stock markets in five countries, two in Asia and two in Latin America, significantly react to U.S. monetary shocks. The pattern of response is similar to the domestic case, a U.S. contractionary monetary shock reduces stock market returns. Therefore, there is evidence that monetary policy is relevant for stock markets.

In Chapters 2 and 3, our approach to foreign shocks is to analyze the case of international transmission of U.S. monetary shocks. The results indicate that such transmission takes place for emerging economies.

We are nonetheless curious that other foreign shocks may significantly impact developing economies. U.S. monetary policy actions are an organized and structured decision taken by monetary authorities in the United States. What would be the impact for developing economies of a foreign shock that is not taken by policy authorities?

In Chapter 4, we present a different source of foreign shocks, workers' remittances. Remittances, inflows of money send by immigrants, have been increasing in recent years and have been suggested to be a stable source of external finance. Little research exists in this area. The majority of those few studies concentrate mostly in microeconomic aspects of remittances. However, we decide to explore the impact of remittances at macroeconomic level. In particular, we investigate a new topic, the impact of remittances on money demand and supply in developing economies. In Chapter 4, using the monetary approach to the balance of payments and the currency substitution literature, we were able to capture a hidden aspect of remittances, their impact on the monetary area.

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3 These stock markets are in Brazil, Colombia, India, Indonesia, Korea, Malaysia, Mexico, Peru, and Thailand.
4 These countries are Chile, Colombia, the Philippines, Thailand, and Venezuela.
Because of data limitations, our sample is restricted to Latin American countries, although the countries included are representative of the recipient economies because they are among the top-twenty countries where remittances as a percentage of GDP is the largest. We use panel simultaneous equation models with three-stage least squares as the method of estimation.

Our findings suggest that remittances do have a significant impact on the demand for domestic money. Increases in remittances reduce money demand in these economies. This finding could be considered surprising. However, we argue that an explanation can be found in the possibility that remittances' recipients decide to keep dollars either as cash or deposits, in which case, remittances may facilitate currency substitution. An interesting fact that emerges is the possibility that remittances increase the unofficial dollarization process that is occurring in Latin America. On the other side, remittances do not have a significant impact on the money supply.

In conclusion, the results presented in this dissertation indicate that foreign shocks have a significant influence on emerging economies. The results presented here reveal that there is an influence from U.S. monetary policy actions and also from workers' remittances in a greater extent that it is commonly believed by central banks especially in the case of remittances.

How will the results presented in this dissertation impact policy makers? The conclusion behind our findings is that foreign shocks can alter the plans of domestic policy authorities. Therefore it is necessary that authorities acknowledge the significance of external actions into their decision processes. A particularly interesting insight for policy authorities comes from the importance found for workers' remittances, which have received little attention, because according to our results, they exert a significant influence in the monetary conditions of a developing economy. The central message is, as the International Monetary Fund (2005) affirms, "that policy makers need to take advantage of the scope that globalization provides to facilitate

5 These countries are Colombia, the Dominican Republic, Ecuador, El Salvador, Guatemala, Mexico, and Nicaragua.
adjustment, while remaining mindful that this adjustment must eventually take place, and of the potential risks associated" (IMF, 2005, p. 143).

How will the results presented in this dissertation impact other economic agents? Accurate information is important for any economic agent involved in a decision process. From our results we can state that economic agents need to consider the role of foreign shocks in order to make the best decision with the information available to them. Among those economic agents, investors are probably the ones that can benefit the most from our findings because any additional insight in understanding the economic conditions of a country is particularly helpful for them.
APPENDIX

A Simple Model of International Transmission

The model follows Walsh (2003). It specifies a linear system in log deviations around a steady state and represents a small open-economy where nominal rigidities are created as nominal wages and some contracts are set in advance so that unanticipated movements in inflation affect real output. An asterisk denotes the foreign economy variables, which correspond to the large economy, and \( \rho \) is the real exchange rate. A rise in \( \rho \) represents a real depreciation for the small economy. The model is composed by equations that represent aggregate supply (1), aggregate demand (2), the interest parity condition that links the real interest rate differential to anticipated changes in the real exchange rate (3), real exchange rate (4), the Fisher equation that links the real and nominal interest rate (5), and uncovered interest parity (6):

\[
\begin{align*}
(1) & \quad y_t = -b_1 \rho_t + b_2 (p_t - E_t p_t) + \epsilon_t \\
(2) & \quad y_t = a_1 \rho_t - a_2 r_t + u_t \\
(3) & \quad \rho_t = r_t^* - r_t + E_t \rho_{t+1} \\
(4) & \quad \rho_t = s_t + p_t^* - p_t \\
(5) & \quad r_t = i_t - E_t p_{t+1} + p_t \\
(6) & \quad i_t = E_t s_{t+1} - s_t + i_t^* \\
(7) & \quad i_t^* = r_t^* + E_t p_{t+1}^* - p_t^*
\end{align*}
\]

where \( y_t \) is output, \( p_t \) is prices, \( s_t \) is the nominal exchange rate, and \( r_t \) is real interest rate.

