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ESSAYS ON MONETARY POLICY, GLOBAL FINANCIAL FLOWS AND FINANCIAL STABILITY

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Abstract

Essays on Monetary Policy, Global Financial Flows and Financial Stability

by

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This dissertation analyzes issues in monetary policy, global financial flows and financial stability. Chapters 2 and 3 are empirical and explore the effects of monetary policy on international debt flows to emerging markets and both debt and equity flows to Latin America. Chapter 4 is a theoretical agent based model of financial stability that examines systemic risk in financial networks with banks and non-financial transactors.

Chapter 2 aims at answering the question of whether or not Federal Reserve announcements affect portfolio debt flows to emerging markets since the Global Financial Crisis. This chapter uses two year federal funds futures contracts and expectations derived from a shadow rate term structure model to classify all Federal Reserve announcements from October 2008 until November 2014 as easing (unexpected), tightening (unexpected), easing (expected), and tightening (expected). The classification from the shadow rate model is used for an event study of Federal Reserve announcements on daily frequency portfolio debt flows to emerging markets by currency (all currencies, hard currency, local currency, mixed currency), investor (all investors, active investors, passive investors), and region (all, Asia excluding Japan, Europe Middle East and Africa (EMEA), Latin America, and Global Emerging Markets (Global EM)). The results indicate that tightening (unexpected) announcements cause emerging mar-

ket debt outflows, hard currency debt flows respond more to announcements than local currency debt flows, and that passive investors respond more than active investors. Debt flows to Latin America respond more to announcements than debt flows to Asia ex-Japan, EMEA, and Global EM.

Chapter 3 examines the factors that drive the effects of Federal Reserve announcements on portfolio debt and equity flows to Latin America, Brazil, and Mexico since the Global Financial Crisis. This chapter uses the same shadow rate model classification of Federal Reserve announcements as Chapter 2 but for an event study on daily frequency global financial flows by asset class (debt, equity), currency (all currencies, hard currency, local currency), and region (Latin America, Brazil, Mexico). The results suggest that easing (unexpected) and tightening (unexpected) announcements cause debt outflows but have no effect on equity flows to Latin America. Local currency debt flows to Latin America are more sensitive than the hard currency debt flows and Brazil is the country in Latin America that responds most to these announcements.

Chapter 4 is an agent based model of systemic risk that analyzes the profitability and financial stability of interbank networks (complete, unconnected, circle, and star). The agents in the model include banks and non-financial transactors that follow behavioral rules. When there are good economic conditions, the simulation results suggest that more interconnected bank networks have longer bank lifespans and are more profitable but also experience more bank avalanches than less interconnected networks. The circle network performs best of all the networks. There are smaller differences in network performance when the model has bad economic conditions.

To my parents.

Acknowledgments

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A special thanks goes to Daniel Friedman whose course in evolutionary game theory got me interested in the subject, chaired my oral exam committee, and supported my research on financial stability and agent based modeling. I also consider myself extremely fortunate to have had him as my advisor for a Chancellor's Graduate Teaching Fellowship course that I taught "Financial Crises - Morals and Markets". In that research course, I used his Morals and Markets text and had the opportunity to inspire other students to learn about the latest advances in economics and to pursue their own research interests related to the Global Financial Crisis. This was very special.

I would also like to thank Carl E. Walsh who provided me with a solid theoretical foundation in monetary economics through which to examine issues in international

finance. Any time I got stuck understanding monetary economics related to my research I could usually find the answer in his textbook or from speaking with him in office hours. In taking his macroeconomics courses, I was inspired to pursue my own research in monetary economics. I am very fortunate to have had such a talented, supportive, and experienced dissertation committee throughout my doctoral studies.

My second and third dissertation chapters were inspired from my internship experiences in Washington DC at the U.S. Department of the Treasury and discussions with Anna Wong, Brad Setser, Robert Sockin, Erik Weeks, and Kurt Schuler. I could not have completed these chapters without the feedback from Jens H.E. Christensen at the Federal Reserve Bank of San Francisco and the data from Simon Ringrose at EPFR Global. My fourth dissertation chapter would not have been possible without the great team that included Robert Logan, Judith Samson, and Thomas Schmitz. Robert Logan was extremely helpful in improving the fourth chapter simulation and results.

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Chapter 1

Introduction

The Global Financial Crisis (GFC) came as a surprise to most observers and has been the most severe international economic crisis since the Great Depression. The collapse of Lehman Brothers, a large investment bank, in September 2008 almost took down the entire financial system. The policy response has included a large bail-out of the financial industry as well as a massive monetary and fiscal stimulus have been used to restore financial stability and support economic recovery. The Dodd-Frank Act of 2010 represents the most comprehensive financial regulatory reform taken since the Great Depression. The Federal Reserve responded swiftly to the crisis by lowering short term interest rates and purchasing large quantities of U.S. Treasuries, mortgage backed securities, and agencies. Other countries have followed the U.S. and have enacted financial regulation to mitigate financial risks and have used unconventional monetary policies to provide economic stimulus and promote financial stability.

This dissertation examines the effects of monetary policy on global financial

flows and on financial stability since the Global Financial Crisis. Chapter 2 of this dissertation explores the effect of Federal Reserve announcements since the GFC on debt flows to emerging markets by currency (all, hard currency, local currency, mixed currency), investor (active investors, passive investors), and region (Asia excluding Japan, Europe Middle East Africa (EMEA), Latin America, and Global Emerging Markets (Global EM). Chapter 3 studies the effect on monetary surprises on global financial flows to Latin America by asset class (equity, debt), currency (hard currency, local currency, mixed currency), and region (Latin America, Brazil, Mexico). Chapter 4 is an agent based model of systemic risk that analyzes the profitability and financial stability of bank networks (complete, unconnected, circle, and star).

Chapter 2 begins by classifying all of the Federal Reserve announcements since the GFC and then analyzing their effects on emerging market debt flows. Before the financial crisis, the effect of Federal Reserve announcements could be measured using federal fund futures contracts up to six months (Kuttner (2001), Bernanke and Kuttner (2005), Gürkaynak et. al. (2007)). Since the GFC, however, short term interest rates reached the zero lower bound and the Federal Reserve began unconventional monetary policies to influence longer term interest rates. Therefore, this chapter classifies Federal Reserve announcements using two year federal fund futures contracts and compares this classification to a classification using two year expectations from a shadow rate term structure model (Christensen and Rudebusch (2014)). The chapter then uses an event study methodology to examine the effects of these announcements on daily frequency debt flows to emerging markets by currency, investor, and region. Previous authors have

examined the financial stability of emerging market debt (Eichengreen and Haussman (1999 and 2003)), the rise of local currency debt issuance (Miyajima et. al. (2012), Hale et. al. (2014)), the role of foreign investors (Peiris (2010), Ebeke and Lu (2014)), as well as the spillover effects of Federal Reserve announcements (Eichengreen and Gupta (2013), Ahmed and Zlate (2013), Aizenman et. al. (2014), Lim et. al (2014)). This paper analyzes the effects of Federal Reserve announcements on daily frequency financial flows tracked by EPFR Global. Other authors have used EPFR Global data to study issues in international finance and the effect of Federal Reserve announcements (Fratzscher et. al. (2013), Koepke (2014), Rai and Suchanek (2014), Dahlhaus and Vasishtha (2014), and Curcuru et. al (2015)). This chapter classifies Federal Reserve announcements using daily measures of expectations from asset prices and a shadow rate term structure model and to then examine their effects on emerging market debt flows. The event study results show that Federal Reserve announcements classified using expectations from a shadow rate model indicate that tightening (unexpected) announcements cause emerging market debt outflows and especially for hard currency debt flows, passive investor flows, and debt flows to Latin America.

Chapter 3 is a case study of monetary surprises and portfolio flows to Latin America. This chapter uses the same Federal Reserve announcement classification and an event study methodology as the second chapter but focuses on debt flows and equity flows for Latin America, Brazil, and Mexico. The financial crises in Latin America in the 1990s prompted the monetary authorities in this region to move from a system of fixed exchange rates to ones with an independent monetary policy (Mishkin (2000),

BIS (2009), BIS (2015), and Edwards (2016)). Brazil and Mexico have successfully transitioned from fixed exchange rate to inflation targeting regimes (Bernanke (2013), DePooter et. al. (2014)) but are still affected by monetary policy spillovers the the form of capital flows (Fratzscher et. al. (2013), Ahmed and Zlate (2014), and Curcuru et. al. (2015)), increased credit (Morais et. al. (2015)), and capital controls (Forbes et. al. (2012), Jinjarak et. al. (2013)). This chapter finds that easing (unexpected) and tightening (unexpected) announcements cause debt outflows but have no effect on equity flows to Latin America. Furthermore, the local currency debt flows to Latin America are more sensitive than the hard currency debt flows and Brazil is the country in Latin America that responds the most to Federal Reserve announcements.

Chapter 4 is an agent based model of systemic risk in different bank networks. Earlier explanations of banking crises include panic among depositors (Diamond and Dybvig (1983)), contagion in the interbank market (Allen and Gale (2002)). This chapter builds upon ideas from Friedman (1998) and the concept of self-criticality from Bak et. al. (1988). Recent research on networks and systemic risk include Goyal (2007), Jackson (2010), Caballero and Simsek (2011), Gai, Haldane, and Capadia (2011), and Acemoglu, Ozdaglar, Tahbaz-Salehi (2013). Agent based models are used to analyze issues in financial stability (Bookstaber (2012), Bookstaber et. al. (2014), Battiston et. al. (2016)). Under good economic conditions the interconnected bank networks have longer bank lifespans and are more profitable than less connected networks. The circle network performs the best. There are minor differences in network performance when the model is calibrated under bad economic conditions.

Chapter 2

U.S. Monetary Expectations and Emerging Market Debt Flows

2.1 Introduction

What are the effects of Federal Reserve announcements on U.S. monetary expectations and on emerging market debt flows since the Global Financial Crisis? Does it matter if the debt flows are in hard or local currency? If the debt flows are through active investor or passive investor funds? And are there differences in the effects of that the Federal Reserve announcements across regions? History has shown that while foreign debt inflows have allowed emerging economies to finance current account deficits the hot money component later also presented macroeconomic financial stability challenges. The 1990s were a prescient example in which emerging countries in Latin America and Asia defaulted on their hard currency debt. As the Federal Reserve

raised interest rates in the 1990s, and the U.S. dollar appreciated, emerging economies experienced foreign debt outflows and in some cases were forced to abandon their fixed exchange rate and even default on their debt. In early 2000, emerging economies had issued approximately $1.3 trillion in hard currency debt. Fifteen years later, emerging economies have issued approximately $6.3 trillion in hard currency and local currency debt outstanding. Of this total, hard currency debt has increased from $576 billion to $1 trillion and local currency debt has increased from $716 billion to $5.2 trillion. Even though short term interest rates in the United States have remained near zero since the global financial crisis, short term interest rate expectations have changed throughout the period, causing massive swings in foreign debt flows invested in hard and local currency debt and affecting financial stability in emerging economies.

This chapter examines the effect that changes to U.S. monetary expectations around Federal Reserve announcement days have on foreign debt flows to emerging markets using a new measure of monetary expectations and a novel data set on foreign debt flows that has not yet been explored in the literature. The expectations measure used in this chapter is derived from a shadow rate term structure model estimated at daily frequency of short rate expectations in two years. This measure of expectations is used to classify announcements. Previous literature has used 30 day expectations using federal fund futures contracts but is unable to accurately classify announcements since the global financial crisis when interest rates have been near zero. The emerging market debt flow data used in this chapter is measured at the daily frequency and analyzed by currency denomination (all currencies, hard currency, local currency, mixed currency),

investor (all investors, active investors, passive investors), and region (all regions, Asia excluding Japan, Europe Middle East and Africa (EMEA), Latin America, and Global Emerging Markets (Global EM)). Although previous literature has examined the effects of monetary policy on portfolio flows to emerging markets it has not done so by using expectations to classify all announcements nor has it explored the specific effects on debt flows by currency denomination, investor category, and region. The type of announcement, currency denomination of the emerging market debt, investor type, and their regional focus should all influence the effect of announcements on foreign debt flows. Announcements should have a greater impact if they are unexpected than if they are expected. The response of hard currency debt flows and local currency debt flows should differ depending on the degree of investor perception of default risk and foreign currency risk. Announcements may also have different effects on passive investors that follow a benchmark and on active investors trade according to a strategy. Finally, the effects of announcements on emerging market debt flows may depend on regional characteristics, size and level of debt flows, and the composition of hard currency and local currency debt.

This chapter analyzes the effect of changes to U.S. monetary expectations on foreign debt flows to emerging markets in two stages. First, the chapter presents two daily measures of expectations of short term interest rates, federal fund futures and a shadow rate model, and uses them to classify all Federal Reserve announcements since the global financial crisis as easing (unexpected), tightening (unexpected), easing (expected) and tightening (expected). The classification results show that the shadow

rate model provides a better measure than federal funds futures for classifying Federal Reserve announcements. Second, the chapter presents the daily emerging market debt flows data from EPFR Global that tracks regulated funds and estimates the effect that the announcements classified by the shadow rate model have on these emerging market debt flows. The debt flows are analyzed by whether they are in hard currency or local currency and whether they are traded by active or passive investors. The debt flows are also classified and analyzed by whether the fund invests in Asia excluding Japan, Europe Middle East and Africa (EMEA), Latin America, or invest across multiple regions and classified as Global Emerging Markets (Global EM). The results show that tightening (unexpected) announcements affect debt flows more than any other announcement category and that hard currency debt flows respond more to this category of announcements than local currency debt flows. The results also show that active investors respond more to tightening (unexpected) announcements in local currency debt while passive investors respond more to tightening (unexpected) announcements in hard currency debt. The easing (unexpected) announcements and tightening (unexpected) announcements have a significant effect on hard currency debt flows but not all currency debt flows or local currency debt flows to Asia excluding Japan. On the other hand, easing (unexpected) and tightening (unexpected) announcements affect local currency debt flows but not hard currency debt flows to Latin America. The tightening (unexpected) announcements affect all currency debt flows and hard currency debt flows but not local currency debt flows to the EMEA region and to Global EM.

This chapter proceeds in the following manner. Section 2 motivates the chapter

by explaining its relation to the literature on the classifying announcements at the zero lower bound, the financial stability of emerging market hard currency debt and local currency debt, and the effect of monetary policy on international portfolio flows. Section 3 presents the expectations data from federal funds futures and shadow rate model, the Federal Reserve announcement days, the portfolio flow data from EPFR Global. Section 4 explains the methodology for classifying Federal Reserve announcements from October 8, 2008 until October 29, 2014 and for estimating the effect of Federal Reserve announcements on emerging market debt flows. Section 5 presents the results from the Federal Reserve announcement classification and from the event study on the effects of Federal Reserve announcements on emerging market debt flows. Section 6 conducts a robustness check by adding the VIX and oil prices as control variables into the analysis. Section 7 concludes with suggestions for future work.

2.2 Related Literature

This chapter relates to the monetary policy literature by classifying all Federal Reserve announcements since the global financial crisis until the end of quantitative easing as either easing (unexpected), tightening (unexpected), easing (expected), tightening (expected) using a shadow rate model of expectations of the short term interest rate. Thirty day federal fund futures contracts is the best measure of expectations to categorize announcements when monetary policy is conducted by setting the federal funds rate (Kuttner (2001), Bernanke and Kuttner (2005), Gürkaynak et. al. (2007)).

However, several authors have shown that the Federal Reserve has used methods other than the federal funds rate to conduct monetary policy since the global financial crisis and monetary policy reached the zero lower bound (Gagnon et al (2011), D'Amico et.al. (2012), Krishnamurthy Vissing-Jorgensen (2013), Christensen and Rudebusch (2013), and Walsh (2014)).[1] During this time period, thirty day federal fund futures contracts do not capture the effect that announcements have on expectations and Eurodollar contracts, which measure the london interbank offer rate (LIBOR), are also not able to capture these effects (Gürkaynak et al. (2007), Christensen and Kwan (2014)). This chapter classifies announcements using short rate expectations from a shadow rate term structure model estimated at the daily frequency and developed by Christensen and Rudebusch (2014). This measure overcomes the liquidity and term premia issues from using federal fund futures contracts and eurodollar futures contracts at longer horizons and zero lower bound issues when using standard term structure models (Kim and Wright (2005), Piazzesi and Swanson (2008), Piazzesi (2010), Christensen and Rudebusch (2013), Adrian et. al. (2013), Christensen and Rudebusch (2014), Andreasen and

[1]In December 2008, the Federal Reserve lowered the target for its key monetary policy rate, the overnight federal funds rate, to a range between zero and 25 basis points. As shown in Figure 2.1 the Federal Reserve provided additional stimulus through large scale asset purchases that expanded its balance sheet. The first large balance sheet expansion occurred with LSAP 1 from November 2008 until March 2010 and led to the purchase of $300 billion in U.S. Treasuries, $1.25 trillion in agency mortgage backed securities and $170 billion of agency debt. This LSAP 1 program was followed by a brief pause in asset purchases until the Fed launched its LSAP 2 program from November 2010 until June 2011. The LSAP 2 program involved purchases of long-term U.S. Treasuries. From July 2011 until December 2012, the total balance sheet remained at a somewhat constant level of around $2.8 to 2.9 trillion. During this time, the Federal Reserve altered its balance sheet by purchasing long-term Treasuries with financing from its sale of short-term Treasuries referred to as the maturity extension program (MEP). The Federal Reserve launched the start of LSAP 3 in September 2012 which, unlike previous programs, did not include a fixed mount of purchases but instead included purchases of $45 billion of U.S. Treasuries and $40 billion of MBS per month with no end date. The LSAP 3 asset purchasing program was reduced or "tapered" until the program was completed in October 2014 with the Fed balance sheet of around $4.3 trillion.

Meldrum (2014), Lombardi and Zhu (2014), Krippner (2015)).

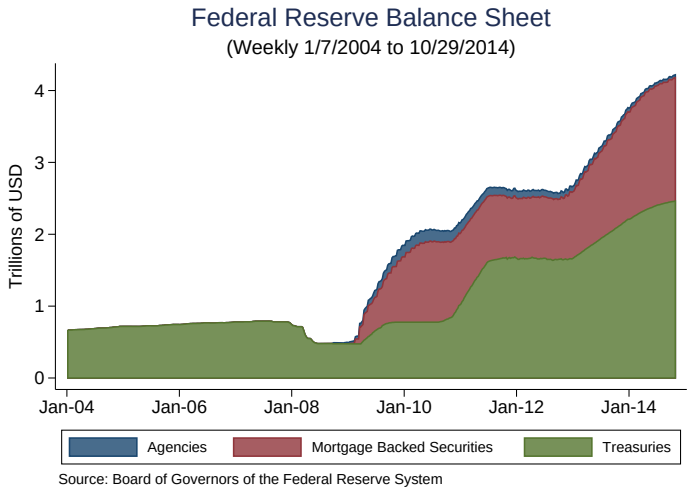


Figure 2.1: Federal Reserve Balance Sheet from January 7, 2004 until October 29, 2014.

This chapter also relates and contributes to the literature on financial stability of emerging market debt markets by examining the effect of Federal Reserve announcements on all currency debt flows, hard currency debt flows, and local currency debt flows since the global financial crisis. During the 1980s, 1990s, and early 2000s, a number of sovereign debt crises engulfed emerging markets in which governments borrowed from foreign investors in foreign currency during good times only to later default on their external debt as economic conditions deteriorated.[2] Eichengreen and Hausmann

[2]See Roubini and Setser (2004) for more detailed discussion of financial crises in Latin America in the 1980s and Asia in the 1990s driven by massive debt financed by foreign portfolio flows in hard currency. These portfolio inflows brought currency appreciation, lower domestic policy rates, and credit expansion to the private sector. However, portfolio debt outflows also brought currency depreciation and higher interest payments on domestic debt can even trigger a default and a full blown financial crisis. The crises in Mexico (1994), Korea (1996), Thailand (1996), Indonesia (1996), Malaysia (1996), Russia (1997), Brazil (1998), Ecuador (1998), Pakistan (1998), Ukraine (1998), Turkey (2000), Argentina (2000), Uruguay (2001), and Brazil (2002) demonstrated that unsustainable foreign currency denominated debt levels have the potential to trigger contagion, massive portfolio outflows, currency depreciation, higher domestic policy rates.

(1999) described the scenario as "original sin" in which emerging markets issued debt denominated in hard currencies, such as the dollar, instead of their own local currency. International financial institutions (World Bank and IMF (2001), Bank for International Settlements (2007)) supported local debt market development in emerging economies following the foreign currency debt problems in these economies the mid-1990s (Eichengreen and Hausmann (2003)). Local currency debt now accounts for 90 percent of all sovereign debt, compared to 70 percent a decade ago, and trading volumes for local currency debt are five times higher than hard currency debt (Hale et.al. (2014), LCBM (2014)). Local currency debt markets now exceed $4 trillion compared with only $1 trillion in the mid-1990s (Burger and Warnock (2006), Burger and Warnock (2012)). In fact, since the financial crisis, emerging market debt has increasingly become seen as a "safe" asset class by foreign investors (Miyajima et.al. (2012)). Some studies have shown that foreign investors reduce long-term local currency government debt yields and volatility (Peiris (2010)) while others have shown that they also increase volatility since the post-Lehman period (Ebeke and Lu (2014)). Foreign investors in emerging markets can trigger sudden stops and this chapter examines the effect of announcements on hard currency and local currency debt flows (Miyajima et.al. (2012), IMF Global Financial Stability Report (2014)).[3]

This chapter also contributes to the literature on the effect of monetary policy on international portfolio flows by using announcements classified by expectations for

[3]Countries that issue the largest quantity of local currency debt include Argentina, Brazil, Chile, China, Colombia, Croatia, Hungary, Indonesia, India, Lebanon, Malaysia, Mexico, Pakistan, Peru, Philippines, Russia, Saudi Arabia, South Africa, Thailand, and Turkey (LCBM, 2014).

an event study on debt flows, focusing on the debt flow currency denomination, differentiating between investors, and exploring regional debt flow differences. Several papers have examined transmission channel through which changes to expectations can affect portfolio investment by market participants (Morris and Shin (2014), Feroli et. al. (2014), Stein (2014), Global Financial Stability Report IMF (2014), Plantier (2015)). This chapter classifies all Fed announcements using measures of expectations from October 2008 until October 2014 and uses this classification to examine the response of emerging market debt flows by heterogeneous investors (Turner (2013), Shin (2013), Haldane (2014), Elliott (2014), Office of Financial Research (2013)).[4] Several empirical studies have examined the global effects of conventional and unconventional U.S. monetary policy (Edwards (2012), Rey (2013), Berge and Cao (2014), Rogers et.al. (2014), Gilchrist et.al. (2014), McCauley et.al. (2015)), the response of emerging market asset prices to U.S. monetary policy (Moore et.al. (2013), Bowman et.al.(2014)), and the effect of tapering news on emerging market financial markets (Eichengreen and Gupta (2013), Aizenman et.al. (2014)). Other papers have studied the effect of monetary policy on portfolio flows to emerging market economies using quarterly IMF balance of payments data (Ahmed and Zlate (2013), Lim et.al. (2014))[5] as well as daily, weekly, and monthly frequency portfolio flow data from Emerging Portfolio Funds Research (EPFR) Global (Fratzscher et.al. (2013), Koepke (2014), Rai and Suchanek (2014),

[4]The five largest asset managers (BlackRock, Vanguard, State Street, Fidelity, and PIMCO) had combined assets of $12 trillion under management and the ten largest asset managers had $18 trillion (Office of Financial Research (2013)).