\[1\] The aggregate supply relationship is written in terms of the unanticipated price level rather than inflation because they are equivalent: \( p_t - E_t p_t = p_t - p_{t-1} \cdot (E_t p_t - p_{t-1}) \).
Real exchange rate depreciation reduces aggregate supply because of the increase in the price of imported materials and in consumer prices. A rise in $p_t$ makes domestically produced goods less expensive than foreign goods, so $p_t$ is positively related with aggregate demand. The disturbance terms, $u_t$ and $e_t$, are shocks that create a role for stabilization policy. The shocks are assumed to have mean zero and be serially uncorrelated. Because foreign income and consumption are exogenous, the impact of world consumption on the domestic economy can explain the existence of $u_t$.

The real money supply is usually given by $m_t q_t = y_t - c_t + v_t$, but in our model, money is not the policy variable. The policy instrument is $i_t$, which more closely reflects the way in which central banks implement their policy. Taylor rule (Taylor, 1993) models have been used to describe the policy behavior of central banks (Clarida, Gall and Gertler, 2000; Bullard and Mitra, 2002). In the classical Taylor rule, the instrument is set to react to domestic inflation ($\pi_t$) and output gap. But in an open economy the variables toward which monetary policy can react is larger. Specifically, the exchange rate regime influences the way in which foreign monetary actions affect the small open economy (Walsh, 2003). Simple rules from Benigno and Benigno (2004) are used to infer the transmission mechanism under flexible, fixed, and managed exchange rates.

When a flexible regime is considered, the nominal exchange rate is free to adjust and the interest rate does not react explicitly to the exchange rate. The nominal interest rate follows (8) $i_t = \gamma i_{t-1} + \Phi \pi_t + \psi y_t$, with $\gamma$, $\Phi$, and $\psi$ positive. Replacing (8) into equations (1)–(7) and using the method of undetermined coefficients, the next section shows that the solutions for $p_t$ and $s_t$ consistent with (1)–(9) are:

\begin{equation}
(9) \quad p_t = i_{t-1} + \left[ (A-1)/a_i \right] + (B-C) \Phi \psi y_t + (1/D) u_t - (1/D) e_t
\end{equation}

---

2 Consumer prices in the domestic economy are defined by $q_t = h p_t + (1-h) (s_t + \pi_t')$, where $h$ is the share of domestic output in the consumer price index.

\begin{equation}
\begin{align*}
(10) \quad s_t &= \alpha_t + A[(1/\alpha_1) + B\Phi \psi]y_t - p^*_t + i^*_t \\
\text{where} \quad A &= (a_1 + b_1 + b_2) / b_2, \quad B = [(a_1 + a_2) / a_1 - (a_1 + a_2 + b_1)(a_1 + b_1 + b_2)], \quad C = (a_1 + a_2) / a_1, \quad \text{and} \\
D &= (a_1 + a_2 + b_1 + b_2)(a_1 + a_2 + b_1) \Phi.
\end{align*}
\end{equation}

A flexible exchange rate insulates the domestic economy from foreign shocks. Foreign prices and foreign interest rate do not affect domestic prices, but they affect the nominal exchange rate. The domestic currency depreciates in response to an increase in the foreign interest rate. A contractionary monetary shock from the large country is absorbed by the exchange rate fluctuations. There is almost no international transmission. Under a system of fixed exchange rates, the monetary authority commits to use the policy instrument in order to maintain a constant nominal exchange rate. The nominal interest rate in the small country follows the foreign nominal interest rate and reacts to deviations of the exchange rate: (11) \( i_t = i^*_t - \lambda s_t \) with \( \lambda > 0 \). As before, we replace the policy measure (11) into equations (1) to (7) and solve for exchange rate and price level:

\begin{equation}
\begin{align*}
(12) \quad p_t &= [((b b_2 / A)g^2 + 1) p^*_t + (1/C) u_t - (1/C) e_t \\
(13) \quad s_t &= (a_1 b_2 / A)g p^*_t - (a_2 / A g)(b_1 + b_2) i^*_t
\end{align*}
\end{equation}

where \( A = a_1(a_1 + b_1 + a_2 \lambda) - (a_1 + a_2 \lambda)(a_1 + b_1 + b_2), \quad B = (a_1 + a_2 \lambda), \quad \text{and} \quad C = (a_1 + a_2 + b_1 + b_2). \)

Comparing (12) with (9) reveals that under fixed exchange rates, foreign prices affect domestic prices and output. Also the foreign interest rate, the monetary instrument of the large economy, affects domestic prices and output. Then, in the case of fixed exchange rates there is more international monetary transmission.

Finally, we consider a managed exchange rate, also known as a "dirty" float. A small open economy reacts to changes in the nominal exchange rate from a defined target:

\begin{itemize}
\item[4] The monetary authority commits to sell or buy domestic currency to maintain the fixed exchange rate. In the case of selling, a crucial aspect is the availability of reserves of foreign currency. This can produce speculative attacks (Garber and Svensson, 1995). We consider only the case of a sustainable fixed rate.
\end{itemize}
Then, when we replace (14) into (1) through (7) and solve we obtain:

\[
(15) \quad p_t = (\psi - A - 1) y_t + \left(\frac{1-a_1-b_1}{b_2}\right) p_{t-1}^* + \left(\frac{1}{B}\right) u_t - \left(\frac{1}{B}\right) e_t \\
(16) \quad s_t = A y_t - i_t^* + \left(\frac{(a_1 + b_1 + b_2 - 1)}{b_2}\right) p_{t-1}^*
\]

where \( A = \frac{[(a_1 + b_2)(\psi - 1) - (a_1 + b_1)]}{b_2} \), and \( B = a_1 + a_2 + b_1 + b_2 + (a_1 + b_1 - a_2) \Phi \).

Comparing (15) with (12) and with (9) reveals that under a managed exchange rate regime, there is a partial impact from foreign shocks. Foreign prices affect domestic prices and output, but foreign interest rates do not. Of course, foreign prices will be affected by changes in foreign interest rates, the monetary instrument of the large economy, so the effect on the domestic economy is indirect. International monetary transmission is present, although it is weaker than it is under a fixed exchange rate regime.

The deductions for international transmission where interest rate is the monetary variable, do not substantially differ from those reached using money as the monetary variable (as in Walsh, 2003). Therefore, from the theoretical point of view, there are clear results expected for international transmission of monetary shocks: full transmission for fixed exchange rate regimes, no transmission for pure flexible exchange regimes, and semi-transmission for mixed or managed exchange rate regimes. Our purpose is to find if those results really reflect what occurs in the transmission of U.S. monetary shocks to emerging economies.

**Derivation of equilibrium values under Flexible Exchange Rate regime:**

In equations (1) and (2) replace (6) and (9) and solve for \( p_t \):

\[
(A.1) \quad p_t = \left(a_1 + a_2 + b_1 + b_2 - (a_1 + a_2 + b_1) \Phi\right) = b_2 E_t p_t + (a_1 + b_1) E_t s_{t-1} \\
+ \left(a_2 - (a_1 - a_2 + b_1) \Phi\right) E_t p_{t-1} - a_2 (y_{t-1} + \psi y_t)
\]
+ (a_i + b_i) \left( i_t^* - \gamma_{i-1} - \psi y_{t-1} + p_t^* \right) + u_t - e_t

Using the method of undetermined coefficients to obtain a solution to (A.1), we begin by writing \( p_t \) as a linear function of the predetermined "state variables". The state variables at time \( t \) are \( i_{t-1}, y_t, i_t^*, p_t^* \), and the various random disturbances. To rule out possible bubble solutions, we follow McCallum (1983) and hypothesize minimum state variable solutions of the form:

(A.2) \quad p_t = k_0 + i_{t-1} + k_1 y_t + k_2 p_t^* + k_3 i_t^* + k_4 u_t + k_5 e_t

(A.3) \quad s_t = d_0 + i_{t-1} + d_1 y_t + d_2 p_t^* + d_3 i_t^* + d_4 u_t + d_5 e_t

These imply:

(A.4) \quad E_t p_t = k_0 + i_{t-1} + k_1 y_{t-1} + k_2 p_{t-1}^* + k_3 i_{t-1}^*

(A.5) \quad E_t p_{t-1} = k_0 + i_{t-1} + k_1 y_{t-1} + k_2 p_{t-1}^* + k_3 i_{t-1}^*

(A.6) \quad E_t s_{t-1} = d_0 + i_{t-1} + d_1 y_{t-1} + d_2 p_{t-1}^* + d_3 i_{t-1}^*

Substituting (A.2)-(A.6) into (A.1) and in the equation resulting from replacing (6) and (9) into (2), it is possible to solve for the values of \( k_i, d_i \). Then replacing those values in (A.2) and (A.3) we obtain the following solutions reported in (10) and (11).

The same procedure is used to obtain the solutions for the cases of Flexible and managed exchange rate regimes.
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