[5]Ahmed and Zlate (2013) use quarterly IMF data from 2002Q1 to 2012Q2 for twelve countries (India, Indonesia, Korea, Malaysia, Philippines, Taiwan, Thailand, Argentina, Brazil, Chile, Colombia, Mexico) and show that net private capital inflows to emerging market countries are driven by a combination of interest rate differentials and global risk appetite.

Dahlhaus and Vasishtha (2014)).[6]

There are two papers that are closest to this one and for which it is worth highlighting similarities and differences. A paper by Koepke (2014) uses monthly EPFR data and federal funds futures in an OLS regression and examines the sign and statistical significance of federal funds futures to explain the change in flows. He finds that changes in federal funds futures are a statistically significant factor for emerging market portfolio flows. A working paper by Curcuru et. al. (2015) examines the effects of unconventional monetary policies by the Federal Reserve, Bank of England, European Central Bank, and Bank of Japan and on international capital flows. The focus of their paper is on developed market bond and equity funds as well as emerging market bond and equity funds. They classify announcements using monetary policy shocks (Rogers et.al. 2014) and find that the flows do not respond to the Federal Reserve or Bank of Japan but they do respond to the Bank of England and the European Central Bank. This paper classifies announcements using a shadow rate model estimated daily and conducts an event study on daily frequency debt flows from EPFR Global to differentiate between the effects of announcements on hard currency and local currency debt flows, between active and passive investors, and by the regional composition of the debt flows.

[6]Fratzscher et al. (2013) uses daily EPFR Global data from January 2007 until December 2010 for 42 emerging markets and 21 advanced economies and find that Quantitative Easing 1 lowered sovereign yields and raised equity markets; Quantitative Easing 2 raised equity markets and had no effect on bond yields.

2.3 Data

Federal fund futures contracts are used as one measure of monetary expectations in this chapter. Federal funds futures contracts are traded on the Chicago Board of Trade and have a payout at maturity based on the average effective federal funds rate that is realized for the calendar month in the contract. In this way, the price of these federal funds futures contract is closely related to the expectations of the average federal funds rate for the month studied. In normal times, 30 day federal fund futures contracts are used to estimate monetary expectations for the next meeting and for categorizing announcements. However, this measure of expectations does not change after the global financial crisis when the short-term policy rate reached the zero lower bound. These federal funds futures contracts are liquid up to five or six months but decrease dramatically after five or six months.[7] The federal fund futures measure used in this chapter is obtained through Bloomberg which gets its data from the Chicago Mercantile Exchange (CME) and sorts it into a moving time series for many different time periods. This chapter uses the two-year federal fund futures rate that has the Bloomberg ticker symbol FF24 Comdty.[8] This is the 24 month ahead futures contract through 2010 and the weighted average of the rates on the 24- and 25-month contracts thereafter (Christensen (2015)). After downloading this ticker symbol from Bloomberg, the variable is

[7]Several asset prices can be used to measure monetary policy expectations of the short term rate. Kuttner (2001) uses the current month federal fund futures contract, Bomfim (2003) uses the month-ahead federal fund futures contract, Cochrane and Piazzesi (2002) use the one-month eurodollar deposit rate, Rigobon and Sack (2002) use the three-month ahead eurodollar futures rate. Although Gürkaynak et al. (2007) finds that federal funds futures is the best measure of monetary expecations for up to six months the Eurodollar futures contracts may be better measures of monetary expectations at longer horizons.

[8]The Bloomberg function FFIP can be used to extract probabilities derived from options markets.

then converted into an interest rate by subtracting from 100. Figure 2.2 shows U.S. monetary expectations and includes the time series for federal funds futures 2 years.

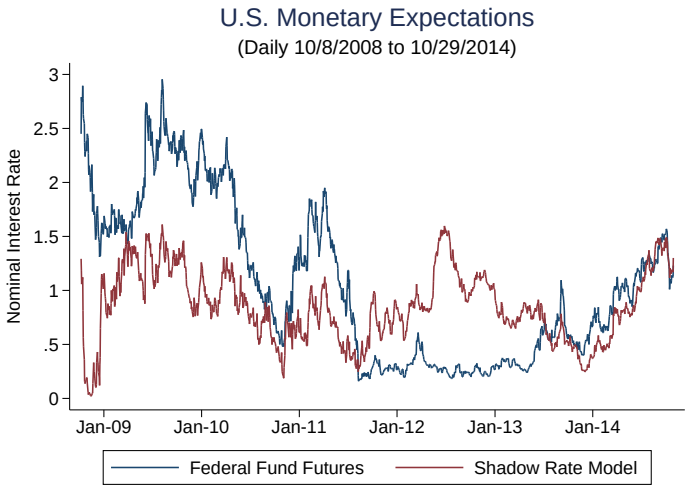


Figure 2.2: Federal Fund Futures and Shadow Rate Model two year short rate expectations.

The other measure of monetary expectations used in this chapter are the expected short rates from a shadow rate term structure model. Term structure models are widely used by financial market practitioners and central banks to examine the dynamic evolution of the yield curve using observed prices and estimating the slope, level and curvature of the yield curve. The most widely used term structure model is the one developed by Nelson-Siegel (1987) that provides a good yield curve fit for a cross section of yields (Kim and Wright (2005)). This chapter uses the short rate expectations from a shadow rate Arbitrage-Free Nelson-Siegel model developed by Christensen and Rudebusch (2013) that assumes interest rates have a lower bound of zero.[9] As

[9]More details on the Arbitrage-Free Nelson-Siegel (AFNS) model and the shadow rate Arbitrage-Free Nelson-Siegel (B-AFNS) model for estimating expectations and are included in Appendix A. Please refer to Christensen and Rudebusch (2013) for even more detail.

shown in Figure 2.2, this chapter uses the estimates of the two year expectations from the shadow rate model in order to compare with the federal fund futures measure of expectations.

The Federal Reserve announcement dates included in the analysis in this chapter are listed in Appendix Table 2.4 and all occurred between October 8, 2008 and October 29, 2014. The announcements that happened during this time period include all of the regularly scheduled Federal Reserve Open Market Committee (FOMC) announcement days and a few important announcements related to large scale asset purchases that were not part of the regularly scheduled FOMC announcement days. All of the FOMC announcement days are made publicly available and were obtained from the Federal Reserve Board of Governors website.[10] All of the additional days were taken from Rogers, Scotti, and Wright (2014) examining the effect of Federal Reserve announcements on asset prices. However, unlike Rogers, Scotti, and Wright (2014) which include announcement days until early 2014, this chapter includes FOMC announcement days until the end of large scale asset purchases in October 2014. In total, there are 54 announcements of which ten were Tuesday announcements, forty one were Wednesday announcements, one was a Thursday announcement, and two were Friday announcements.

The proprietary emerging market debt flow data used in this chapter is collected and distributed by Emerging Portfolio Funds Research (EPFR) Global. Headquartered in Cambridge, MA, EPFR Global was founded in 1995 and tracks regulated

[10]The Federal Reserve Board of Governors website: http://www.federalreserve.gov

mutual fund and exchange traded fund (ETF) flows that it collects from its direct relationships with fund managers and administrators. EPFR Global then uses this information to produce indicators for fund flows, country allocations, sector allocations and industry allocations and together with an allocation data series is able to estimate the flow data for country flows, sector flows, and industry flows. EPFR Global reports this data at the daily, weekly, and monthly frequencies.[11] EPFR Global currently tracks around 15,000 funds with investments across 130 countries and that cover $23.5 trillion worth of globally domiciled funds primarily domiciled in the United States and Europe. Of the $23.5 trillion of assets covered, approximately $16.2 trillion are from funds domiciled in the United States and $5.6 trillion in Europe.[12] The data covers 93 countries for equity flows, 100 countries for debt flows, and regional flows.

The flow data provided by EPFR Global is widely used among market participants and economic policymakers because of its timely release and its high frequency but has only recently been used by academic researchers.[13] The daily frequency flows are made available at 5pm EST for the previous day, the weekly fund fund flows data are made available at 5pm EST each Thursday for the previous 7 days, and the monthly

[11]Personal correspondence with EPFR Global indicates that many of the funds already report this data to regulators and to Bloomberg at these frequencies and so reporting to EPFR Global does not incur much cost. In addition, funds may receive some marketing value by reporting their activities to EPFR Global as they are included among other funds included in the data.

[12]To put this in perspective, the Investment Company Institute estimates in their Annual Report for 2015 that there are $33.5 trillion invested in mutual funds and ETFs worldwide. Therefore, EPFR Global covers roughly 75-80 percent of these funds.

[13]Emerging Portfolio Funds Research (EPFR) Global data has been used in 16 papers in topics related to political economy (Pepinsky (2014), Frot and Santiso (2012), capital flows (Miao and Pant (2012), Lo Duca (2012), Fratzscher et al. (2013), Fratzscher et.al. (2014), Jinjarak et al. (2011), Jotikasthira et al. (2012), Wei et al. (2010)), captial controls (Forbes et al. (2012), Jinjarak et al. (2013)), financial stability (Gelos (2011), Raddatz and Schmukler (2012), Yeyati and Williams (2012), Jones (2014), Puy (2016)), and international economic policy.

data is reported at 5pm EST on the 23rd for the previous month. EPFR Global provides historical data for equity flows since January 1995 (monthly), October 2000 (weekly), and May 2007 (daily) and debt flows since January 2004 (monthly), April 2004 (weekly) and May 2007 (daily). The fund flows data includes daily flows in U.S. dollars, cumulative flows in U.S. dollars, daily percentage change in flows, daily percentage change in cumulative flows, total net assets, valuation change due to exchange rate, net asset value percentage change, and the percentage change in cumulative net asset value. As shown in Appendix Table 2.2, almost all of the funds that report at the weekly frequency also report at the daily frequency. However, not all of the funds that report at the monthly frequency also report at the daily and weekly frequencies.

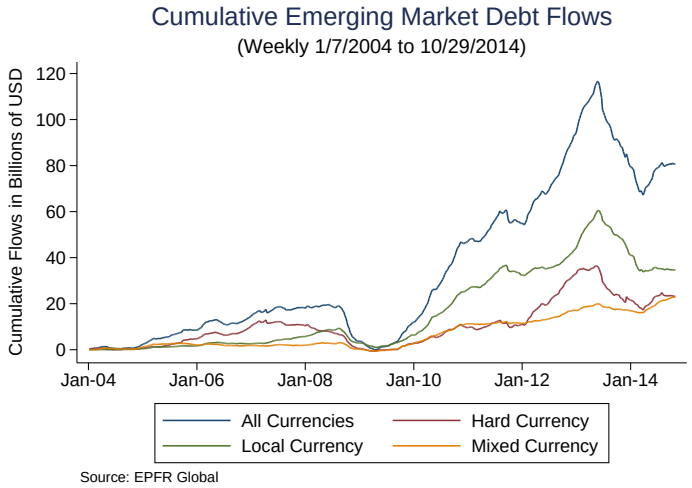


Figure 2.3: Emerging market debt flows by currency denomination.

The flow data from EPFR Global and flow data IMF Balance of Payments are different in several ways. The IMF Balance of Payments data tracks cross-border capital

flows but is only available on a quarterly basis and with a significant lag. Debt flows in the Balance of Payments are located in the financial account under portfolio investments and under liabilities. This portfolio liabilities line in the Balance of Payments covers all the cross border debt held by non-residents in that particular country. EPFR Global data is available at a much higher frequency than IMF Balance of Payments data and is released on a timely basis but covers a slightly different type of flows. The flow data provided by EPFR Global includes investment by residents and non-residents whereas the Balance of Payments data separates the debt flows by residency. EPFR Global data tracks fund flows that are domiciled globally but the vast majority of which are in the United States and Europe. In addition, EPFR Global portfolio flow data accounts for approximately 60 percent of total portfolio flows into emerging market funds. The EPFR Global data only tracks regulated managed funds and so does not track hedge funds, proprietary trading desks, foreign insurance companies investing in excess cash, and wealthy individuals and individual companies unless they invest in regulated managed funds. Miao and Pant (2012) find that the debt and equity data released by EPFR Global data closely matches quarterly IMF data on debt and equities that are released at 3 to 6 month lags. These authors also find that because 80 percent of the funds in the EPFR Global are U.S. domiciled and U.S. investors and can be considered foreign investors in emerging markets. Nonetheless, the EPFR Global data and IMF Balance of Payments data are different in the sense that the Balance of Payments data by definition captures the transactions between residents and non-residents whereas fund flows cover inflows in and out of mutual funds and exchange

traded funds.

The EPFR Global data can also be classified by the currency denomination of the debt flow. As shown in Figure 2.3, debt flows can be classified by whether the funds invest in hard currency, local currency debt, or mixed currency debt. The hard currency debt flows includes funds that invest 75 percent or more of their investment in traditional currency debt. These hard currency debt securities are denominated in U.S. dollars, Euros, British pound, Swiss franc, Japanese yen, Canadian dollar, Australian dollar, and Swedish krona. The local currency debt flows includes funds that invest 75 percent or more of their overall investment in local currency debt. These currencies include the Brazilian real, Polish zloty, Indian rupee, Chinese yuan and any currency other than the ones listed under hard currencies. The mixed currency debt funds invest in a combination of both such that they are less than 75 percent of either local currency debt and hard currency debt. The mixed currency debt flows are another category group in EPFR Global data and represent flows that are neither 75 local currency debt nor 75 hard currency debt. The sum of local currency, hard currency, and mixed currency debt flows is the equivalent to all the debt fund flows to emerging markets.

The EPFR Global data for emerging market debt flows can be classified into active and passive investor categories.[14] The categorization as active or passive is made by EPFR Global based on information provided by each fund. The active investor

[14]EPFR Global defines the retail investor category as including funds that are marketed towards and have a primary focus for retail investors. Funds with less than $100,000 in assets are classified as a retail funds. The institutional investor category includes funds that are marketed towards and have a primary focus for institutional investors. Funds with more than $100,000 in assets are classified as an institutional fund. The sum of the retail and institutional investor categories for every asset class of debt funds is the same as the all investor category.

category includes funds that use discretion because their allocations and investment decisions are not tied to an index or to a performance benchmark. An active fund is actively managed by an individual manager or team of managers.[15] The active fund managers build and maintain a portfolio and use discretion to make decisions about securities to buy, sell, or hold as part of their investment portfolio. The active fund managers make investments based on research and judgments about fundamentals, economic trends and cycles for industries or asset classes. The passive investor category do not have discretion to make these independent strategic decisions because their investment strategy tied to an index or benchmark. The passively managed funds must match the holdings and returns of a particular market index or benchmark such as the MSCI or the EMBI.[16] Mutual funds are usually categorized as active funds because the fund manager makes strategic decisions about the portfolio whereas exechange traded funds (ETFs) are typically considered passive funds because the manager does not have the ability to make strategic decisions.

The EPFR Global debt flows data can also be classified into regions. These regional classifications include Asia excluding Japan, EMEA, Latin America, and Global Emerging Markets (Global EM).[17] The Global EM classification includes funds that

[15]Large active managers include Franklin Templeton, Fidelity, and Capital Group.

[16]MSCI has provided equity index products since 1969 and became a public company in November 2007 by its only two shareholders Morgan Stanley and Capital Group International Inc. ("Capital Group International"). EMBI was set up in 1992 to track external debt instruments in emerging markets and originally only covered Brady bonds, loans, and Eurobonds. J.P. Morgan has since introduced EMBI+ to track debt in emerging markets with a minimum face value of $500 million and that meet strict criteria as well as the less strict Emerging Market Global Index (EMBIG) to track local currency and hard currency denominated debt in emerging markets with a face value of at least $500 million.

[17]The hard currency debt is grouped as Asia ex-Japan Regional Funds (Asia ex-Japan Regional Funds, Philippines Funds), EMEA Funds (Africa Regional Funds, Emerging Europe Regional Funds, Middle East Regional Funds, Russia Funds, Slovak Republic Funds), GEM Funds (Global Emerging Markets

may invest across a number of regions. For example, a fund that invests in Brazil, Russia, India and China would fall under the Global EM category since it invests in Latin America, Europe Middle East and Africa, and Asia excluding Japan. Although EPFR Global also provides the allocation data for Global EM funds, and estimates the regional flows based on the flow and allocations data it receives from fund managers and administrators, this data does not have information on the currency denomination of the investments. By analyzing Global EM as its own regional group this chapter is able to focus on the hard currency debt flows, local currency debt flows, and mixed currency debt flows.

The robustness checks in this chapter use volatility and oil price measures obtained from Bloomberg. The VIX is a commonly used indicator of volatility and measures the implied volatility of the S&P 500 index options calculated by the Chicago Board Options Exchange (CBOE) that measures the stock market's expectations of stock market volatility over the next 30 day period. The West Texas Instruments (WTI) Cushing crude oil price is the most commonly used benchmark for global oil prices. The WTI Cushing crude oil price measures the price of crude at Cushing, OK and trades in pipeline lots of 1,000 to 5,000 barrels a day for delivery between the 25th

Funds), Latin America Funds (Brazil Funds, Latin America Regional Funds, Mexico Funds). The local currency debt is grouped as: Asia ex-Japan Regional Funds (Asia ex-Japan Regional Funds, China Funds, Greater China Funds, India Funds, Indonesia Funds, Korea (South) Funds, Malaysia Funds, Taiwan Funds, Thailand Funds), EMEA Funds (Czech Republic Funds, Emerging Europe Regional Funds, Hungary Funds, Israel Funds, Poland Funds, Romania Funds, Russia Funds, South Africa Funds, Turkey Funds), GEM Funds (BRIC Funds, Global Emerging Markets Funds), Latin America Funds (Brazil Funds, Colombia Funds, Latin America Regional Funds, Mexico Funds). The mixed currency debt flows are grouped as Asia ex-Japan Funds, EMEA Funds (Africa Regional Funds, Emerging Europe Regional Funds, Europe Middle East and Africa Regional Funds, Middle East and Africa Regional Funds, Middle East Regional Funds, Poland Funds, Russia Funds, Turkey Funds), GEM Funds (BRIC Funds, Global Emerging Market Funds), Latin America Funds (Latin America Regional Funds).

of one month to the 25th of the next month.

2.4 Methodology

This section describes the methodology used for estimating the effect of changes to U.S. monetary expectations on emerging market debt flows in two parts. First, this section explains the methodology used for classifying the Federal Reserve announcement as easing (unexpected), tightening (unexpected), easing (expected) and tightening (expected) using changes to monetary expectations measured by federal funds futures and a shadow rate model. Second, this section explains the methodology for estimating the effects of expectations of the short-term rate have on emerging market debt flows.[18]

2.4.1 Classifying Federal Reserve Announcements

Federal Reserve announcements are classified by measuring the changes in expectations around announcement days. As described in the previous section these market expectations of the future short rate used in this chapter include federal funds futures and the shadow rate term structure model. These measures of market expectations of the future short rate can change even if the actual short term policy rate remains unchanged. Both of these measures of expectations are used to classify Federal Reserve announcements into one of the following four categories: easing (unexpected), tightening (unexpected), easing (expected), and tightening (expected). An announcement cannot

[18]Previous approaches to understanding the reaction of portfolio fund flows to Federal Reserve monetary policy have relied on VAR methods (Feroli et. al. (2014), Rai and Suchanek (2014), Dahlhaus and Vasishtha (2014), Global Financial Stability Report IMF (2014), McCauley et. al. (2014), Plantier (2015)), OLS regressions (Edwards (2012), Koepke (2014)), and an event study (Curcuru et. al. (2015).

be classified if the measure of expectations does not change on the announcement day.

The Federal Reserve announcements between October 8, 2008 and October 29, 2014 are classified in the following manner. First, each daily measure of expectations is converted into the daily percentage change of that measure of expectations. This daily percentage change measure is then converted into positive values by taking the absolute value of all the daily percentage change observations. Second, the mean change in the absolute value of all the daily percentage change observations is calculated to find the average level of daily change in expectations over the entire sample period. Third, each of the Federal Reserve announcements are classified by comparing the percentage change in expectations on that day relative to mean absolute value of the change in that measure of expectations on all the other days in the sample period. If the change in expectations on an announcement day is above an average change in expectations on all the other days in the sample period then it is unexpected. Conversely, if the change expectations on an announcement day is less than an average change in expectations on all other days, then it is expected. Announcements are classified as easing if the change in expectations is negative and tightening if the change in expectations is positive.

2.4.2 Effects of Federal Reserve Announcements on EM Debt Flows

The event study methodology used to estimate the effect of Federal Reserve announcements on emerging market debt flows uses the announcements classified by the shadow rate model together with the EPFR Global data. Equation (1) is the regression specification that is used to understand the effect of announcements on emerging market

debt flows.

$$\textit{Debt Flows}_{ijrt} = \widehat{\beta}_0 + \widehat{\beta}_1(\textit{Shadow Rate Announcements}_{kt}) + \varepsilon_{ijrt} \tag{1}$$

The *Debt Flows* variable on the left hand side of (1) is the daily frequency debt fund data on flows to emerging markets from EPFR Global. This variable is categorized by investor subscript i for whether these portfolio debt fund flows are from all investors, active investors, or passive investors. The subscript j denotes whether they are all currency flows, hard currency flows or local currency flows. The subscript r specifies the regional focus of the debt flows as either Asia excluding Japan, EMEA, Latin America, or Global EM. Finally, the subscript t denotes the time of the announcement to indicate the precise time for the debt flows around that announcement day. On the right hand side of equation (1) is the *Shadow Rate Announcements* variable that are categorized using market expectations from the shadow rate model. These announcements are denoted by subscript k to specify the announcements as easing (unexpected), tightening (unexpected), easing (expected), and tightening (expected). Furthermore, the subscript t emphasizes the announcement day.

The event study uses announcements classified by the shadow rate model and seven day event windows.[19] All four measures of flows i are examined across all four announcement categories k for each of the investor categories i, asset classes j, and regions r. For example, to understand the response of all emerging debt flows j by all

[19]The seven day window size is large enough to capture the time that portfolio investors can take to respond to events while at the same time is small enough so that it captures effects from Federal Reserve announcements.

investors i to all announcements k we take all the announcements that are classified as easing (unexpected) announcements and examine the effect of these announcements on emerging market debt flows the seven days before and after these announcements. This process is repeated for every other announcement classification tightening (unexpected), easing (expected), tightening (expected). Once all four announcement classifications have been examined on all flows, for all investors, and all regions, the procedure is repeated for each of the other currency classifications j (hard currency, local currency, mixed currency), investors classifications i (active investors, passive investors), and regional classifications (Asia excluding Japan, EMEA, Latin America, Global EM). Each event study is standardized according to the mean and standard deviation of the flows in that group in order to be able to compare the coefficients and significance across each of the announcement classifications.

$$\textit{Debt Flows}_{ijrt} = \widehat{\beta}_0 + \widehat{\beta}_1(\textit{Shadow Rate Announcements}_{kt}) + \textit{Control}_{mt} + \varepsilon_{ijrt} \quad (2)$$

The robustness checks used in the chapter involves including additional control variables into the event study regressions. The *Debt Flows* variable and the *Shadow Rate Announcements* variable in equation (2) are the same as those variables in Equation (1). The control variables *Control* are introduced into the regression equation (2) to make sure that the changes in flows before and after Federal Reserve are not the result of changes in other factors. These control factors denoted by subscript m at time t are introduced separately into the regressions and include a measure of uncertainty the

VIX and commodity prices. The robustness checks including these control variables for regional emerging market debt flows (Asia excluding Japan, EMEA, Latin America, and Global EM) are reported in Appendix Table 2.7 to Appendix Table 2.10.

2.5 Results

The results are separated into a section for classifying Federal Reserve announcements and a section for the effects of Federal Reserve announcements on emerging market debt flows. The results for the effects of Federal Reserve announcements on emerging market debt flows are grouped into a subsection for overall emerging debt flows and into a subsection for regional emerging market debt flows.

2.5.1 Classifying Federal Reserve Announcements

As shown in Table 2.1, the two measures of U.S. monetary expectations classify the 54 Federal Reserve announcements between October 8, 2008 and October 29, 2014 differently. The federal fund futures 2 years ahead measure classifies 47 announcements and the shadow rate model classifies 54 announcements. The following analysis will show that the shadow rate model classifies the announcements during this time period the best and will be used for analyzing the effect of announcements on debt flows to emerging markets.

The federal fund futures 2 years ahead measure of expectations classifies 47 announcements in the sample: 15 easing (unexpected) events, 10 tightening (unexpected) events, 9 easing (expected) events, and 13 tightening (expected) events. These events

Table 2.1: Federal Reserve Announcements Classification Results

	Federal Fund Futures	Shadow Rate Model
	(1)	(2)
Easing (Unexpected)	15	14
Tightening (Unexpected)	10	9
Easing (Expected)	9	16
Tightening (Expected)	13	15
Unclassified	7	0
Total	47	54

are shown graphically in Figure 2.4. The absolute value mean daily percentage change in the fed futures over the sample period, and the threshold for being an unexpected announcement was 3.96 percent with a standard deviation of 4.32 percent. The smallest change was 0 and the largest change in federal fund futures was 49.39 percent. The federal fund futures measure of expectations could not classify 7 of the announcements in the period because it remained unchanged on those days. A significance test of the daily percentage change in federal fund futures measure of expectations on the announcement day relative to the previous seven days is shown in Appendix Figure 2.16.

There are two main criticisms for using the federal fund futures 2 years ahead measure of expectations of monetary policy. First, although federal fund futures may be the best measure of Fed monetary policy at shorter duration of up to 6 months they are not actively traded at longer horizons. The lack of liquidity in federal fund futures contracts at duration beyond six months helps explain why this measure of expectations did not change on seven of the announcement days Second, federal fund futures contracts at longer duration have term premia that bias their measure of expectations. If term premia change during the sample period then changes in federal fund futures may

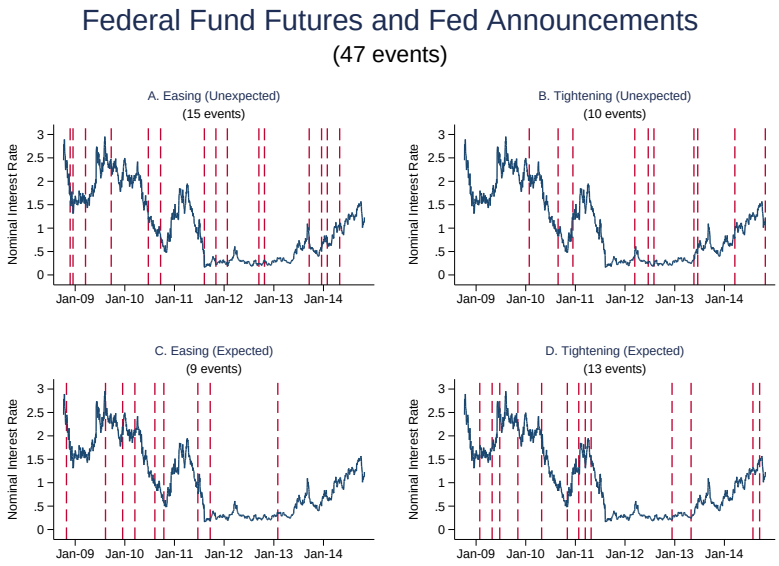


Figure 2.4: Classification of Federal Reserve announcements by Federal Fund Futures as easing (unexpected), tightening (unexpected), easing (expected), and tightening (expected).

not reflect changes in expectations of Fed policy but instead reflect changes in market risk and overall financial conditions.

The shadow rate model classifies all 54 announcements over the sample period: 14 easing (unexpected) events, 9 tightening (unexpected) events, 16 easing (expected) events, and 15 tightening (expected) events. These events are shown graphically in Figure 2.5. The mean absolute value change in expectations for the shadow rate model is 5.40 percent and with a standard deviation of 10.25 percent. The minimum change in expectations was 0 percent and the maximum change in expectation was 191.49 percent. Indeed, this is because the shadow rate model imposes a zero lower bound on the expectations for the short rate, which makes the model and the expectations for

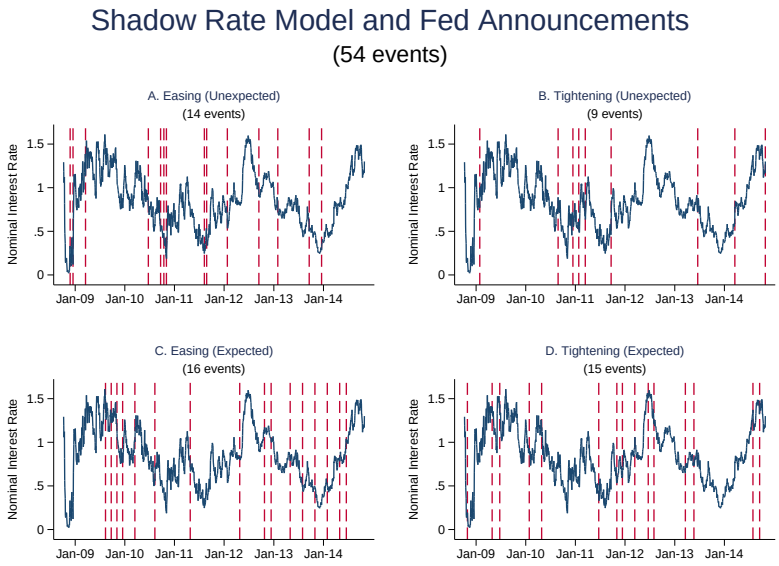


Figure 2.5: Classification of Federal Reserve announcements by the Shadow Rate Model as easing (unexpected), tightening (unexpected), easing (expected), and tightening (expected).

the short rate much more stable. A significance test of the daily percentage change in shadow rate model measure of expectations on the announcement day relative to the previous seven days is shown in Appendix Figure 2.17.

In conclusion, this section showed that the expected short rate estimations from the shadow rate model provides the best measure of short rate expectations at the two year horizon for classifying Fed announcements. The shadow rate model classifies all of the announcements and overcomes the issues with liquidity, term premia, and stability that make the other measures unable to properly classify monetary announcements. The comprehensive results of the Federal Reserve announcement classification is shown in Appendix Table 2.4. In the next section, the announcements classified as easing

(unexpected), tightening (unexpected), easing (expected), and tightening (expected) by the shadow rate model will be used in an event study to examine their effect on emerging market debt flows.

2.5.2 Effects of Federal Reserve Announcements on EM Debt Flows

This section explains the event study results of Federal Reserve announcements on emerging market debt flows. The main result from this analysis will show that announcements classified as tightening (unexpected) announcements have a statistically significant effect on emerging market debt flows, leading to outflows from emerging markets. An examination of these tightening (unexpected) announcements on emerging market debt classified by currency shows that hard currency debt flows respond more to announcements than local currency debt flows. Furthermore, active investors respond more to local currency debt flows and passive investors respond more to hard currency debt flows. The regional event study results are used to explain differences across regions in addition to their currency and investor categories. The event study using regional emerging market debt flows indicates that flows to Asia excluding Japan respond to both easing (unexpected) and tightening (unexpected) in hard currency flows but not in local currency flows. However, easing (unexpected) and tightening (unexpected) announcement affect local currency debt flows to Latin America but not hard currency debt flows.

Overall EM Debt Flows

As shown in Figure 2.6, the main result is that tightening (unexpected) announcements are the only announcement classification that has an effect on all emerging market debt flows within a seven day event window for all emerging market debt flows. The tightening (unexpected) announcements reduce all debt flows by all investors by 0.47 standard deviations or $177.64 million less per week in flows the week after than the week before a tightening (unexpected) Federal Reserve announcement.[20] These tightening (unexpected) announcements reduce hard currency debt flows by .46 standard deviations the week following an announcement from the mean level of flows before a tightening (unexpected) announcement or the equivalent of $72.31 million. The tightening (unexpected) announcements do not have a statistically significant effect on local currency debt flows. The tightening (unexpected) announcements reduce mixed currency debt flows by 0.47 standard deviations the week following an announcement from the mean level of flows before a tightening (unexpected) announcement or the equivalent of $30.19 million.

The event study results for active investors tell a similar story. As shown in Figure 2.7, active investors respond only to the tightening (unexpected) announcements and not to the other announcement classifications in a significant manner. However, active investors respond to tightening (unexpected) announcements regardless if they are invested in hard or local currency debt. Tightening (unexpected) announcements re-

[20]To obtain a dollar figure the same regression is used without standardizing to the mean and standard deviation of flows.

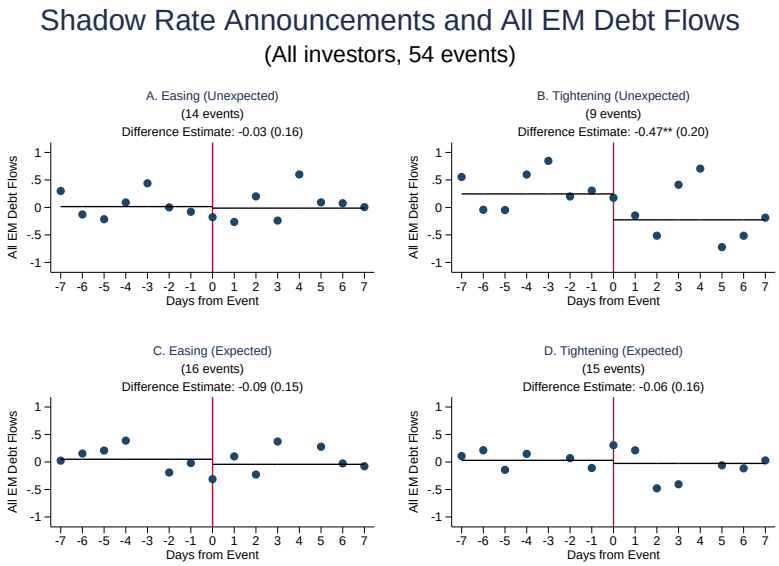


Figure 2.6: Standardized effects of Federal Reserve announcements classified by the Shadow Rate Model on all emerging market debt flows by all investors.

duce all flows to emerging markets by .44 standard deviations, or approximately $194.44 million, the week after an announcement. The tightening (unexpected) announcements reduce hard currency flows by .37 standard deviations or $47.07 million and local currency flows .36 standard deviations or $72.37 million. The tightening (unexpected) announcements reduce mixed currency debt flows by active investors by 0.47 standard deviations or $29.99 million in the week after these announcements.

The passive investors behave differently from active investors. Passive investors only respond to tightening (unexpected) announcements all currency debt flows and for hard currency flows but not for local currency debt flows. The tightening (unexpected) announcements reduce flows by .49 standard deviations and hard currency

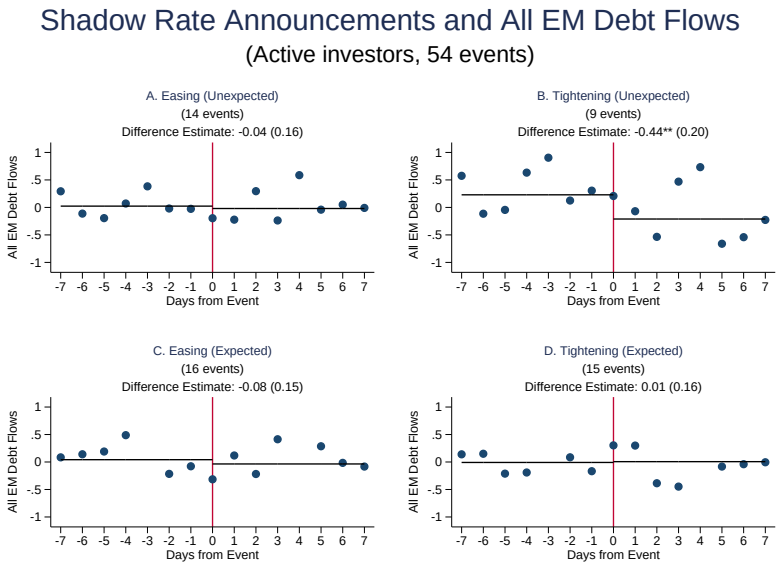


Figure 2.7: Standardized effects of Federal Reserve announcements classified by the Shadow Rate Model on all emerging market debt flows by active investors.

flows, as shown in Figure 2.8, by .51 standard deviations. This is equal to $28.20 million for all currency debt flows and $25.24 million for hard currency debt flows. There is not sufficient data for mixed currency debt flows by passive investors to be able to analyze their response to announcements.

Overall, these results suggest that announcements classified as tightening (unexpected) affect emerging market debt flows more than any other kind of announcement category and cause outflows from emerging markets. These overall results are available in Appendix Table 3.6. Hard currency debt flows respond more to these tightening (unexpected) announcements than the local currency debt flows. In addition, while the active investors respond to tightening (unexpected) announcements in all currency

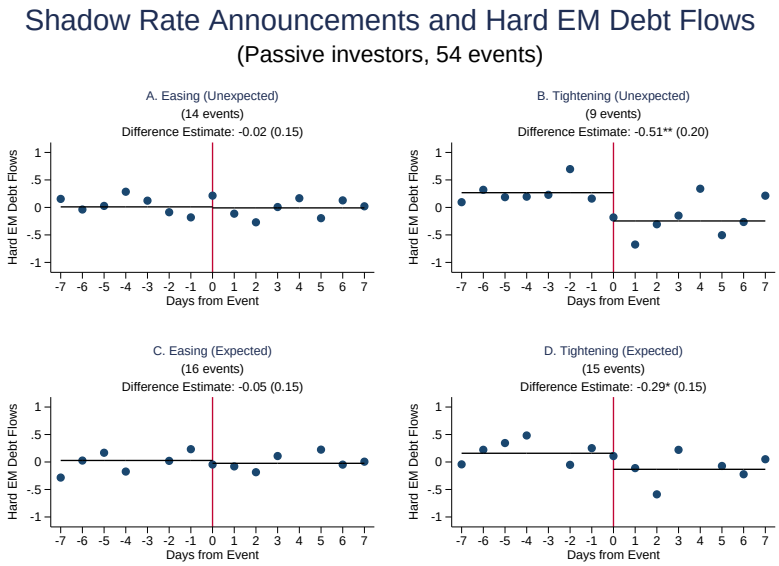


Figure 2.8: Standardized effects of Federal Reserve announcements classified by the Shadow Rate Model on hard currency emerging market debt flows by passive investors.

debt flows, hard currency debt flows, and local currency debt flows the passive investors only exhibit a strong reaction in all currency debt flows, hard currency debt flows but not the local currency debt flows. There is not sufficient data for passive investors and mixed flows to be able to include their response to announcements in this analysis.

Regional EM Debt Flows

The same methodology for examining overall debt flows to emerging markets is used to analyze the regional debt flows to emerging markets by all investors and by whether the flows are classified as all currency debt flows, hard currency debt flows, local currency debt flows, or mixed currency debt flows. EPFR Global data classifies

the debt flows into Asia excluding Japan, EMEA, Latin America, and Global Emerging Markets (Global EM). The emerging market debt funds that are classified as Global EM do not invest in one region but may have investments across regions.

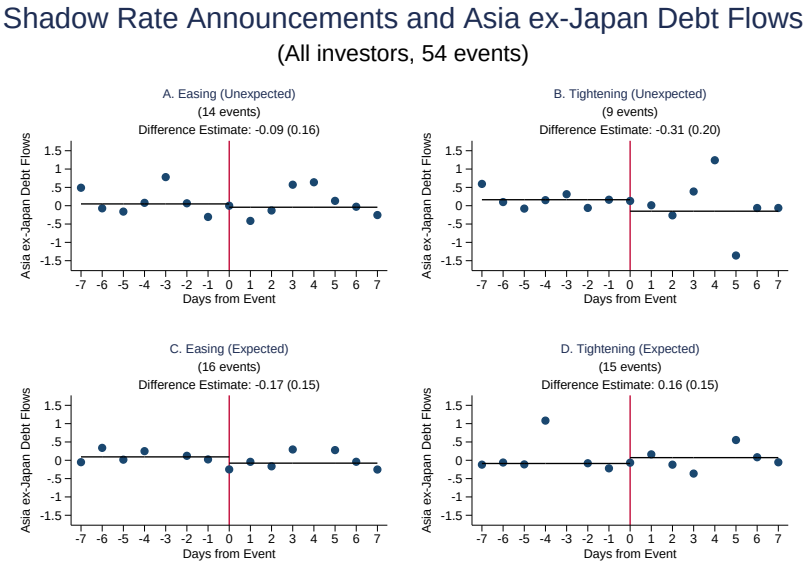


Figure 2.9: Standardized effects of Federal Reserve announcements classified by the Shadow Rate Model on Asia excluding Japan debt flows by all investors.

The emerging market debt flows to Asia respond the least among all the regions to Federal Reserve announcements. As seen from Figure 2.9, debt flows to Asia excluding Japan show no significant response to any announcement classification. The hard currency debt flows to Asia excluding Japan respond to both the easing (unexpected) announcements and the tightening (unexpected) announcements. An easing (unexpected) announcement increases hard currency debt flows to the region by .29 standard deviations compared to before the announcement, which is the equivalent of

$1.24 million. A tightening (unexpected) announcement has almost twice the size and a negative effect on flows of .43 standard deviations, which is the equivalent of $2.36 million. Interestingly, neither the local currency debt flows nor the mixed currency debt flows to Asia excluding Japan respond to any announcement.

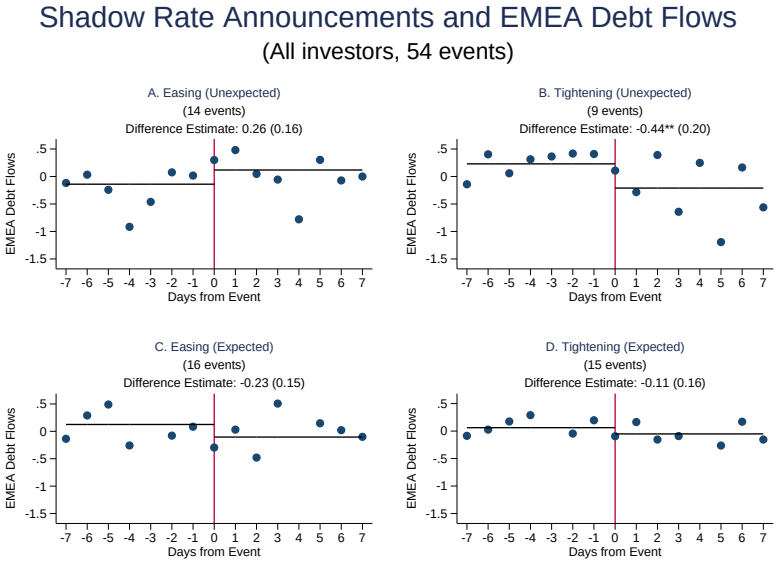


Figure 2.10: Standardized effects of Federal Reserve announcements classified by the Shadow Rate Model on EMEA debt flows by all investors.

The emerging market debt flows to the EMEA region respond to tightening (unexpected) announcements for all flows but not for hard currency debt flows or for local currency debt flows. As seen from Figure 2.10, the tightening (unexpected) announcement classification reduces all flows by .44 standard deviations, which is the equivalent of $5.01 million. The hard currency and local currency debt flows to the EMEA region do not show a statistically significant response to any classification of

announcement. The mixed currency debt flows reduce to the EMEA region reduce by -.41 standard deviations, which is equal to $2.28 million.

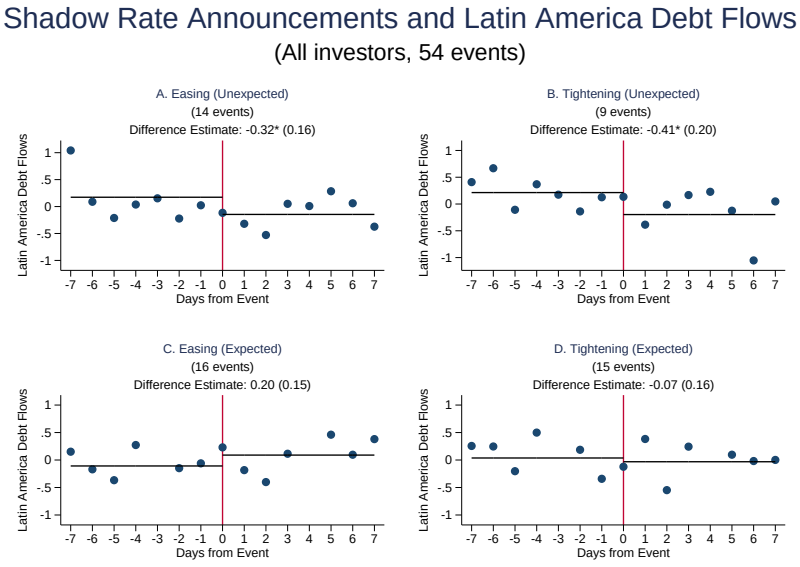


Figure 2.11: Standardized effects of Federal Reserve announcements classified by the Shadow Rate Model on Latin America debt flows by all investors.

The emerging market debt flows classified as going to Latin America respond the most to announcements compared to emerging market debt flows to any the other region. The debt flows to Latin America, in contrast to the debt flows to Asia excluding Japan, respond to announcements in all currency debt flows and local currency debt flows but not the hard currency debt flows category. From Figure 2.11, all currency debt flows for Latin America respond negatively to easing (unexpected) announcements by .32 standard deviations or $11.01 million and negatively to tightening (unexpected) announcements by .41 standard deviations or $12.69 million. The hard currency debt

flows to Latin America do not respond to announcements, including tightening (unexpected) announcements. The local currency debt flows to Latin America reduce by .34 standard deviations or $11.66 million following an easing (unexpected) announcement or by .46 or $12.98 million following a tightening (unexpected) announcement. The mixed currency debt flows only respond positively to easing (unexpected) announcements and increase by 0.29 standard deviations, or $.10 million.

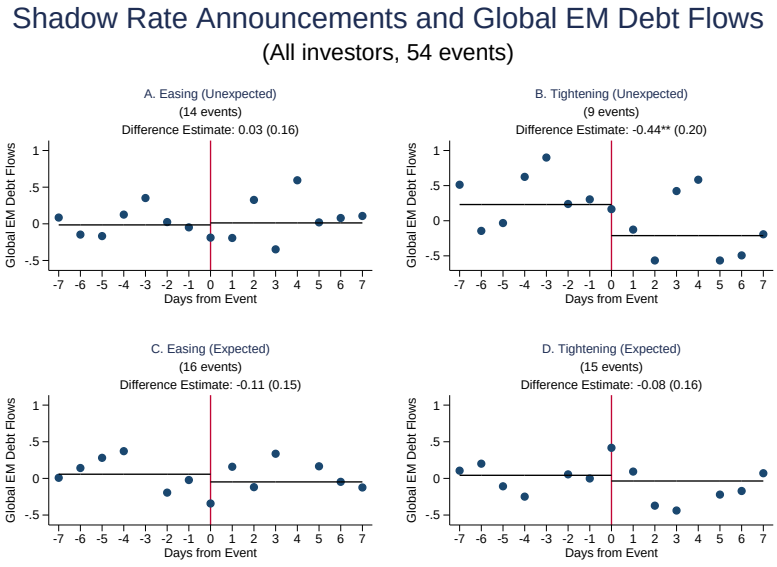


Figure 2.12: Standardized effects of Federal Reserve announcements classified by the Shadow Rate Model on Global EM debt flows by all investors.

The emerging market debt flows classified as going to Global Emerging Markets (Global EM) respond to tightening (unexpected) announcements. As seen from Figure 2.12, the Global EM debt flows respond negatively by .44 standard deviations or $143.56 million after an tightening (unexpected) announcement but not to any other

announcement classification. The hard currency debt flows to Global EM respond negatively by .46 standard deviations or $70.04 million in the week after tightening (unexpected) announcement compared to before a tightening (unexpected) announcement. The local currency debt flows to Global EM do not show a significant response to any announcement classification, including tightening (unexpected) announcements. The mixed currency debt flows to Global EM respond negatively by .47 standard deviations or $27.65 million to tightening (unexpected) announcements.

In summary, the results from analyzing the emerging market debt flows by region suggest that Latin America is the most responsive to Federal Reserve announcements and that the Asia excluding Japan region is the least responsive to these same announcements. These comprehensive regional emerging market debt flow results are also shown in Appendix Table 2.6. An analysis of debt flows by currency indicates that hard currency debt flows to Asia respond to announcements whereas the hard currency debt flows to Latin America do not respond to announcements. The emerging market debt flows in local currency do not respond to any announcement category in local currency to Asia excluding Japan, which suggest that the debt flows in local currency are relatively more stable than the hard currency debt flows to this region. For the Latin America region, however, local currency debt flows respond to the announcements but the hard currency debt flows do not respond to the announcements. The EMEA debt flows only respond to tightening (unexpected) announcements for all currency debt flows but not separately for hard currency debt flows or for local currency debt flows. The debt flows in the Global EM category behave similar to the Asia excluding Japan

regional debt flows except that the tightening (unexpected) announcements also affect all currency debt flows. The local currency debt flows in the Global EM category do not respond to tightening (unexpected) announcements as they do in the debt flows to Latin America. The mixed currency debt flows to the EMEA region and Global EM respond to tightening (unexpected) announcements but otherwise do not respond to announcements any statistically significant way.

2.6 Robustness

The first robustness check uses the VIX as a control in regression equation (1) to check for whether changes to debt flows is due to the announcements and not to changes in the VIX on debt flows. The second robustness check uses oil price as a control in regression equation (1) to see whether the changes to debt flows can be explained by the change in oil prices in the week before and after the announcements.

2.6.1 VIX

Previous literature has shown that global risk aversion, measured by the VIX, may help explain portfolio flows to emerging markets (Ahmed and Zlate (2013), Nier, Sedik, and Mondino (2014), Rey (2014), Ananchotikul and Zhang (2014), Koepke (2014)). When global risk aversion is high, for example, global investors are more likely to put their money into "safe" assets such as U.S. Treasuries and less likely to put their money into emerging market debt. The VIX is added to the regression in order to make sure that the emerging market debt flows are responding to Federal Reserve

announcements and not to changes in global risk aversion as measured by the VIX. The VIX control variable is a popular measure of implied volatility of the S&P 500 index options calculated by the Chicago Board Options Exchange (CBOE) and measures the stock market's expectations of stock market volatility over the next 30 day period. The results from this robustness check, shown in Appendix Table 2.7 and Appendix Table 2.8, indicate that adding the VIX to the specification does not change the results for either overall emerging market debt flows nor does it change the results for regional emerging market debt flows.

2.6.2 Oil Price

The oil price, West Texas Intermediate (WTI) is used another separate control variable that may affect emerging market debt flows. Emerging economies that are net oil exporters reliant on petroleum export receipts will be negatively affected by lower oil prices while emerging economies that are net oil importers benefit from decline in oil price. Adding a control for oil prices before and after Federal Reserve announcements ensures that the debt flows are responding to the announcements and not the oil prices. The results from the robustness check, shown in Appendix Table 2.9 and Appendix Table 2.10, indicate that adding the oil price into the specification does not invalidate the results for overall emerging market debt flows and for regional emerging market debt flows.

2.7 Conclusion

The purpose of this chapter was to examine the effect of Federal Reserve announcements on emerging market debt flows since the Global Financial Crisis. First, the chapter provided two ways to measure expectations, federal fund futures and a shadow rate model, and used them to classify all the Federal Reserve announcements from October 8, 2008 until October 29, 2014 as either easing (unexpected), tightening (unexpected), easing (expected), or tightening (expected). The shadow rate model measure of expectations was better able to classify the announcements than the federal fund futures measure. Second, the chapter used the announcements classified by the shadow rate model for an event study on emerging market debt flows classified by currency denomination, investor, and region. The results showed that tightening (unexpected) announcements had an effect on emerging market debt flows but that the effect differed depending on whether the debt was denominated in hard or local currency and whether the debt flow was by an active or passive investor. Furthermore, an examination of the debt flows by region showed that Asia excluding Japan, Europe Middle East and Africa (EMEA), Latin America, and Global Emerging Markets (Global EM) differed in their response to tightening (unexpected) announcements. Although Asia excluding Japan responded the least to announcements, especially in local currency debt, the hard currency debt flows to Asia excluding Japan were sensitive to easing (unexpected) and tightening (unexpected) announcements. In contrast, Latin America responded the most to announcements. The emerging market debt flows to Latin America responded

to easing (unexpected) and tightening (unexpected) announcements announcements in all currencies and in local currencies but not in hard currencies.

Consistent with the literature on the transmission of monetary policy to financial markets this chapter found that the effect of Federal Reserve announcements on financial markets depends on whether the information content in these announcements is expected or unexpected. The conventional way of classifying Federal Reserve announcements as expected or unexpected or as easing or tightening uses a 30 day measure of monetary expectations from federal funds futures. This is 30 day measure of expectations is not a useful measure of expectations for classifying announcements since the Global Financial Crisis because expectations in 30 days did not change substantially at the zero lower bound. Changes to the two year expectations of the short rate using federal fund futures and a shadow rate model were used to classify the Federal Reserve announcements during this time period. The shadow rate model was better able to classify all of the announcements than federal fund futures because it was more actively traded and did not have term premia. Therefore, the announcements classified by the shadow rate model as easing (unexpected), tightening (unexpected), easing (expected), and tightening (expected) were used for an event study to estimate the effect of announcements on emerging market debt flows.

The chapter then used the four announcement classifications to estimate their effect on daily frequency emerging market debt flows by their currency denomination and their investor. The results showed that tightening (unexpected) announcements had the most significant effect on emerging market debt flows. Furthermore, these tightening

(unexpected) announcements were significant for all debt flows and hard currency debt flows for all investors, active investors, and passive investors. Tightening (unexpected) announcements had a greater effect on hard currency debt flows than for local currency debt flows. The local currency debt flows category by all investors did not respond to tightening (unexpected) announcements and neither did the local currency debt flows by passive investors. However, active investors were equally responsive to tightening (unexpected) announcements regardless of whether the emerging market debt was in hard currency or local currency. This analysis of overall debt flows suggests that local currency debt flows are less volatile to announcements than hard currency debt flows.

After finding that announcements affect overall emerging market debt flows the chapter then turned towards an examination of whether certain regions were more affected by announcements than other regions. The emerging market debt flows were classified into four regions and analyzed separately for Asia excluding Japan, EMEA, Latin America and Global EM. Consistent with the analysis on overall debt flows, the regional analysis showed that tightening (unexpected) announcements had the most significant on emerging market debt flows. Furthermore, these tightening (unexpected) announcements had the smallest effect on debt flows to the Asia excluding Japan region showed the largest effect on debt flows to Latin America. Emerging market debt flows Asia excluding Japan denominated in hard currency, however, did respond to easing (unexpected) and tightening (unexpected) announcements even though the debt flows to this region in local currency did not respond to these announcements. On the other hand, debt flows denominated in hard currency to Latin America did not

respond to announcements while they did respond to easing (unexpected) and tightening (unexpected) announcements in local currency. Finally, an examination of the regional debt flows by whether they were by an active or passive investor showed that the active investors respond similarly to all investors. Due to limited data available for passive investors by region, the analysis was only able to show that passive investors respond to tightening (unexpected) announcements by reducing their emerging market debt flows to Global EM in all and hard currency.

This chapter provides insights on the effects of Federal Reserve announcement days on emerging market debt flows. Future work could focus on additional issues related to the currency, investor, and region of emerging market debt flows. This chapter found that tightening (unexpected) announcements matter for debt flows and that hard currency debt flows are more sensitive to tightening (unexpected) announcements than local currency debt flows. Interestingly, the chapter found that passive investors are more sensitive to Federal Reserve announcements than active investors. Future work could explore whether these differential responses are driven by strategic moves by active investors, by the slow response of active investors, or the specific nature of passive investors. In addition, this research could explore whether these differences between active and passive investors are unique to debt flows or if they also show up for equity flows. This chapter found that Latin America is the region most sensitive to the tightening (unexpected) Federal Reserve announcements. It would be interesting to explore which countries in Latin America are most sensitive to Federal Reserve announcements and to determine whether these differences are due to fundamentals or

to liquidity conditions. Finally, this methodology and data could be used to examine effects of announcements by other central banks on international financial flows.

2.8 Appendix Figures and Tables

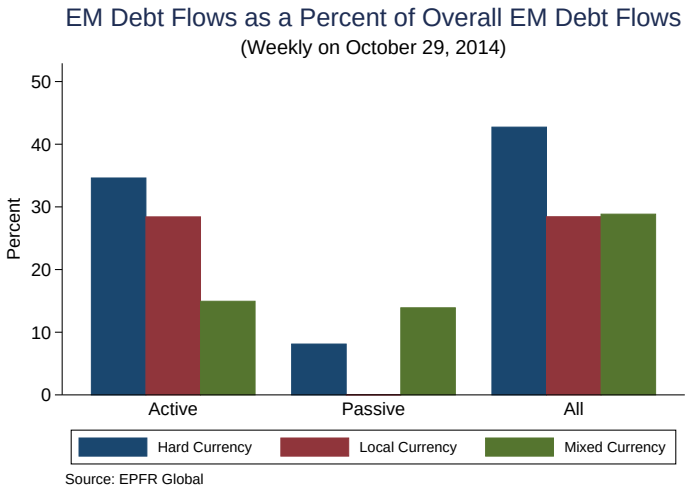


Figure 2.13: Cumulative emerging market debt flows by investor and region.

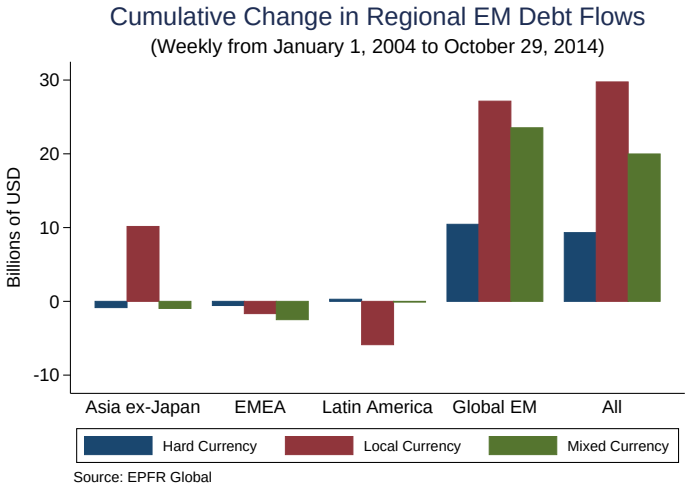


Figure 2.14: Cumulative change in emerging market debt flows by region and currency.

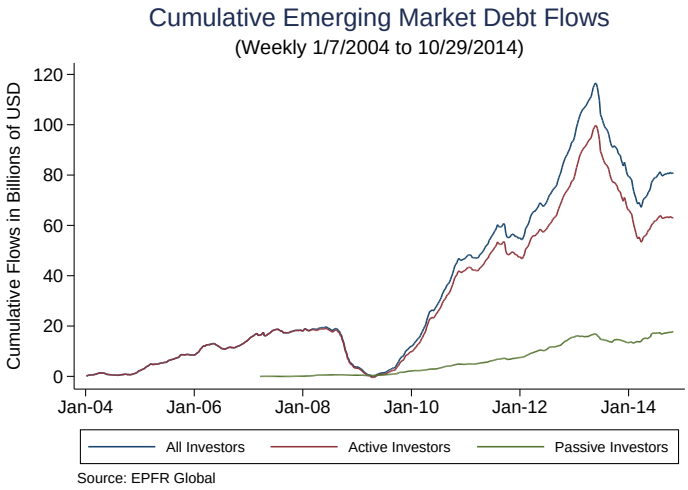


Figure 2.15: Cumulative emerging market debt flows by investor.

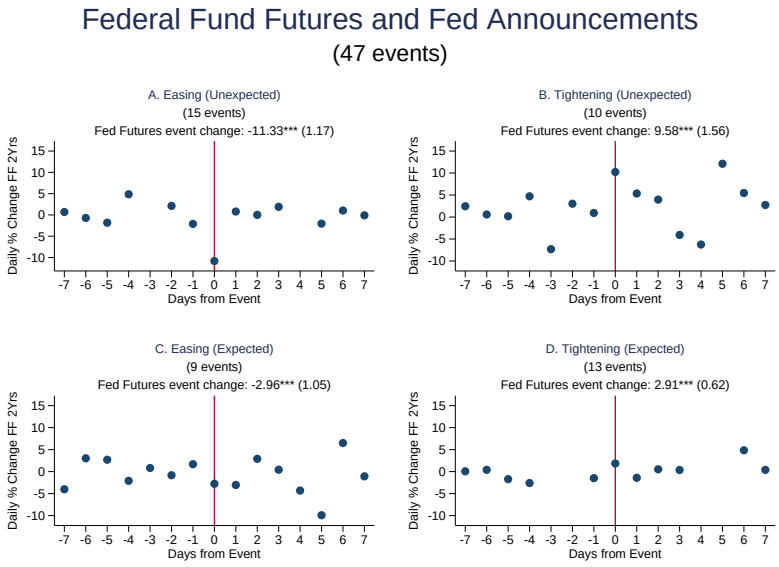


Figure 2.16: Significance test of the daily percentage change in Federal Fund Futures two year short rate expectations on the Fed announcement day relative to the previous seven days.

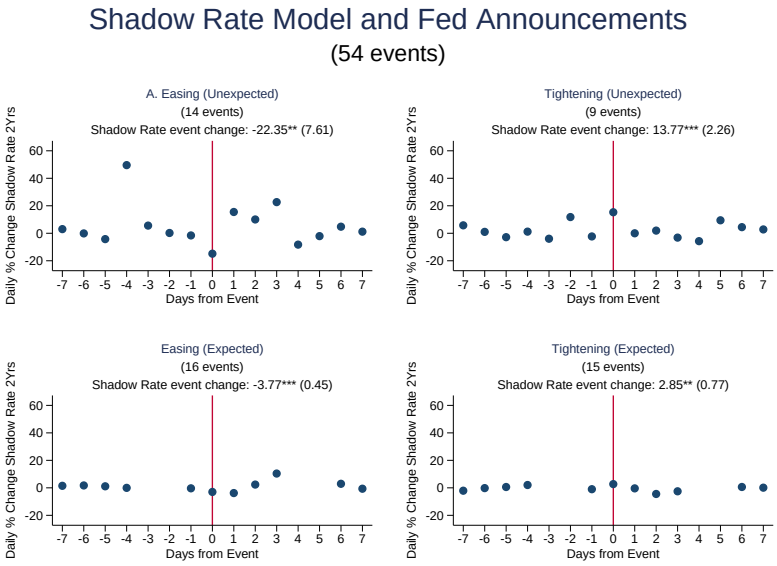


Figure 2.17: Significance test of the daily percentage change in Shadow Rate Model two year short rate expectations on the Fed announcement day relative to the previous seven days.

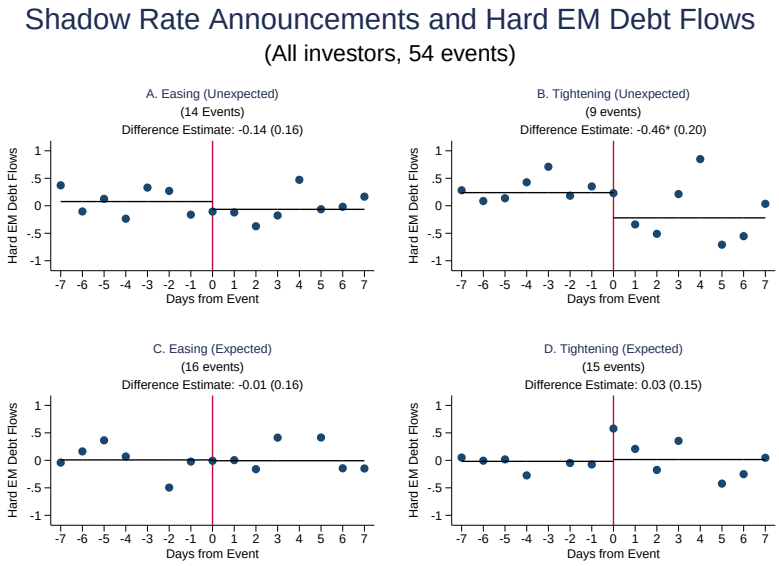


Figure 2.18: Standardized effects of Federal Reserve announcements classified by the Shadow Rate Model on hard currency emerging market debt flows by all investors.

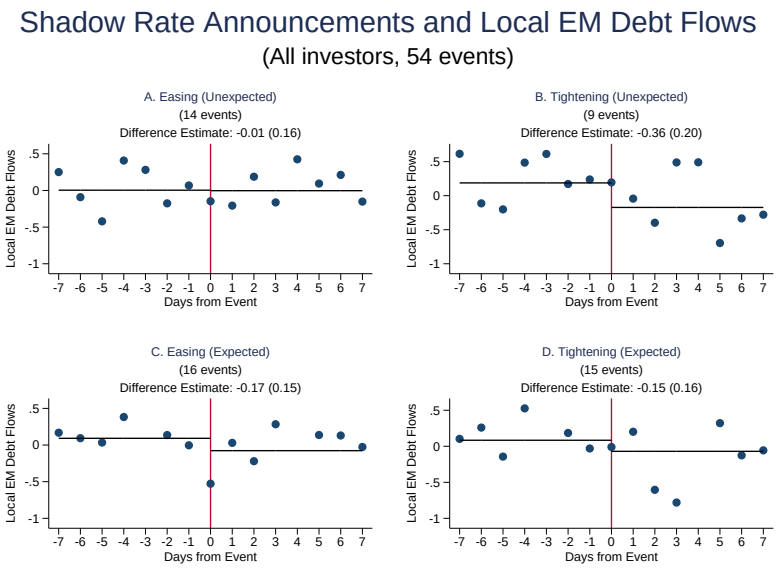


Figure 2.19: Standardized effects of Federal Reserve announcements classified by the Shadow Rate Model on local currency emerging market debt flows by all investors.

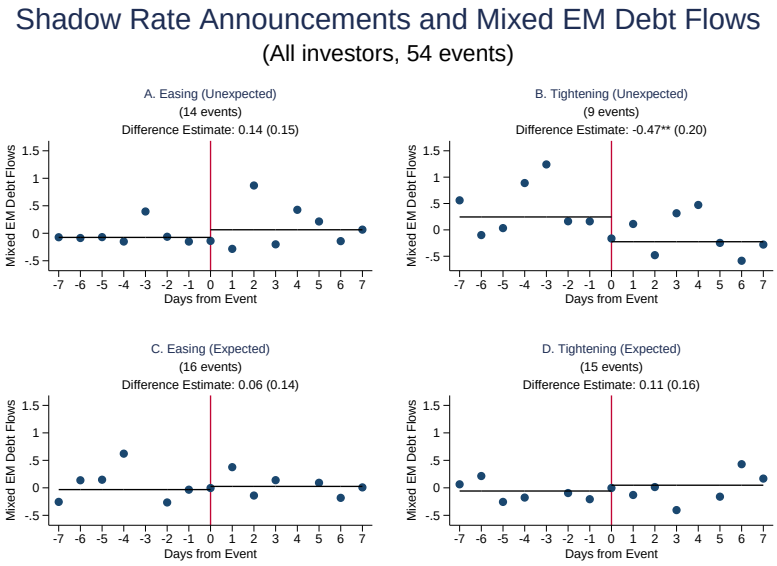


Figure 2.20: Standardized effects of Federal Reserve announcements classified by the Shadow Rate Model on mixed currency emerging market debt flows by all investors.

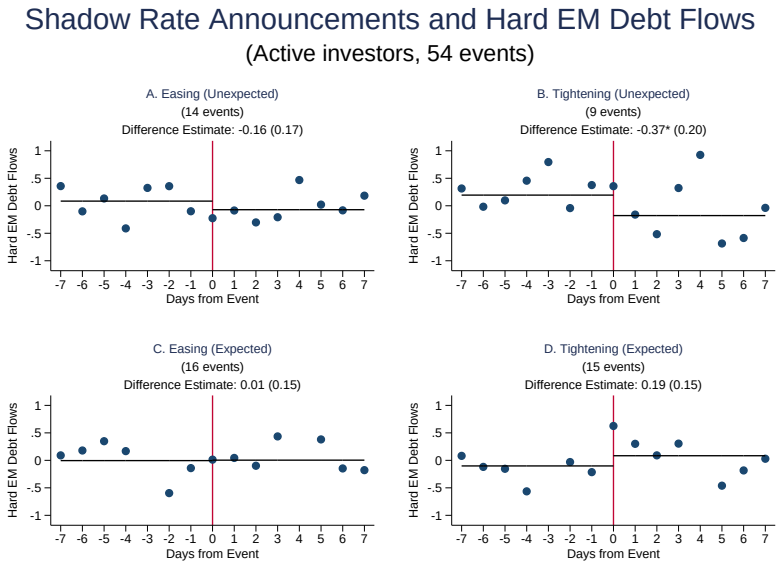


Figure 2.21: Standardized effects of Federal Reserve announcements classified by the Shadow Rate Model on hard currency emerging market debt flows by active investors.

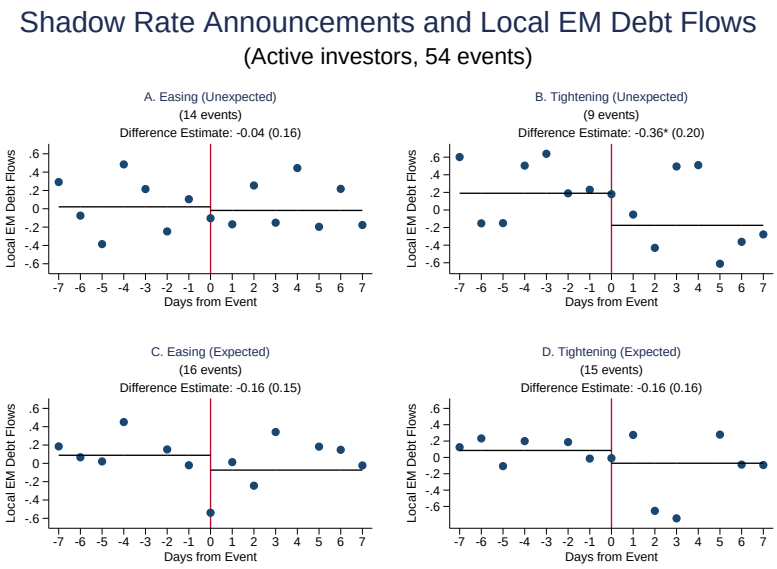


Figure 2.22: Standardized effects of Federal Reserve announcements classified by the Shadow Rate Model on local currency emerging market debt flows by active investors.

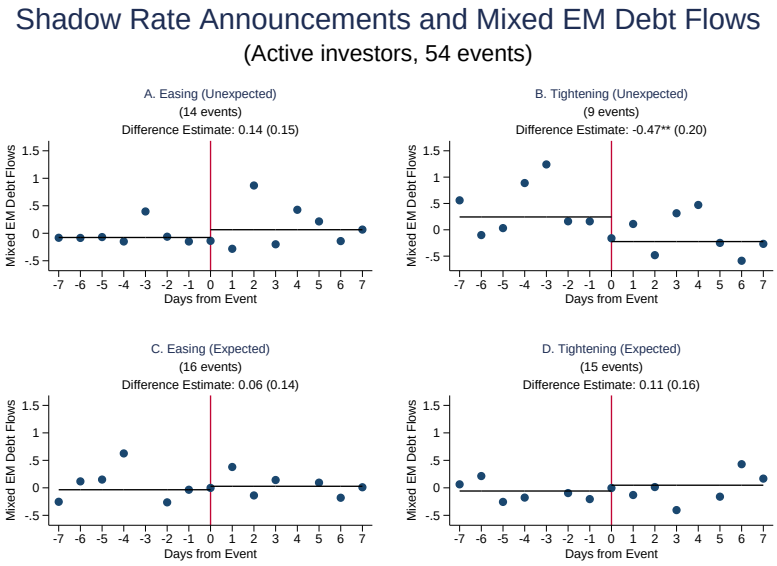


Figure 2.23: Standardized effects of Federal Reserve announcements classified by the Shadow Rate Model on mixed currency emerging market debt flows by active investors.

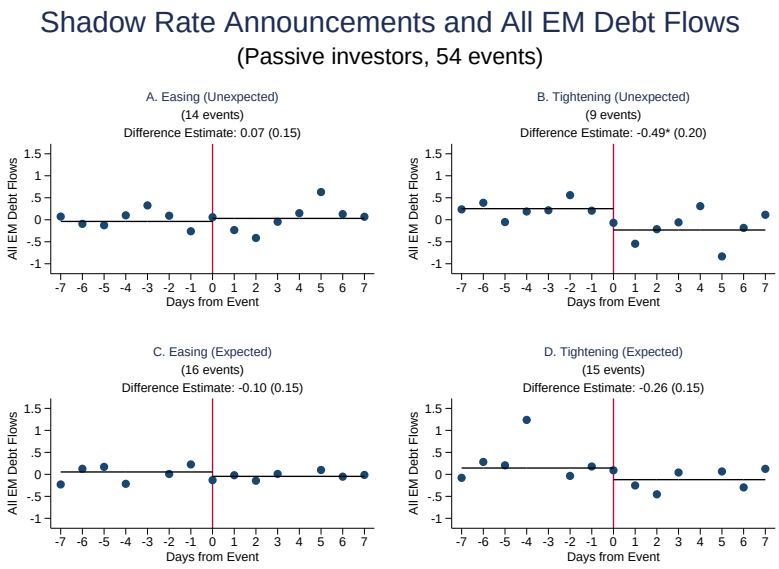


Figure 2.24: Standardized effects of Federal Reserve announcements classified by the Shadow Rate Model on all emerging market debt flows by passive investors.

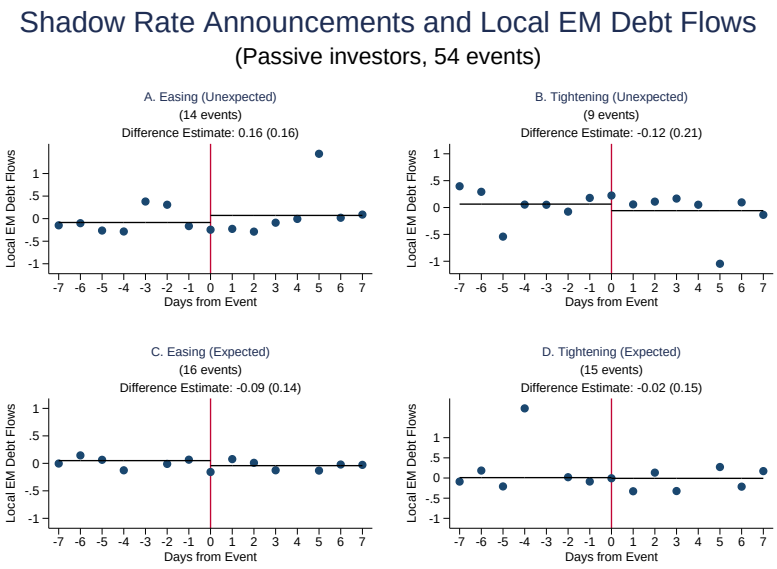


Figure 2.25: Standardized effects of Federal Reserve announcements classified by the Shadow Rate Model on local currency emerging market debt flows by passive investors.

Table 2.2: EPFR Global Debt Flow Coverage

	Daily Frequency		Weekly Frequency		Monthly Frequency	
Fund Group	# of Funds	$US Billions	# of Funds	$US Billions	# of Funds	$US billions
	(1)	(2)	(3)	(4)	(5)	(6)
Balanced	1,657	590	1,676	591	2,354	1,321
Emerging Markets	2,728	227	2,735	228	3,029	314
Global	5,030	923	5,051	930	6,045	1,458
High Yield	2,112	451	2,134	461	2,437	627
Money Market	2,400	3,505	2,411	3,528	2,650	3,793
USA	3,935	1,305	4,174	1,358	5,201	2,653
Total	17,862	7,001	18,181	7,096	21,716	10,166

Source: EPFR Global

Table 2.3: Summary Statistics for Emerging Market Debt Flows

	Obs	Mean	Std. Dev.	Min	Max
All Investors					
All	1573	40.43	226.47	-1443.86	1772.20
Hard	1573	10.64	119.54	-617.73	2153.71
Local	1573	17.14	129.77	-751.89	957.56
Mixed	1573	12.64	51.73	-288.64	570.53
Asia ex-Japan, All	1573	3.94	34.58	-315.32	194.66
Asia ex-Japan, Hard	1573	-0.59	5.03	-38.79	78.48
Asia ex-Japan, Local	1573	6.33	30.32	-309.86	194.17
Asia ex-Japan, Mixed	1573	-0.68	11.33	-97.13	112.69
EMEA, All	1573	-2.01	14.77	-156.56	155.17
EMEA, Hard	1573	-0.31	5.45	-40.07	152.40
EMEA, Local	1573	-0.83	13.34	-138.56	178.68
EMEA, Mixed	1573	-0.87	5.81	-155.44	26.06
Latin America, All	1573	-3.49	39.61	-420.60	458.93
Latin America, Hard	1573	0.37	5.26	-36.96	33.66
Latin America, Local	1573	-3.80	38.73	-418.31	458.21
Latin America, Mixed	1573	-0.07	1.29	-32.72	18.50
Global EM, All	1573	40.85	201.11	-1224.42	1921.28
Global EM, Hard	1573	11.17	117.12	-601.60	2157.76
Global EM, Local	1573	15.44	104.96	-651.90	949.27
Global EM, Mixed	1573	14.27	48.72	-348.58	563.61
Active Investors					
All	1573	29.66	207.39	-1208.16	1766.32
Hard	1573	3.84	104.68	-518.37	2153.78
Local	1573	13.18	122.06	-720.22	931.76
Mixed	1573	12.63	51.70	-288.64	570.53
Asia ex-Japan, All	1573	3.15	28.66	-297.27	201.42
Asia ex-Japan, Hard	1573	-0.63	4.96	-38.79	78.48
Asia ex-Japan, Local	1573	5.43	23.65	-289.64	209.38
Asia ex-Japan, Mixed	1573	-0.68	11.33	-97.13	112.69
EMEA, All	1573	-2.01	14.72	-156.56	155.17
EMEA, Hard	1573	-0.33	5.39	-40.07	152.40
EMEA, Local	1573	-0.81	13.33	-138.56	178.68
EMEA, Mixed	1573	-0.87	5.81	-155.44	26.06
Latin America, All	1573	-3.20	39.56	-420.53	458.93
Latin America, Hard	1573	0.38	5.26	-36.96	33.66
Latin America, Local	1573	-3.52	38.72	-418.23	458.21
Latin America, Mixed	1554	-0.07	1.29	-32.72	18.50
Global EM, All	1573	30.73	183.75	-1101.83	1921.39
Global EM, Hard	1573	4.42	102.22	-511.21	2157.80
Global EM, Local	1573	12.08	100.17	-657.76	949.25
Global EM, Mixed	1573	14.26	48.72	-348.58	563.61
Passive Investors					
All	1573	10.77	49.85	-407.71	333.29
Hard	1573	6.80	40.54	-287.31	315.95
Local	1573	3.96	27.40	-427.35	251.83
Mixed	900	0.02	1.11	-16.97	18.40
Asia ex-Japan, All	1573	0.79	17.55	-327.25	150.74
Asia ex-Japan, Hard	698	0.08	1.36	-18.24	22.55
Asia ex-Japan, Local	1573	0.90	17.75	-327.27	150.74
Asia ex-Japan, Mixed	-	-	-	-	-
EMEA, All	1362	0.01	1.14	-25.38	24.64
EMEA, Hard	257	0.15	2.04	-12.24	24.64
EMEA, Local	1362	-0.02	0.71	-25.38	2.90
EMEA, Mixed	-	-	-	-	-
Latin America, All	1305	-0.35	4.79	-94.55	42.26
Latin America, Hard	1305	-0.01	0.29	-5.14	4.00
Latin America, Local	1305	-0.34	4.70	-94.55	42.26
Latin America, Mixed	670	0.01	1.21	-16.97	18.40
Global EM, All	1573	10.12	46.63	-259.16	326.31
Global EM, Hard	1573	6.75	40.59	-287.32	315.97
Global EM, Local	1108	4.77	22.63	-157.97	252.85
Global EM, Mixed	230	0.03	0.74	-2.44	9.46

Table 2.4: Federal Reserve Announcements Classification Results

Date	Event	Federal Fund Futures	Shadow Rate Model	Federal Fund Futures	Shadow Rate Model
		(1)	(2)	(3)	(4)
10/8/2008	FOMC/Joint CB Statement				
10/29/2008	FOMC Meeting	Easing (Expected)	Tightening (Expected)	-3.78	1.72
LSAP 1					
11/25/2008	Fed MBS/Agency Purchases	Easing (Unexpected)	Easing (Unexpected)	-10.05	-23.48
12/16/2008	FOMC Meeting	Easing (Unexpected)	Easing (Unexpected)	-9.34	-38.97
1/28/2009	FOMC Meeting	Tightening (Expected)	Tightening (Unexpected)	1.96	14.27
3/18/2009	FOMC Meeting	Easing (Unexpected)	Easing (Unexpected)	-4.52	-17.90
4/29/2009	FOMC Meeting	Tightening (Expected)	Tightening (Expected)	2.34	0.56
6/24/2009	FOMC Meeting	Tightening (Expected)	Tightening (Expected)	2.98	3.02
8/12/2009	FOMC Meeting	Easing (Expected)	Easing (Expected)	-3.44	-2.83
9/23/2009	FOMC Meeting	Easing (Unexpected)	Easing (Expected)	-4.50	-3.89
11/4/2009	FOMC Meeting	Tightening (Expected)	Easing (Expected)	1.10	-3.93
12/16/2009	FOMC Meeting	Easing (Expected)	Easing (Expected)	-1.82	-2.70
1/27/2010	FOMC Meeting	Tightening (Unexpected)	Tightening (Expected)	4.19	5.34
3/16/2010	FOMC Meeting	Easing (Expected)	Easing (Expected)	-3.84	-2.58
4/28/2010	FOMC Meeting	Tightening (Expected)	Tightening (Expected)	2.06	4.01
6/23/2010	FOMC Meeting	Easing (Unexpected)	Easing (Unexpected)	-6.67	-6.93
LSAP 2					
8/10/2010	FOMC Meeting	Easing (Expected)	Easing (Expected)	-2.99	-3.63
8/27/2010	Bernanke at Jackson Hole	Tightening (Unexpected)	Tightening (Unexpected)	12.14	13.20
9/21/2010	FOMC Meeting	Easing (Unexpected)	Easing (Unexpected)	-9.09	-10.53
10/15/2010	Bernanke at Boston Fed	Easing (Expected)	Easing (Unexpected)	-3.20	-6.66
11/3/2010	FOMC Meeting	Tightening (Expected)	Easing (Unexpected)	0.99	-11.46
12/14/2010	FOMC Meeting	Tightening (Unexpected)	Tightening (Unexpected)	8.09	6.49
1/26/2011	FOMC Meeting	Tightening (Expected)	Tightening (Unexpected)	1.59	6.87
3/15/2011	FOMC Meeting	Tightening (Expected)	Tightening (Unexpected)	0.35	5.82
4/27/2011	FOMC Meeting	Tightening (Expected)	Easing (Expected)	0.67	-1.53
6/22/2011	FOMC Meeting	Easing (Expected)	Tightening (Expected)	-0.55	0.12
MEP					
8/9/2011	FOMC Meeting	Easing (Unexpected)	Easing (Unexpected)	-49.40	-31.48
8/26/2011	Bernanke at Jackson Hole	Unclassified	Easing (Unexpected)	-	-14.39
9/21/2011	FOMC Meeting	Easing (Expected)	Tightening (Unexpected)	-2.63	31.38
11/2/2011	FOMC Meeting	Easing (Unexpected)	Tightening (Expected)	-6.38	0.31
12/13/2011	FOMC Meeting	Unclassified	Tightening (Expected)	0.00	1.06
1/25/2012	FOMC Meeting	Easing (Unexpected)	Easing (Unexpected)	-15.38	-14.76
3/13/2012	FOMC Meeting	Tightening (Unexpected)	Tightening (Unexpected)	7.50	4.42
4/25/2012	FOMC Meeting	Unclassified	Easing (Expected)	-	-2.37
6/20/2012	FOMC Meeting	Tightening (Unexpected)	Tightening (Expected)	6.00	3.18
8/1/2012	FOMC Meeting	Tightening (Unexpected)	Tightening (Expected)	12.82	2.33
LSAP 3					
9/13/2012	FOMC Meeting	Easing (Unexpected)	Easing (Unexpected)	-9.80	-6.51
10/24/2012	FOMC Meeting	Easing (Unexpected)	Easing (Expected)	-5.00	-2.04
12/12/2012	FOMC Meeting	Tightening (Expected)	Easing (Expected)	2.44	-1.46
1/30/2013	FOMC Meeting	Easing (Expected)	Easing (Unexpected)	-2.67	-5.91
3/20/2013	FOMC Meeting	Unclassified	Tightening (Expected)	-	4.30
5/1/2013	FOMC Meeting	Tightening (Expected)	Easing (Expected)	2.08	-2.00
5/22/2013	Bernanke Testimony	Tightening (Unexpected)	Tightening (Expected)	4.76	4.96
6/19/2013	FOMC Meeting	Tightening (Unexpected)	Tightening (Unexpected)	15.73	16.29
7/31/2013	FOMC Meeting	Unclassified	Easing (Expected)	-	-3.16
9/18/2013	FOMC Meeting	Easing (Unexpected)	Easing (Unexpected)	-17.28	-13.56
10/30/2013	FOMC Meeting	Unclassified	Easing (Expected)	-	-1.13
12/18/2013	FOMC Meeting	Easing (Unexpected)	Easing (Unexpected)	-4.76	-5.53
1/29/2014	FOMC Meeting	Easing (Unexpected)	Easing (Expected)	-5.76	-3.50
3/19/2014	FOMC Meeting	Tightening (Unexpected)	Tightening (Unexpected)	22.29	32.20
4/30/2014	FOMC Meeting	Easing (Unexpected)	Easing (Expected)	-4.37	-4.21
6/18/2014	FOMC Meeting	Unclassified	Easing (Expected)	-	-1.70
7/30/2014	FOMC Meeting	Tightening (Expected)	Tightening (Expected)	2.30	2.89
9/17/2014	FOMC Meeting	Tightening (Expected)	Tightening (Expected)	3.11	2.80
10/29/2014	FOMC Meeting	Tightening (Unexpected)	Tightening (Unexpected)	8.85	11.12

Table 2.5: Shadow Rate Announcements and Overall EM Debt Flows

	All Investors				Active Investors				Passive Investors		
	All	Hard	Local	Mixed	All	Hard	Local	Mixed	All	Hard	Local
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Easing (Unexpected)	-0.03	-0.14	-0.01	0.14	-0.04	-0.16	-0.04	0.14	0.07	-0.02	0.16
	(0.16)	(0.16)	(0.16)	(0.15)	(0.16)	(0.17)	(0.16)	(0.15)	(0.15)	(0.15)	(0.16)
Observations	153	153	153	153	153	153	153	153	153	153	153
Tightening (Unexpected)	-0.47**	-0.46*	-0.36	-0.47**	-0.44**	-0.37*	-0.36*	-0.47**	-0.49*	-0.51**	-0.12
	(0.20)	(0.19)	(0.20)	(0.20)	(0.20)	(0.20)	(0.20)	(0.20)	(0.20)	(0.20)	(0.20)
Observations	94	94	94	94	94	94	94	94	94	94	94
Easing (Expected)	-0.09	-0.01	-0.17	0.06	-0.08	0.01	-0.16	0.06	-0.1	-0.05	-0.09
	(0.15)	(0.16)	(0.15)	(0.14)	(0.15)	(0.15)	(0.15)	(0.14)	(0.15)	(0.15)	(0.14)
Observations	176	176	176	176	176	176	176	176	176	176	176
Tightening (Expected)	-0.06	0.03	-0.15	0.11	-0.01	0.19	-0.16	0.11	-0.26	-0.29*	-0.02
	(0.16)	(0.15)	(0.16)	(0.16)	(0.16)	(0.15)	(0.16)	(0.16)	(0.15)	(0.15)	(0.15)
Observations	165	165	165	165	165	165	165	165	165	165	165

Robust standard errors in parentheses ***p<0.01, **p<0.05,*p<0.1

Table 2.6: Shadow Rate Announcements and Regional EM Debt Flows

	Asia ex-Japan				EMEA				Latin America				Global EM			
	All	Hard	Local	Mixed	All	Hard	Local	Mixed	All	Hard	Local	Mixed	All	Hard	Local	Mixed
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
Easing (Unexpected)	-0.09	0.27*	-0.15	-0.05	0.26	-0.05	0.21	0.29*	-0.32*	0.17	-0.34*	-0.29**	0.03	-0.16	0.12	0.14
	(0.16)	(0.16)	(0.17)	(0.16)	(0.16)	(0.15)	(0.16)	(0.17)	(0.16)	(0.17)	(0.16)	(0.16)	(0.16)	(0.16)	(0.16)	(0.15)
Observations	153	153	153	153	153	153	153	153	153	153	153	153	153	153	153	153
Tightening (Unexpected)	-0.31	-0.43*	-0.31	0.03	-0.44**	-0.32	-0.2	-0.41**	-0.41*	0.19	-0.46**	-0.22	-0.44*	-0.46**	-0.26	-0.47**
	(0.20)	(0.20)	(0.20)	(0.21)	(0.20)	(0.20)	(0.20)	(0.20)	(0.20)	(0.20)	(0.20)	(0.20)	(0.19)	(0.20)	(0.21)	(0.20)
Observations	94	94	94	94	94	94	94	94	94	94	94	94	94	94	94	94
Easing (Expected)	-0.17	0.24	-0.21	-0.09	-0.23	-0.22	-0.08	-0.21	0.2	0.22	0.18	-0.12	-0.1	-0.03	-0.21	0.1
	(0.15)	(0.15)	(0.15)	(0.15)	(0.15)	(0.16)	(0.16)	(0.14)	(0.15)	(0.16)	(0.15)	(0.16)	(0.15)	(0.16)	(0.15)	(0.14)
Observations	176	176	176	176	176	176	176	176	176	176	176	176	176	176	176	176
Tightening (Expected)	0.16	-0.21	0.23	0.00	-0.11	0.16	-0.18	0.03	-0.07	-0.05	-0.06	-0.12	-0.08	0.04	-0.22	0.12
	(0.15)	(0.16)	(0.15)	(0.16)	(0.16)	(0.17)	(0.15)	(0.16)	(0.16)	(0.16)	(0.16)	(0.15)	(0.16)	(0.15)	(0.16)	(0.16)
Observations	165	165	165	165	165	165	165	165	165	165	165	165	165	165	165	165

Robust standard errors in parentheses ***p<0.01, **p<0.05,*p<0.1

Table 2.7: Overall EM Debt Flows Controlling for the VIX

	All Investors				Active Investors				Passive Investors		
	All	Hard	Local	Mixed	All	Hard	Local	Mixed	All	Hard	Local
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Easing (Unexpected)	-0.06	-0.17	-0.03	0.11	-0.07	-0.19	-0.05	0.12	0.05	-0.03	0.14
	(0.16)	(0.16)	(0.16)	(0.15)	(0.16)	(0.16)	(0.16)	(0.15)	(0.15)	(0.15)	(0.15)
Observations	153	153	153	153	153	153	153	153	153	153	153
Tightening (Unexpected)	-0.47**	-0.48**	-0.35**	-0.46**	-0.44**	-0.40*	-0.35*	-0.45*	-0.49**	-0.52**	-0.13
	(0.02)	(0.20)	(0.20)	(0.20)	(0.20)	(0.20)	(0.20)	(0.20)	(0.20)	(0.20)	(0.21)
Observations	94	94	94	94	94	94	94	94	94	94	94
Easing (Expected)	-0.09	-0.01	-0.17	0.06	-0.08	0.01	-0.16	0.06	-0.1	0.05	-0.09
	(0.15)	(0.16)	(0.15)	(0.14)	(0.15)	(0.15)	(0.15)	(0.14)	(0.15)	(0.15)	(0.15)
Observations	176	176	176	176	176	176	176	176	176	176	176
Tightening (Expected)	-0.12	0.00	-0.20	0.04	-0.05	0.15	-0.20	0.04	-0.27*	-0.29*	-0.04
	(0.13)	(0.15)	(0.14)	(0.13)	(0.13)	(0.14)	(0.14)	(0.13)	(0.15)	(0.15)	(0.15)
Observations	165	165	165	165	165	165	165	165	165	165	165

Robust standard errors in parentheses ***p<0.01, **p<0.05,*p<0.1

Table 2.8: Regional EM Debt Flows Controlling for the VIX

	Asia ex-Japan				EMEA				Latin America				Global EM			
	All	Hard	Local	Mixed	All	Hard	Local	Mixed	All	Hard	Local	Mixed	All	Hard	Local	Mixed
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
Easing (Unexpected)	-0.11	0.27*	-0.16	-0.06	0.23	-0.06	0.19	0.28*	-0.32**	0.16	-0.34**	-0.27**	0	-0.19	0.1	0.11
	(0.16)	(0.16)	(0.16)	(0.16)	(0.15)	(0.15)	(0.15)	(0.17)	(0.16)	(0.17)	(0.16)	(0.15)	(0.16)	(0.16)	(0.16)	(0.15)
Observations	153	153	153	153	153	153	153	153	153	153	153	153	153	153	153	
Tightening (Unexpected)	-0.32	-0.44**	-0.31	0.01	-0.41**	-0.28	-0.17	-0.41**	-0.42**	0.2	-0.47**	-0.23	-0.44**	-0.48**	-0.25	-0.45**
	(0.20)	(0.20)	(0.20)	(0.21)	(0.19)	(0.19)	(0.20)	(0.20)	(0.21)	(0.21)	(0.20)	(0.21)	(0.20)	(0.20)	(0.20)	(0.19)
Observations	94	94	94	94	94	94	94	94	94	94	94	94	94	94	94	94
Easing (Expected)	-0.177	0.24	-0.21	-0.09	-0.23	-0.22	-0.08	-0.21	0.2	0.22	0.18	-0.12	-0.1	-0.03	-0.21	0.1
	(0.15)	(0.15)	(0.15)	(0.15)	(0.15)	(0.16)	(0.16)	(0.14)	(0.15)	(0.16)	(0.15)	(0.16)	(0.15)	(0.15)	(0.15)	(0.14)
Observations	176	176	176	176	176	176	176	176	176	176	176	176	176	176	176	176
Tightening (Expected)	0.12	-0.25	0.20	-0.05	-0.15	0.13	-0.20	-0.01	-0.07	-0.06	-0.05	-0.12	-0.13	0.02	-0.27*	0.07
	(0.13)	(0.15)	(0.14)	(0.14)	(0.15)	(0.16)	(0.15)	(0.15)	(0.16)	(0.16)	(0.16)	(0.15)	(0.13)	(0.15)	(0.14)	(0.14)
Observations	165	165	165	165	165	165	165	165	165	165	165	165	165	165	165	165

Robust standard errors in parentheses ***p<0.01, **p<0.05,*p<0.1

Table 2.9: Overall EM Debt Flows Controlling for the Oil Price

	All Investors				Active Investors				Passive Investors		
	All	Hard	Local	Mixed	All	Hard	Local	Mixed	All	Hard	Local
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Easing (Unexpected)	-0.02	-0.14	0	0.14	-0.04	-0.15	-0.04	0.14	0.07	-0.02	0.16
	(0.16)	(0.16)	(0.16)	(0.15)	(0.16)	(0.16)	(0.16)	(0.15)	(0.15)	(0.15)	(0.15)
Observations	153	153	153	153	153	153	153	153	153	153	153
Tightening (Unexpected)	-0.48**	-0.47**	-0.36*	-0.47*	-0.45*	-0.38*	-0.37*	-0.45*	-0.49*	-0.52*	-0.12
	(0.20)	(0.20)	(0.20)	(0.20)	(0.20)	(0.20)	(0.20)	(0.20)	(0.20)	(0.20)	(0.21)
Observations	94	94	94	94	94	94	94	94	94	94	94
Easing (Expected)	-0.12	-0.02	-0.17	0.06	-0.08	0.01	-0.17	0.06	-0.1	-0.06	-0.09
	(0.13)	(0.15)	(0.15)	(0.14)	(0.15)	(0.15)	(0.15)	(0.14)	(0.15)	(0.15)	(0.15)
Observations	176	176	176	176	176	176	176	176	176	176	176
Tightening (Expected)	-0.05	0.04	-0.15	0.11	0.02	0.19	-0.15	0.04	-0.26*	-0.29*	-0.01
	(0.15)	(0.15)	(0.16)	(0.15)	(0.15)	(0.15)	(0.16)	(0.13)	(0.15)	(0.15)	(0.15)
Observations	165	165	165	165	165	165	165	165	165	165	165

Robust standard errors in parentheses ***p<0.01, **p<0.05,*p<0.1

Table 2.10: Regional EM Debt Flows Controlling for the Oil Price

	Asia ex-Japan				EMEA				Latin America				Global EM			
	All	Hard	Local	Mixed	All	Hard	Local	Mixed	All	Hard	Local	Mixed	All	Hard	Local	Mixed
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
Easing (Unexpected)	-0.09	0.27*	-0.14	-0.04	0.26	-0.05	0.21	0.29*	-0.32**	0.17	-0.34**	-0.30**	0.03	-0.19	0.12	0.14
	(0.16)	(0.16)	(0.16)	(0.16)	(0.15)	(0.15)	(0.16)	(0.16)	(0.16)	(0.17)	(0.16)	(0.15)	(0.16)	(0.16)	(0.16)	(0.15)
Observations	153	153	153	153	153	153	153	153	153	153	153	153	153	153	153	153
Tightening (Unexpected)	-0.32	-0.44**	-0.32	0.03	-0.44**	-0.31	-0.19	-0.41**	-0.41**	0.19	-0.46**	-0.22	-0.45**	-0.47**	-0.27	-0.47**
	(0.20)	(0.20)	(0.20)	(0.21)	(0.20)	(0.19)	(0.21)	(0.20)	(0.20)	(0.20)	(0.20)	(0.20)	(0.20)	(0.19)	(0.21)	(0.20)
Observations	94	94	94	94	94	94	94	94	94	94	94	94	94	94	94	94
Easing (Expected)	-0.18	0.24	-0.22	-0.09	-0.15	-0.22	-0.08	-0.2	0.19	0.22	0.17	-0.12	-0.11	-0.03	-0.22	0.1
	(0.15)	(0.15)	(0.15)	(0.15)	(0.15)	(0.16)	(0.16)	(0.14)	(0.15)	(0.16)	(0.15)	(0.16)	(0.15)	(0.15)	(0.15)	(0.14)
Observations	176	176	176	176	176	176	176	176	176	176	176	176	176	176	176	176
Tightening (Expected)	0.17	-0.21	0.24	0.00	-0.11	0.16	-0.18	0.03	-0.07	-0.05	-0.06	-0.12	-0.07	0.05	-0.22	0.13
	(0.15)	(0.16)	(0.15)	(0.15)	(0.16)	(0.16)	(0.15)	(0.16)	(0.16)	(0.16)	(0.16)	(0.15)	(0.15)	(0.15)	(0.16)	(0.15)
Observations	165	165	165	165	165	165	165	165	165	165	165	165	165	165	165	165

Robust standard errors in parentheses ***p<0.01, **p<0.05,*p<0.1

Table 2.11: Federal Reserve Announcements Classification Results

Date	Event	Federal Fund Futures	Shadow Rate Model	RSW (2014)	Federal Fund Futures	Shadow Rate Model	RSW (2014)
		(1)	(2)	(3)	(4)	(5)	(6)
10/8/2008	FOMC/Joint CB Statement						
10/29/2008	FOMC Meeting	Easing (Expected)	Tightening (Expected)	Easing	-3.78	1.72	-0.009
LSAP 1							
11/25/2008	Fed MBS/Agency Purchases	Easing (Unexpected)	Easing (Unexpected)	Easing	-10.05	-23.48	-0.061
12/16/2008	FOMC Meeting	Easing (Unexpected)	Easing (Unexpected)	Easing	-9.34	-38.97	-0.270
1/28/2009	FOMC Meeting	Tightening (Expected)	Tightening (Unexpected)	Tightening	1.96	14.27	0.020
3/18/2009	FOMC Meeting	Easing (Unexpected)	Easing (Unexpected)	Easing	-4.52	-17.90	-0.370
4/29/2009	FOMC Meeting	Tightening (Expected)	Tightening (Expected)	Tightening	2.34	0.56	0.053
6/24/2009	FOMC Meeting	Tightening (Expected)	Tightening (Expected)	Tightening	2.98	3.02	0.109
8/12/2009	FOMC Meeting	Easing (Expected)	Easing (Expected)	Easing	-3.44	-2.83	-0.026
9/23/2009	FOMC Meeting	Easing (Unexpected)	Easing (Expected)	Easing	-4.50	-3.89	-0.099
11/4/2009	FOMC Meeting	Tightening (Expected)	Easing (Expected)	Easing	1.10	-3.93	-0.024
12/16/2009	FOMC Meeting	Easing (Expected)	Easing (Expected)	Tightening	-1.82	-2.70	0.028
1/27/2010	FOMC Meeting	Tightening (Unexpected)	Tightening (Expected)	Tightening	4.19	5.34	0.064
3/16/2010	FOMC Meeting	Easing (Expected)	Easing (Expected)	Easing	-3.84	-2.58	-0.043
4/28/2010	FOMC Meeting	Tightening (Expected)	Tightening (Expected)	Easing	2.06	4.01	-0.009
6/23/2010	FOMC Meeting	Easing (Unexpected)	Easing (Unexpected)	Easing	-6.67	-6.93	-0.025
LSAP 2							
8/10/2010	FOMC Meeting	Easing (Expected)	Easing (Expected)	Easing	-2.99	-3.63	-0.085
8/27/2010	Bernanke at Jackson Hole	Tightening (Unexpected)	Tightening (Unexpected)	Tightening	12.14	13.20	0.086
9/21/2010	FOMC Meeting	Easing (Unexpected)	Easing (Unexpected)	Easing	-9.09	-10.53	-0.071
10/15/2010	Bernanke at Boston Fed	Easing (Expected)	Easing (Unexpected)	Unclassified	-3.20	-6.66	0.000
11/3/2010	FOMC Meeting	Tightening (Expected)	Easing (Unexpected)	Easing	0.99	-11.46	-0.057
12/14/2010	FOMC Meeting	Tightening (Unexpected)	Tightening (Unexpected)	Tightening	8.09	6.49	0.032
1/26/2011	FOMC Meeting	Tightening (Expected)	Tightening (Unexpected)	Easing	1.59	6.87	-0.019
3/15/2011	FOMC Meeting	Tightening (Expected)	Tightening (Unexpected)	Tightening	0.35	5.82	0.068
4/27/2011	FOMC Meeting	Tightening (Expected)	Easing (Expected)	Easing	0.67	-1.53	-0.034
6/22/2011	FOMC Meeting	Easing (Expected)	Tightening (Expected)	Tightening	-0.55	0.12	0.037
MEP							
8/9/2011	FOMC Meeting	Easing (Unexpected)	Easing (Unexpected)	Easing	-49.40	-31.48	-0.142
8/26/2011	Bernanke at Jackson Hole	Unclassified	Easing (Unexpected)	Easing	-	-14.39	-0.008
9/21/2011	FOMC Meeting	Easing (Expected)	Tightening (Unexpected)	Tightening	-2.63	31.38	0.032
11/2/2011	FOMC Meeting	Easing (Unexpected)	Tightening (Expected)	Unclassified	-6.38	0.31	0.000
12/13/2011	FOMC Meeting	Unclassified	Tightening (Expected)	Tightening	0.00	1.06	0.007
1/25/2012	FOMC Meeting	Easing (Unexpected)	Easing (Unexpected)	Easing	-15.38	-14.76	-0.057
3/13/2012	FOMC Meeting	Tightening (Unexpected)	Tightening (Unexpected)	Tightening	7.50	4.42	0.047
4/25/2012	FOMC Meeting	Unclassified	Easing (Expected)	Tightening	-	-2.37	0.015
6/20/2012	FOMC Meeting	Tightening (Unexpected)	Tightening (Expected)	Tightening	6.00	3.18	0.015
8/1/2012	FOMC Meeting	Tightening (Unexpected)	Tightening (Expected)	Tightening	12.82	2.33	0.053
LSAP 3							
9/13/2012	FOMC Meeting	Easing (Unexpected)	Easing (Unexpected)	Tightening	-9.80	-6.51	0.016
10/24/2012	FOMC Meeting	Easing (Unexpected)	Easing (Expected)	Easing	-5.00	-2.04	-0.002
12/12/2012	FOMC Meeting	Tightening (Expected)	Easing (Expected)	Tightening	2.44	-1.46	0.005
1/30/2013	FOMC Meeting	Easing (Expected)	Easing (Unexpected)	Easing	-2.67	-5.91	-0.024
3/20/2013	FOMC Meeting	Unclassified	Tightening (Expected)	Tightening	-	4.30	0.011
5/1/2013	FOMC Meeting	Tightening (Expected)	Easing (Expected)	Tightening	2.08	-2.00	0.003
5/22/2013	Bernanke Testimony	Tightening (Unexpected)	Tightening (Expected)	Tightening	4.76	4.96	0.031
6/19/2013	FOMC Meeting	Tightening (Unexpected)	Tightening (Unexpected)	Tightening	15.73	16.29	0.198
7/31/2013	FOMC Meeting	Unclassified	Easing (Expected)	Easing	-	-3.16	-0.054
9/18/2013	FOMC Meeting	Easing (Unexpected)	Easing (Unexpected)	Easing	-17.28	-13.56	-0.223
10/30/2013	FOMC Meeting	Unclassified	Easing (Expected)	Tightening	-	-1.13	0.048
12/18/2013	FOMC Meeting	Easing (Unexpected)	Easing (Unexpected)	Easing	-4.76	-5.53	-0.020
1/29/2014	FOMC Meeting	Easing (Unexpected)	Easing (Expected)	Easing	-5.76	-3.50	-0.013
3/19/2014	FOMC Meeting	Tightening (Unexpected)	Tightening (Unexpected)	Tightening	22.29	32.20	0.147
4/30/2014	FOMC Meeting	Easing (Unexpected)	Easing (Expected)	Easing	-4.37	-4.21	-0.017
6/18/2014	FOMC Meeting	Unclassified	Easing (Expected)	Easing	-	-1.70	-0.022
7/30/2014	FOMC Meeting	Tightening (Expected)	Tightening (Expected)	Easing	2.30	2.89	-0.012
9/17/2014	FOMC Meeting	Tightening (Expected)	Tightening (Expected)	Tightening	3.11	2.80	0.078
10/29/2014	FOMC Meeting	Tightening (Unexpected)	Tightening (Unexpected)	Tightening	8.85	11.12	0.055

Chapter 3

Monetary Surprises and Portfolio Flows: A Case Study of Latin America

3.1 Introduction

This chapter examines the effects of Federal Reserve announcements since the Global Financial Crisis (GFC) on portfolio flows to Latin America. The combination of unconventional monetary policies by the Federal Reserve and other central banks in advanced economies as well as new banking regulations after the GFC has coincided with an increase in market based funding to emerging market economies in Latin America. The search for yield among international investors, and the global interconnectedness of emerging economies with the advanced economies, has generated massive portfolio inflows from advanced to emerging economies. While capital flows provide benefits in terms of financing for emerging economies they also present vulnerabilities in the

form of asset price misalignment, macroeconomic distortions, and increased financial volatility. As the Federal Reserve has started its policy normalization from the zero lower bound these capital flows have become more volatile and uncertain for emerging market economies. These spillover effects of unconventional monetary policy is of particular concern to central banks and policymakers in Latin America.

Movements in foreign portfolio flows to Latin America since the 2008 Global Financial Crisis can be explained by a combination of factors including Federal Reserve unconventional monetary policy. One relevant example of the global spillover effects of Federal Reserve unconventional monetary policy occurred when Federal Reserve Chairman Ben Bernanke eventually hinted at ending unconventional monetary policy, in May and June of 2013, and the markets revised their expectations of future Federal Reserve rate hikes. This event, later termed the "taper tantrum", led to revisions in emerging market asset prices and portfolio outflows from emerging markets and Latin America. In Brazil, policymakers have responded to capital flow volatility with a combination of capital controls and foreign exchange intervention. In Mexico, policymakers have not used currency intervention nor have they used capital controls.[1] Nonetheless, the Bank of Mexico has remain concerned about the exchange rate with the peso and adjusted

[1] According to a speech by Ben Bernanke at the Bank of Mexico on October 14, 2013: "When the recent financial crisis in the United States and other advanced economies threatened to spill over to Mexico, the inflation credibility enjoyed by the Bank of Mexico allowed it to counter economic weakness by easing monetary conditions, even though headline inflation was running above its target range at the time. The Bank's rate cuts helped stabilize the economy, and Mexican output returned to its pre-crisis level by late 2010. Strong countercyclical policy actions of this type were unlikely to have been feasible in Mexico a few decades ago; with little in the way of inflation-fighting credibility and an immature financial sector, the monetary authority in earlier years was often forced to respond to a crisis by tightening monetary conditions, rather than loosening them, in an effort to limit capital flight, exchange rate depreciation, and increases in inflation." Source: http://www.federalreserve.gov/newsevents/speech/bernanke20131014a.htm

its policy rate in step with the Federal Reserve to stem movements in capital flows. The authorities in Mexico have the greatest tolerance for volatility and, while concerned about exchange rate overshooting, show little inclination to intervene in foreign exchange markets.[2]

This chapter addresses several related research questions. What are the effects of Federal Reserve announcements on portfolio equity and debt flows to Latin America since the Global Financial Crisis? Do these effects differ for debt flows and equity flows? Do these effects differ for debt flows in hard currency and and in local currency? Do these effects differ for Brazil and Mexico? To what degree are these effects explained by changes in global uncertainty, market liquidity, and economic fundamentals?

This chapter answers these questions in two parts. First, the chapter classifies all of the Federal Reserve announcements since the GFC using daily measures of interest rate expectations. This classification allows the announcements to be classified as easing (unexpected), tightening (unexpected), easing (expected), and tightening (expected). Second, the chapter uses the announcement classification to conduct an event study to examine the effect of announcements on daily frequency data for equity flows and debt flows for funds dedicated to investing in Latin America, Brazil and Mexico. Brazil and Mexico receive the largest fraction of portfolio flows in Latin America and have globally domiciled funds dedicated to investing in their countries. Furthermore, robustness checks are conducted using intra-day data on interest rate expectations as well as daily frequency measures of the liquidity of the U.S. treasury market, uncertainty as measured

[2]Jude Webber. "Fed Lift-off is Mexico's rate rise dilemma" Financial Times December 15, 2015.; Jonathan Wheatley "Mexico bank chief calls for EM Policy Action" Financial Times January 17, 2016.

by the VIX, global oil and commodity prices, and country fundamentals. This chapter contributes to the literature by using market expectations to classify the Federal Reserve announcements and by explaining their effects on portfolio equity and debt flows to Latin America. The empirical results indicate that easing (unexpected) and tightening (unexpected) Federal Reserve announcements cause debt outflows but have no effect on equity flows to Latin America. Local currency debt flows to Latin America are more sensitive than the hard currency debt flows and Brazil is the country in Latin America that responds most to these announcements.

This chapter proceeds in the following manner. Section 2 motivates the chapter by explaining its relation to the literature on classifying announcements at the zero lower bound, the effect of monetary policy on international portfolio flows, and financial stability in Latin America. Section 3 presents the daily data used to classify the Federal Reserve announcement days and the portfolio flow data from EPFR Global. Section 4 explains the methodology for classifying Federal Reserve announcements from October 8, 2008 until October 29, 2014 and for estimating the effect of Federal Reserve announcements on portfolio flows to Latin America. Section 5 presents the results from the Federal Reserve announcement classification and from the event study on the effects of Federal Reserve announcements on portfolio flows to Latin America. Section 6 conducts a robustness check by including liquidity measures, uncertainty measures, commodity prices, and country fundamentals into the analysis. Section 7 concludes with suggestions for future work.

3.2 Related Literature

This chapter relates to the unconventional monetary policy literature by classifying all regularly scheduled Federal Reserve announcements using daily data on interest rate expectations. During times when monetary policy is conducted using the federal funds rate, Federal Reserve announcements are classified using thirty day federal fund futures contracts (Kuttner (2001), Bernanke and Kuttner (2005), Gürkaynak et. al. (2007)). However, when interest rates hit the zero lower bound the Federal Reserve used unconventional policies (Gagnon et al (2011), D'Amico et.al. (2012), Krishnamurthy Vissing-Jorgensen (2013), Christensen and Rudebusch (2013), and Walsh (2014)) and these short term measures of expectations do not capture these effects. Furthermore, long term measures of these asset prices suffer from term premia and liquidity issues (Gürkaynak et al. (2007), Christensen and Kwan (2014).[3] For these reasons, this chapter classifies announcements using daily frequency short rate expectations from a shadow rate term structure model developed by Christensen and Rudebusch (2014) which overcomes the liquidity and term premia issues from using federal fund futures

[3]In December 2008, the Federal Reserve lowered the target for its key monetary policy rate, the overnight federal funds rate, to a range between zero and 25 basis points. As shown in Figure 3.1 the Federal Reserve provided additional stimulus through large scale asset purchases that expanded its balance sheet. The first large balance sheet expansion occurred with LSAP 1 from November 2008 until March 2010 and led to the purchase of $300 billion in U.S. Treasuries, $1.25 trillion in agency mortgage backed securities and $170 billion of agency debt. This LSAP 1 program was followed by a brief pause in asset purchases until the Fed launched its LSAP 2 program from November 2010 until June 2011. The LSAP 2 program involved purchases of long-term U.S. Treasuries. From July 2011 until December 2012, the total balance sheet remained at a somewhat constant level of around $2.8 to 2.9 trillion. During this time, the Federal Reserve altered its balance sheet by purchasing long-term Treasuries with financing from its sale of short-term Treasuries referred to as the maturity extension program (MEP). The Federal Reserve launched the start of LSAP 3 in September 2012 which, unlike previous programs, did not include a fixed mount of purchases but instead included purchases of $45 billion of U.S. Treasuries and $40 billion of MBS per month with no end date. The LSAP 3 asset purchasing program was reduced or "tapered" until the program was completed in October 2014 with the Fed balance sheet of around $4.3 trillion.

contracts and eurodollar futures contracts at longer horizons and zero lower bound issues when using standard term structure models (Kim and Wright (2005), Piazzesi and Swanson (2008), Piazzesi (2010), Christensen and Rudebusch (2013), Adrian et. al. (2013), Christensen and Rudebusch (2014), Andreasen and Meldrum (2014), Lombardi and Zhu (2014), Krippner (2015)). This chapter also conducts a robustness check using intra-day changes in U.S. bond yields the fifteen minutes before until 105 minutes after to classify Federal Reserve announcements (Rogers et.al. 2014 and 2015).

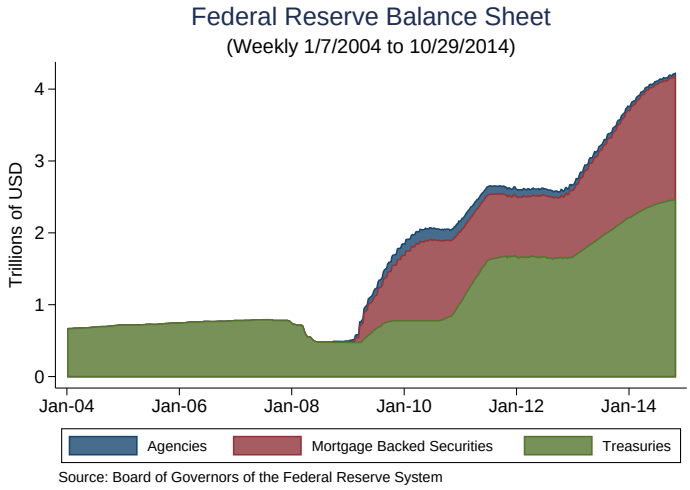


Figure 3.1: Federal Reserve Balance Sheet from January 7, 2004 until October 29, 2014.

This chapter relates to the literature about the global effects of unconventional monetary by looking at international spillovers on daily frequency flows of globally domiciled and regulated mutual funds and exchange traded funds. Several empirical studies have examined the global effects of conventional and unconventional U.S. monetary policy (Edwards (2012), Rey (2013), Berge and Cao (2014), Rogers et.al. (2014), Gilchrist

et.al. (2014), McCauley et.al. (2015)), the response of emerging market asset prices to U.S. monetary policy (Moore et.al. (2013), Bowman et.al.(2014), Rogers et. al. (2014)), and the effect of tapering news on emerging market financial markets (Eichengreen and Gupta (2013), Aizenman et.al. (2014)). Other papers have studied the effect of monetary policy on portfolio flows to emerging market economies using quarterly IMF balance of payments data (Ahmed and Zlate (2013), Lim et.al. (2014))[4] as well as daily, weekly, and monthly frequency portfolio flow data from Emerging Portfolio Funds Research (EPFR) Global (Fratzscher et.al. (2013), Koepke (2014), Rai and Suchanek (2014), Dahlhaus and Vasishtha (2014), and Curcuru et.al. (2015)).[5] This chapter builds upon work by Fischer (2016), which found that Federal Reserve announcements had the greatest effect on portfolio debt flows to Latin America of all the emerging market regions (Asia excluding Japan, Europe Middle East and Africa (EMEA), Latin America, Global Emerging Market (Global EM)) and examines the effects of announcements on both portfolio equity and debt flows to Latin America, Brazil, and Mexico.

This chapter also contributes to the literature on the financial stability of the Latin America region by examining portfolio flows to Latin America as a region and to Brazil and Mexico. The financial crises that occurred in Latin America in the 1990s prompted the monetary authorities in this region to move from a system of fixed

[4]Ahmed and Zlate (2013) use quarterly IMF data from 2002Q1 to 2012Q2 for twelve countries (India, Indonesia, Korea, Malaysia, Philippines, Taiwan, Thailand, Argentina, Brazil, Chile, Colombia, Mexico) and show that net private capital inflows to emerging market countries are driven by a combination of interest rate differentials and global risk appetite.

[5]Fratzscher et al. (2013) uses daily EPFR Global data from January 2007 until December 2010 for 42 emerging markets and 21 advanced economies and find that Quantitative Easing 1 lowered sovereign yields and raised equity markets; Quantitative Easing 2 raised equity markets and had no effect on bond yields.

exchange rates to ones with their own independent monetary policy (Mishkin (2000), BIS (2009), BIS (2015), Edwards (2016)). Although Brazil and Mexico have been successful in their transitions from fixed exchange rates to inflation targeting monetary regimes (Bernanke (2013), DePooter et. al. (2014)) the GFC and monetary policies in advanced economies have had spillovers to Latin America. These spillovers have shown up in the form of volatile capital flows (Fratzscher et. al. (2013), Ahmed and Zlate (2014), and Curcuru et. al. (2015)), increased credit in banking systems in Mexico (Morais et. al. 2015), and the implementation of capital controls in Brazil (Forbes et. al. (2012), Jinjarak et. al. (2013)). Other research has examined the behavior of foreign and domestic mutual funds in Mexico (Zhou et. al. (2014), Xiao (2015)).

3.3 Data

This chapter uses all the Federal Reserve announcement dates between October 8, 2008 and October 29, 2014. These announcements include all of the regularly scheduled Federal Reserve Open Market Committee (FOMC) announcement days and a few important announcements related to large scale asset purchases that were not part of the regularly scheduled FOMC announcement days. All of the FOMC announcement days are made publicly available and were obtained from the Federal Reserve Board of Governors website.[6] Any additional days were taken from Rogers et. al. (2014) examining the effect of Federal Reserve announcements on asset prices. However, unlike Rogers et. al. (2014) which include announcement days until early 2014, this chapter includes

[6]The Federal Reserve Board of Governors website: http://www.federalreserve.gov

FOMC announcement days until the end of large scale asset purchases in October 2014. In total, there are 54 announcements of which ten were Tuesday announcements, forty one were Wednesday announcements, one was a Thursday announcement, and two were Friday announcements.

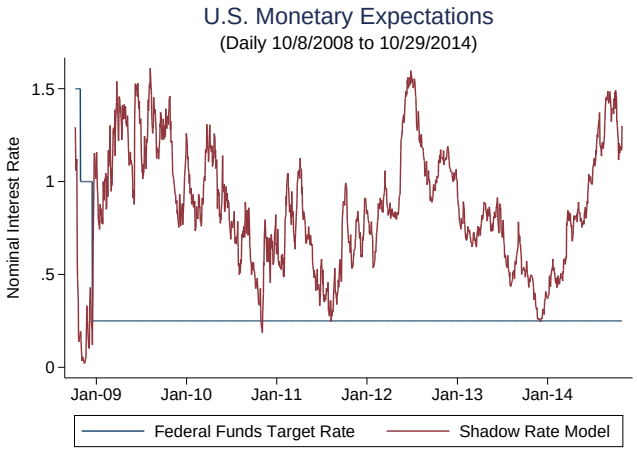


Figure 3.2: Federal Fund Funds Rate and Shadow Rate Model two year short rate expectations.

This chapter uses daily interest rate expectations to classify these Federal Reserve announcements. This chapter uses the daily two-year short rate expectations from a shadow rate Arbitrage-Free Nelson-Siegel model developed by Christensen and Rudebusch (2013) that assumes interest rates have a lower bound of zero.[7] Term structure models are widely used by financial market practitioners and central banks to examine the dynamic evolution of the yield curve using observed prices and estimating the slope, level and curvature of the yield curve. The Nelson-Siegel (1987) term structure model

[7]More details on the Arbitrage-Free Nelson-Siegel (AFNS) model and the shadow rate Arbitrage-Free Nelson-Siegel (B-AFNS) model for estimating expectations and are included in Appendix A. Please refer to Christensen and Rudebusch (2013) for even more detail.

is the most widely used as it provides good yield curve fit for a cross section of yields (Kim and Wright (2005)).

This chapter uses daily frequency portfolio equity and debt flow data collected and distributed by Emerging Portfolio Funds Research (EPFR) Global. Headquartered in Cambridge, MA, EPFR Global was founded in 1995 and tracks regulated mutual fund and exchange traded fund (ETF) flows that it collects from its direct relationships with fund managers and administrators. EPFR Global then uses this information to produce indicators for fund flows, country allocations, sector allocations and industry allocations and together with an allocation data series is able to estimate the flow data for country flows, sector flows, and industry flows. EPFR Global reports this data at the daily, weekly, and monthly frequencies.[8] EPFR Global currently tracks around 15,000 funds with investments across 130 countries and that cover $23.5 trillion worth of globally domiciled funds primarily domiciled in the United States and Europe. Of the $23.5 trillion of assets covered, approximately $16.2 trillion are from funds domiciled in the United States and $5.6 trillion in Europe.[9] The data covers 93 countries for equity flows, 100 countries for debt flows, and regional flows.

The flow data provided by EPFR Global is widely used among market participants and economic policymakers because of its timely release and its high frequency

[8]Personal correspondence with EPFR Global indicates that many of the funds already report this data to regulators and to Bloomberg at these frequencies and so reporting to EPFR Global does not incur much cost. In addition, funds may receive some marketing value by reporting their activities to EPFR Global as they are included among other funds included in the data.

[9]To put this in perspective, the Investment Company Institute estimates in their Annual Report for 2015 that there are $33.5 trillion invested in mutual funds and ETFs worldwide. Therefore, EPFR Global covers roughly 75-80 percent of these funds.

but has only recently been used by academic researchers.[10] The daily frequency flows are made available at 5pm EST for the previous day, the weekly fund fund flows data are made available at 5pm EST each Thursday for the previous 7 days, and the monthly data is reported at 5pm EST on the 23rd for the previous month. EPFR Global provides historical data for equity flows since January 1995 (monthly), October 2000 (weekly), and May 2007 (daily) and debt flows since January 2004 (monthly), April 2004 (weekly) and May 2007 (daily). The fund flows data includes daily flows in U.S. dollars, cumulative flows in U.S. dollars, daily percentage change in flows, daily percentage change in cumulative flows, total net assets, valuation change due to exchange rate, net asset value percentage change, and the percentage change in cumulative net asset value. As shown in Appendix Table 3.4 and 3.5, almost all of the funds that report at the weekly frequency also report at the daily frequency. However, not all funds that report at the monthly frequency also report at the daily and weekly frequencies.

The flow data from EPFR Global and flow data IMF Balance of Payments differ in several ways. The IMF Balance of Payments data tracks cross-border capital flows but is only available on a quarterly basis and with a significant lag. Debt flows in the Balance of Payments are located in the financial account under portfolio investments and under liabilities. This portfolio liabilities line in the Balance of Payments covers all the cross border debt held by non-residents in that particular country. EPFR

[10]Emerging Portfolio Funds Research (EPFR) Global data has been used in 18 papers in topics related to political economy (Pepinsky (2014), Frot and Santiso (2012), capital flows (Miao and Pant (2012), Lo Duca (2012), Fratzscher et al. (2013), Fratzscher et.al. (2014), Curcuru et al. (2015), Jinjarak et al. (2011), Jotikasthira et al. (2012), Wei et al. (2010)), captial controls (Forbes et al. (2012), Jinjarak et al. (2013)), financial stability (Gelos (2011), Raddatz and Schmukler (2012), Yeyati and Williams (2012), Jones (2014), Xiao (2015), Puy (2016)), and international economic policy.

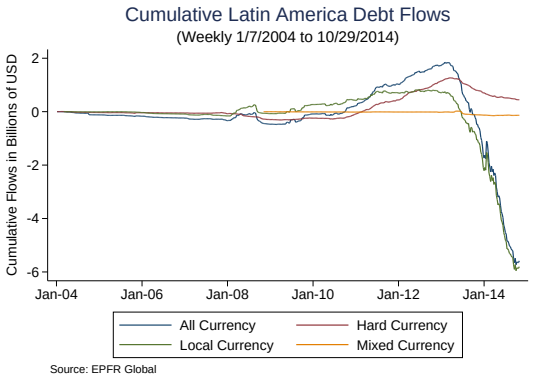


Figure 3.3: Latin America Debt Flows.

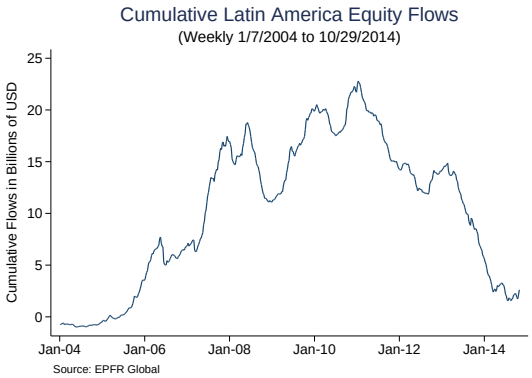


Figure 3.4: Latin America Equity Flows.

Global data is available at a much higher frequency than IMF Balance of Payments data and is released on a timely basis but covers a slightly different type of flows. The flow data provided by EPFR Global includes investment by residents and non-residents whereas the Balance of Payments data separates the debt flows by residency. EPFR Global data tracks fund flows that are domiciled globally but the vast majority of which are in the United States and Europe. In addition, EPFR Global portfolio flow data accounts for approximately 60 percent of total portfolio flows into emerging market funds. The EPFR Global data only tracks regulated managed funds and so does not track hedge funds, proprietary trading desks, foreign insurance companies investing in excess cash, and wealthy individuals and individual companies unless they invest in regulated managed funds. Miao and Pant (2012) find that the debt and equity data released by EPFR Global data closely matches quarterly IMF data on debt and equities that are released at 3 to 6 month lags. These authors also find that because 80 percent of the funds in the EPFR Global are U.S. domiciled and U.S. investors and can

be considered foreign investors in emerging markets. Nonetheless, the EPFR Global data and IMF Balance of Payments data are different in the sense that the Balance of Payments data by definition captures the transactions between residents and non-residents whereas fund flows cover inflows in and out of mutual funds and exchange traded funds.

This chapter uses the daily frequency EPFR Global data for debt and equity fund flows for Latin America, Brazil, and Mexico.[11] The cumulative debt and equity flows to Latin America, shown in Figure 3.3 and 3.4, both show gradual inflows starting in 2008 but equity flows start to decline starting in 2011 and debt flows decline starting in 2013.[12] The decline in debt flows shown in Figure 3.3 starting in 2013 is evident in the local currency debt flows but not in the hard currency debt flows and mixed currency debt flows to Latin America.[13] Figure 3.5 shows the rapid decline in local

[11]The EPFR Global regional classification for equity and debt flows is Asia excluding-Japan, Europe Middle East and Africa (EMEA) funds, Latin America, and Global Emerging Markets (Global EM). The hard currency debt is grouped as Asia ex-Japan Regional Funds (Asia ex-Japan Regional Funds, Philippines Funds), EMEA Funds (Africa Regional Funds, Emerging Europe Regional Funds, Middle East Regional Funds, Russia Funds, Slovak Republic Funds), GEM Funds (Global Emerging Markets Funds), Latin America Funds (Brazil Funds, Latin America Regional Funds, Mexico Funds). The local currency debt is grouped as: Asia ex-Japan Regional Funds (Asia ex-Japan Regional Funds, China Funds, Greater China Funds, India Funds, Indonesia Funds, Korea (South) Funds, Malaysia Funds, Taiwan Funds, Thailand Funds), EMEA Funds (Czech Republic Funds, Emerging Europe Regional Funds, Hungary Funds, Israel Funds, Poland Funds, Romania Funds, Russia Funds, South Africa Funds, Turkey Funds), GEM Funds (BRIC Funds, Global Emerging Markets Funds), Latin America Funds (Brazil Funds, Colombia Funds, Latin America Regional Funds, Mexico Funds). The mixed currency debt flows are grouped as Asia ex-Japan Funds, EMEA Funds (Africa Regional Funds, Emerging Europe Regional Funds, Europe Middle East and Africa Regional Funds, Middle East and Africa Regional Funds, Middle East Regional Funds, Poland Funds, Russia Funds, Turkey Funds), GEM Funds (BRIC Funds, Global Emerging Market Funds), Latin America Funds (Latin America Regional Funds).

[12]Figure 3.3 indicates that cumulative Latin America debt flows in all currency and local currency, but not hard currency or mixed currency, are negative after the summer of 2013. This could be due to a combination of factors including changes in exchange rates, outflows, and EPFR data coverage.

[13]The hard currency debt flows includes funds that invest 75 percent or more of their investment in traditional currency debt. These hard currency debt securities are denominated in U.S. dollars, Euros, British pound, Swiss franc, Japanese yen, Canadian dollar, Australian dollar, and Swedish krona. The local currency debt flows includes funds that invest 75 percent or more of their overall investment in local currency debt. These currencies include the Brazilian real, Polish zloty, Indian rupee, Chinese

currency debt flows to Brazil after 2013 while hard currency debt flows remained around the same and shows that hard and local currency debt flows to Mexico remained small throughout the sample.[14] The equity flows to Brazil and Mexico, shown in Figure 3.6, are not separated by currency and indicate a decline for Mexico and Brazil in 2013. There has been some previous research using EPFR Global data on portfolio flows to Latin America. In particular, a paper by Forbes et. al. (2012) uses monthly EPFR Global data for bonds and equities between January 2006 and July 2011 to examine how the externalities created by the imposition of capital controls (March 2008, October 2008, October 2009, and October 2010) and the imposition or relaxation of controls in Brazil leads to reallocation of portfolio shares to Russia, India, and China. Jinjarak et. al. (2013) use weekly EPFR Global data for Brazil from December 2007 until December 2011 to create a synthetic control and measure how capital controls impact the inflow surge. More recently, a paper by Xiao (2015) examines the differences between domestic and foreign mutual funds in Mexico and finds that foreign mutual funds respond to global financial conditions and engage in more herding, that debt funds are more sensitive than equity funds, and that domestic funds mitigate domestic market stress.

The robustness checks in this chapter uses intra-day data on monetary surprises

yuan and any currency other than the ones listed under hard currencies.

[14]The funds included in Brazil hard currency debt flows include Banco Pactual, Bradesco Asset Management, Deutsche Asset & Wealth Management, Santander Asset Management, UBS Global Asset Management. The funds included in Brazil local currency debt flows include Aberdeen Asset Management, Ashmore Investment Management, Banco Multiplo, Bradesco Asset Management, BTG Pactual Asset Management, Credit Suisse Asset Management, Deutsche Asset & Wealth Management, HSBC Asset Management, Itau Asset Management Unibanco Asset Management, Western Asset Management. The fund included in the Mexico hard currency debt flows is BlackRock.

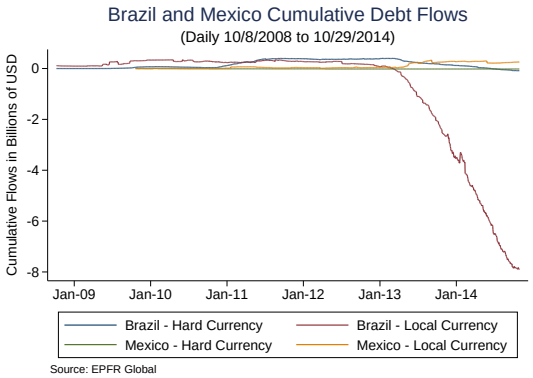


Figure 3.5: Brazil and Mexico Debt Flows.

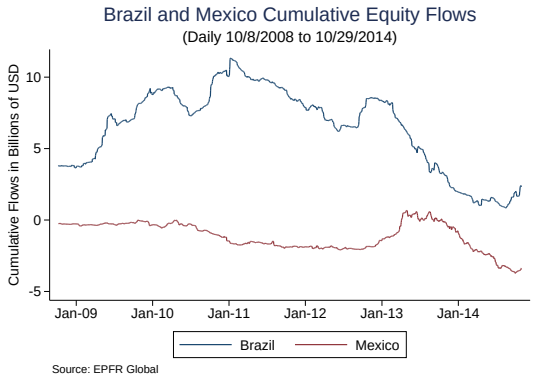


Figure 3.6: Brazil and Mexico Equity Flows.

and daily data volatility, liquidity, commodity prices, and fundamentals. The intra-day data on monetary surprises are calculated from taking the first principal component of the change in future yields for 2 year, 5 year, 10 year, and 30 year Treasury futures in the 15 minutes before and 105 minutes after a Federal Reserve announcement (Rogers et. al. (2014 and 2015), Curcuru et. al. (2015)). The daily data on volatility is the VIX from Bloomberg, which measures the implied volatility of the S&P 500 index options calculated by the Chicago Board Options Exchange (CBOE) that measures the stock market's expectations of stock market volatility over the next 30 day period. The daily data on commodity prices includes the West Texas Instruments (WTI) Cushing crude oil price, which is the most commonly used benchmark for global oil prices. The daily liquidity data is for the U.S. Treasury market and was developed by Hu et. al. (2013) based on the spread between seasoned and recently issued comparable Treasury securities, and weekly average trading volume in the secondary market for Treasury Inflation-Protected Securities (TIPS) as reported by the Federal Reserve Bank of New

York.[15] The WTI Cushing crude oil price measures the price of crude at Cushing, OK and trades in pipeline lots of 1,000 to 5,000 barrels a day for delivery between the 25th of one month to the 25th of the next month. This chapter also uses daily measures from the Bloomberg Commodity Index, which is a diversified group of commodities that relies on liquidity data and U.S. dollar weighted production data to determine the weights for commodities. In 2016, the Bloomberg Commodity Index included energy (31 percent), livestock (6 percent), softs (7 percent), industrial metals (17 percent), grains (23 percent), and precious metals (15 percent). The fundamentals data includes the J.P. Morgan EMBI and the MSCI equity index for Latin America, Brazil, and Mexico.

3.4 Methodology

This section describes the methodology used for estimating the effect of changes to U.S. monetary expectations on emerging market debt flows in two parts. First, this section explains the methodology used for classifying the Federal Reserve announcements as easing (unexpected), tightening (unexpected), easing (expected) and tightening (expected) using changes to monetary expectations measured by the shadow rate model. Second, this section explains the methodology for estimating the effects of Federal Reserve announcements on portfolio flows to Latin America and to Brazil and Mexico.[16]

[15]Hu, Grace Xing and Jun Pan, Jian Wang. 2013. Noise as a Measure of Illiquidity. Journal of Finance. Vol. LXVIII, No. 6. http://www.mit.edu/~junpan/Noise_Measure.xlsx

[16]Previous approaches to understanding the reaction of portfolio fund flows to Federal Reserve monetary policy have relied on VAR methods (Feroli et. al. (2014), Rai and Suchanek (2014), Dahlhaus

3.4.1 Classifying Federal Reserve Announcements

Federal Reserve announcements are classified by measuring the changes in interest rate expectations around announcement days. As described in the previous section these market expectations of the future short rate are measured using daily measures from a shadow rate term structure model. This measure of market expectations of the future short rate can change even if the actual short term policy rate remains unchanged. This measure of expectations is used to classify Federal Reserve announcements into one of the following four categories: easing (unexpected), tightening (unexpected), easing (expected), and tightening (expected). An announcement cannot be classified if the measure of expectations does not change on the announcement day.

The Federal Reserve announcements between October 8, 2008 and October 29, 2014 are classified in the following manner. First, the daily measure of expectations is converted into the daily percentage change of that measure of expectations. This daily percentage change measure is then converted into positive values by taking the absolute value of all the daily percentage change observations. Second, the mean change in the absolute value of all the daily percentage change observations is calculated to find the average level of daily change in expectations over the entire sample period. Third, each of the Federal Reserve announcements are classified by comparing the percentage change in expectations on that day relative to mean absolute value of the change in that measure of expectations on all the other days in the sample period. If the change

and Vasishtha (2014), Global Financial Stability Report IMF (2014), McCauley et. al. (2014), Plantier (2015)), OLS regressions (Edwards (2012), Koepke (2014)), and an event study (Curcuru et. al. (2015).

in expectations on an announcement day is above an average change in expectations on all the other days in the sample period then it is unexpected. Conversely, if the change expectations on an announcement day is less than an average change in expectations on all other days, then it is expected. The announcements are also classified as easing if the change in expectations is negative and tightening if the change in expectations is positive.

3.4.2 Effects on Portfolio Flows to Latin America, Brazil, Mexico

The event study methodology used to estimate the effect of Federal Reserve announcements on portfolio flows uses the announcements classified by the shadow rate model together with the EPFR Global data. Equation (1) is the regression specification that is used to understand the effect of announcements on portfolio flows to Latin America.

$$Flows_{ijrt} = \widehat{\beta}_0 + \widehat{\beta}_1(Shadow\ Rate\ Announcements_{kt}) + \varepsilon_{ijrt} \tag{1}$$

The *Flows* variable on the left hand side of (1) is the data on daily frequency flows to Latin America from EPFR Global. This variable is classified by asset class subscript i for whether these portfolio fund flows are for debt flows or equity flows. The debt flows are in all currencies, local currency, hard currency, and mixed currency but the equity flows are in all currencies. As a result, the subscript j denotes whether debt flows are all currencies, hard currencies, local currencies, or mixed currencies. The subscript r

specifies whether the investment focus is Latin America, Brazil, or Mexico. Finally, the subscript t denotes the day of the announcement to indicate the precise day for the flows around that announcement day. On the right hand side of equation (1) is the *Shadow Rate Announcements* variable that is categorized using market expectations from the shadow rate model. These announcements are denoted by subscript k to specify the announcements as easing (unexpected), tightening (unexpected), easing (expected), and tightening (expected). Furthermore, the subscript t denotes the announcement day.

The event study methodology used in this chapter tests whether there exists a statistically significant difference seven day average flows before and after each of the four Federal Reserve announcement classifications.[17] All four announcement classifications k are analyzed for both equity and debt i, currencies j, and regions r. Recall, the Federal Reserve announcements were classified using the daily expectations from the shadow rate model. Therefore, in order to examine the effect of easing (unexpected) announcements on all currency j debt flows i to Latin America r we examine only the debt flows that occur around the seven days before and after those 14 announcements. The first step in this event study methodology is to make sure that each Federal Reserve announcement occurs at time t equals zero. The next step involves taking each of the 14 easing (unexpected) announcements and assigning a dummy variable for the seven days after each of these announcements. Then, an ordinary least squares regression is used to examine if there is statistically significant difference in the average flows before

[17]The seven day window size is large enough to capture the time that portfolio investors can take to respond to events while at the same time is small enough so that it captures effects from Federal Reserve announcements.

and after all of the easing (unexpected) announcements. This difference estimate for the effect of easing (unexpected) announcements on debt flows to Latin America is reported in the upper left of Figure 3.8 with the average flows in each day represented by the blue dots. This same event study methodology is repeated for tightening (unexpected), easing (expected), and tightening (expected) Federal Reserve announcements. The results for each of event studies is standardized to the mean and standard deviation in order to compare the coefficients and significance across each of the announcement classifications.

This same event study methodology is used to explore the effects of all four announcement classifications on debt flows and equity flows to Latin America, Brazil, and Mexico. The Latin America flows are analyzed separately for debt flows and for equity flows. The Latin America debt flows are further separated into all currencies, hard currencies, local currencies and mixed currencies while the equity flows to Latin America are only in all currencies. The Brazil flows are also analyzed separately for debt flows, separated into hard currency and local currency debt flows, as well was for equity flows. The Mexico flows are analyzed only for equity flows since there is insufficient data on debt flows to Mexico.

$$Flows_{ijrt} = \widehat{\beta}_0 + \widehat{\beta}_1(Shadow\ Rate\ Announcements_{kt}) + Control_{mt} + \varepsilon_{ijrt} \qquad (2)$$

The robustness checks used in the chapter involves using a intra-daily data on interest rate expectations to classify Federal Reserve announcements and including

additional control variables into the event study. The intra-daily data on interest rate expectations is used to classify announcements as easing if the expectations went down and tightening if the interest rate expectations went up. The *Flows* variable and the *Shadow Rate Announcements* variables in (2) are the same as those variables in (1). The control variables *Control* are introduced into the regression equation (2) to make sure that the changes in flows before and after Federal Reserve are not the result of changes in other domestic and international factors. These control factors denoted by subscript m at time t are introduced separately into the regressions and include a measure of uncertainty the VIX, market liquidity in the U.S. Treasury market, commodity prices, as well as J.P Morgan Emerging Market Bond Indices (EMBI) and MSCI equity indices. The robustness checks including these control variables for Latin America debt and equity flows as well as for Brazil debt flows, Brazil equity flows, and Mexico equity flows are reported in Appendix Table 3.9 to Appendix Table 3.18.

3.5 Results

The results are separated into a section for classifying Federal Reserve announcements using expectations from a shadow rate model and a section for the effects of Federal Reserve announcements on portfolio flows to Latin America. The results for the effects of Federal Reserve announcements on portfolio flows to Latin America are grouped into a subsection for overall Latin America flows and into a subsection for Brazil and Mexico.

3.5.1 Classifying Federal Reserve Announcements

The shadow rate model classifies all of the Federal Reserve announcements from October 8, 2008 and October 29, 2014. Table 3.1 and Figure 3.7 show that the shadow rate model classifies the 54 announcements during this time period as 14 easing (unexpected) events, 9 tightening (unexpected) events, 16 easing (expected) events, and 15 tightening (expected) events.

Table 3.1: Daily Classification of Federal Reserve Announcements

	Shadow Rate Model
Easing (Unexpected)	14
Tightening (Unexpected)	9
Easing (Expected)	16
Tightening (Expected)	15
Unclassified	0
Total	54

The mean absolute value change in expectations for the shadow rate model is 5.40 percent and with a standard deviation of 10.25 percent. The minimum change in expectations was 0 percent and the maximum change in expectation was 191.49 percent. Indeed, this is because the shadow rate model imposes a zero lower bound on the expectations for the short rate, which makes the model and the expectations for the short rate much more stable than without this zero lower bound. A significance test of the daily percentage change in shadow rate model measure of expectations on the announcement day relative to the previous seven days is shown in Appendix Figure 3.16.

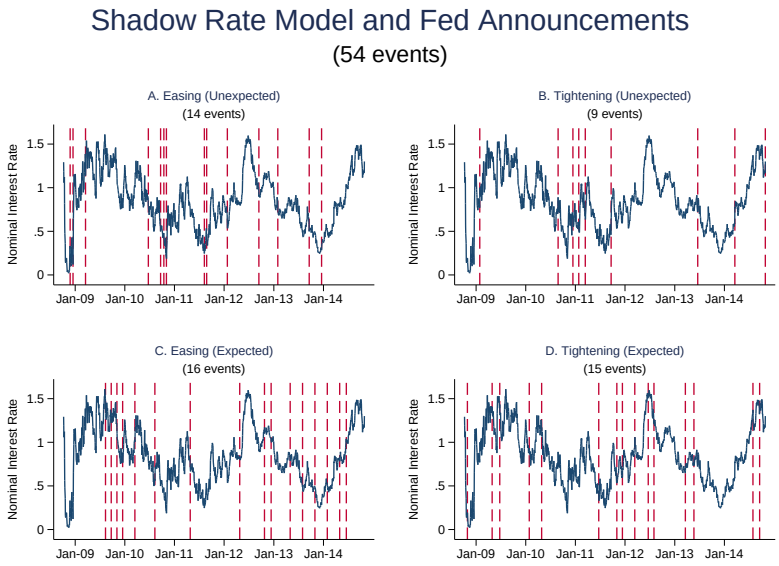


Figure 3.7: Classification of Federal Reserve announcements by the Shadow Rate Model as easing (unexpected), tightening (unexpected), easing (expected), and tightening (expected).

3.5.2 Effects on Portfolio Flows to Latin America, Brazil, Mexico

This section explains the event study results of Federal Reserve announcements on portfolio flows to Latin America. The main result from this analysis is that both easing (unexpected) and tightening (unexpected) announcements have a statistically significant effect on debt flows but not for equity flows to Latin America. Both easing (unexpected) and tightening (unexpected) announcements cause Latin America all currency debt outflows and local currency debt outflows but have no effect on hard currency debt flows. Similarly, the announcements affect debt flows but not equity flows for Brazil and Mexico. Finally, easing (unexpected) and tightening (unexpected) announcements cause local currency debt outflows but have no statistically significant

effect on hard currency debt flows to Brazil.

Portfolio Flows to Latin America

The main result, as seen in Figure 3.8, is that both easing (unexpected) and tightening (unexpected) announcements have a statistically effect on portfolio debt flows to Latin America within a seven day event window for all currencies. The easing (unexpected) announcements reduce all debt flows to Latin America by .32 standard deviations or $11.01 million less per week in flows the week after than the week before an easing (unexpected) Federal Reserve announcement. The tightening (unexpected) announcements reduce all debt flows to Latin America by .38 standard deviations or $12.54 million less per week in flows the week after than the week before a tightening (unexpected) Federal Reserve announcement.

An analysis of debt flows to Latin America by currency indicates that there is no effect for hard currency debt flows but there is an effect for local currency debt flows and mixed currency debt flows. As seen in Appendix Figure 3.18, the easing (unexpected) announcements reduce local currency debt flows to Latin America by .34 standard deviations or $11.66 million less per week in flows the week after than the week before an easing (unexpected) Federal Reserve announcement. The tightening (unexpected) announcements reduce local currency debt flows to Latin America by .41 standard deviations or $12.64 less per week in flows the week after than the week before a tightening (unexpected) Federal Reserve announcement. In Appendix Figure 3.19, easing (unexpected) announcements reduce mixed currency debt flows to Latin America

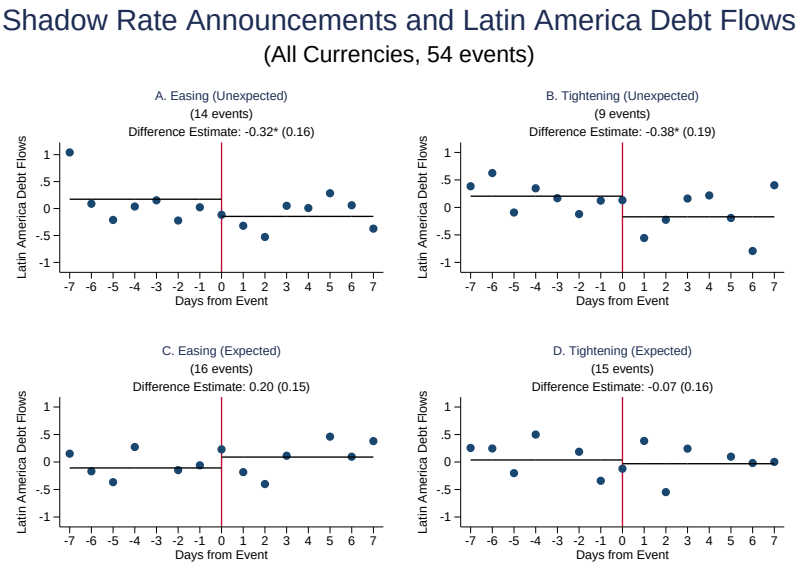


Figure 3.8: Standardized effects of Federal Reserve announcements classified by the Shadow Rate Model on Latin America debt flows.

by .29 standard deviations or $100 thousand less flows the week after from the week before an easing (unexpected) Federal Reserve announcement. Tightening (unexpected) announcements do not affect mixed currency debt flows.

As shown in Figure 3.9, the event study results indicate the Federal Reserve announcements do not have a statistically significant effect on equity flows to Latin America within the seven days before and seven day after event windows. This no result for equity flows to Latin America is in contrast to the statistically significant results for easing (unexpected) and tightening (unexpected) results for debt flows to Latin America.

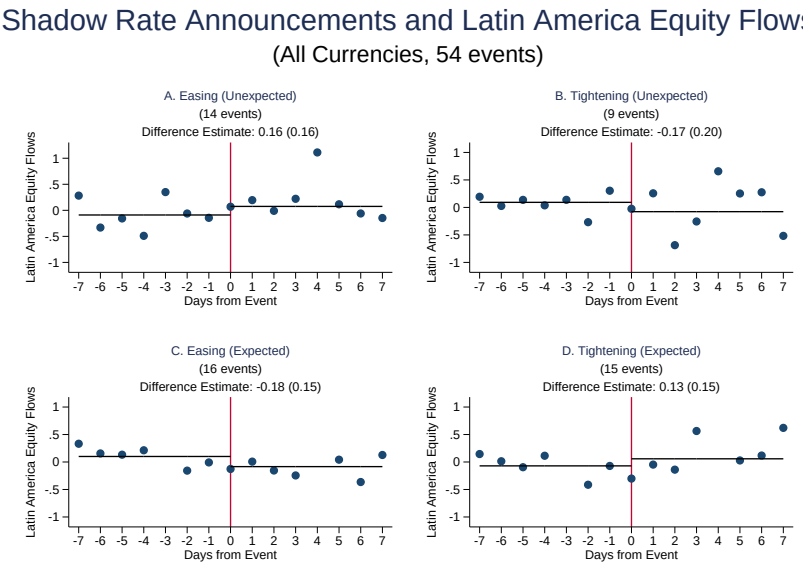


Figure 3.9: Standardized effects of Federal Reserve announcements classified by the Shadow Rate Model on Latin America equity flows.

Portfolio Flows to Brazil and Mexico

The same methodology for examining debt flows and equity flows to Latin America is used to analyze the debt flows and equity flows to Brazil and equity flows to Mexico. The debt flows to Brazil are in hard currency and local currency and the hard currency debt flows to Mexico insufficient to be able to conduct empirical estimations. The equity flows to Brazil and Mexico are not classified by currency.

The event study results indicate that Federal Reserve announcements have an effect on debt flows to Brazil and inconclusive results for the effects on debt flows to Mexico. As seen in Figure 3.11 and Figure 3.10, the easing (unexpected) announcements have an effect on local currency debt flows to Brazil but do not have an effect

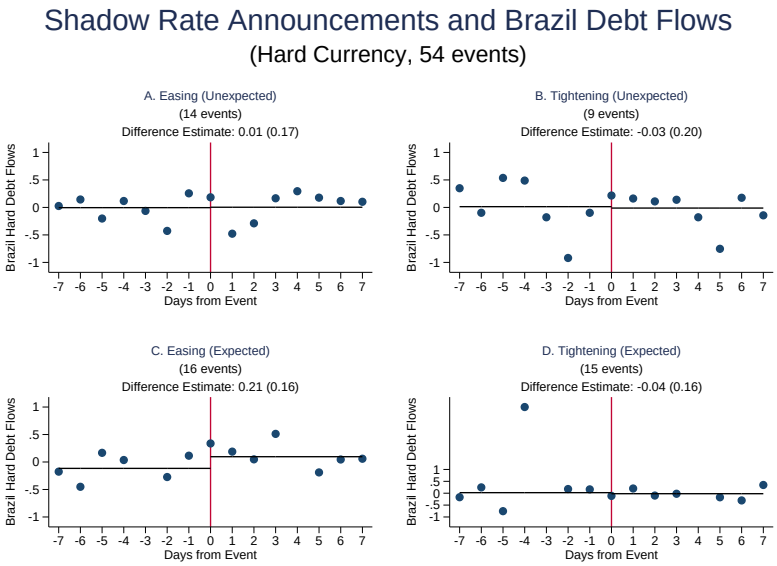


Figure 3.10: Standardized effects of Federal Reserve announcements classified by the Shadow Rate Model on hard currency debt flows to Brazil.

on hard currency debt flows. The easing (unexpected) announcements reduce local currency debt flows to Brazil by .30 standard deviations or $5.44 million less per week in flows the week after than the week before an easing (unexpected) Federal Reserve announcement. As seen in Figure 3.10, the tightening (unexpected), easing (expected), and tightening (expected) announcements do not have a statistically significant effect on hard currency debt flows to Brazil. Data limitations prevent the estimation of Federal Reserve announcements on debt flows to Mexico.

The Federal Reserve announcements do not appear to have an effect on equity flows to Brazil or Mexico. As seen in Figure 3.12, the Federal Reserve announcements do not have an effect on equity flows to Brazil within the seven days before and after

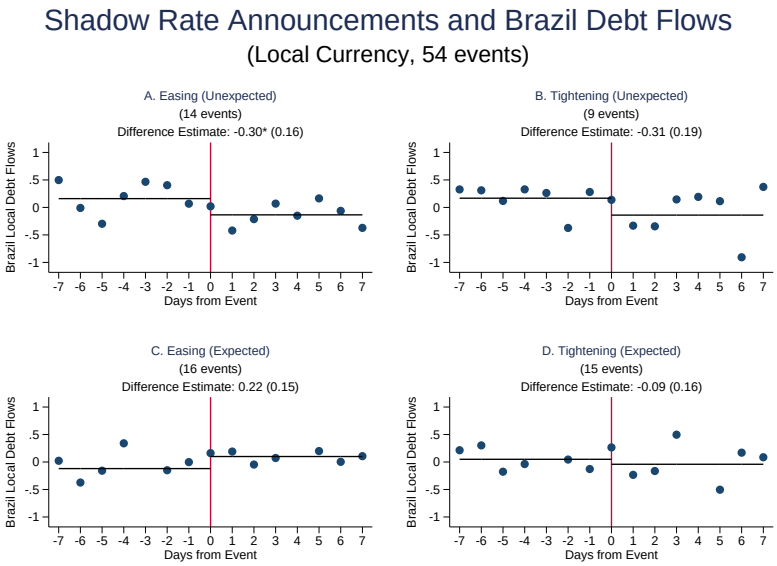


Figure 3.11: Standardized effects of Federal Reserve announcements classified by the Shadow Rate Model on local currency debt flows to Brazil.

a Federal Reserve announcement. Similarly, as seen in Figure 3.13, the equity flows to Mexico do not respond to any kind of Federal Reserve announcement classification within the seven days before and after an announcement.

As mentioned in the introduction, Brazil and Mexico used different set of policy response since the Global Financial Crisis. While authorities in Brazil have used capital controls and foreign exchange intervention the authorities in Mexico have followed a more market driven approach and have not intervened in financial markets. In these empirical results, we see that the easing (unexpected) Federal Reserve announcements cause local currency debt outflows to Brazil and had no effect on hard currency debt flows to Brazil. We also observe that the Federal Reserve announcements have no

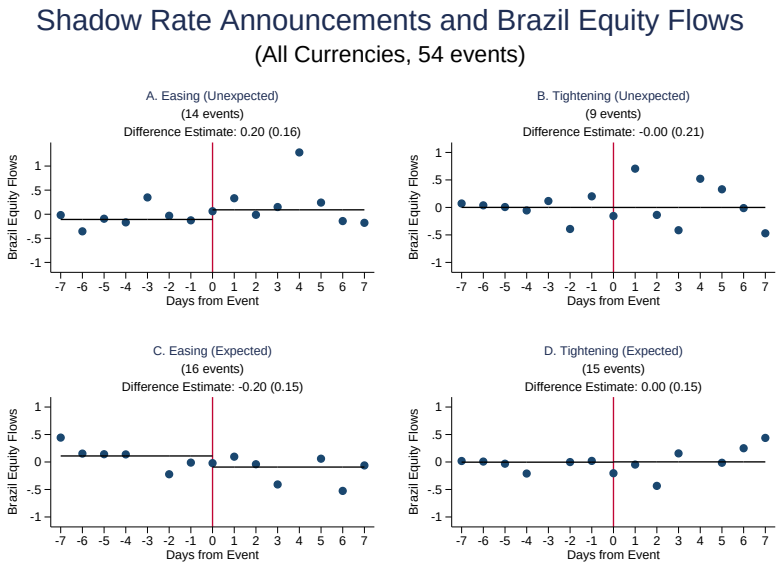


Figure 3.12: Standardized effects of Federal Reserve announcements classified by the Shadow Rate Model on equity flows to Brazil.

effect on equity flows to Brazil or Mexico. Although beyond the scope of this chapter it would be interesting to explore to what degree this statistically insignificant result of Federal Reserve announcements on portfolio flows to Brazil and Mexico is due to the policy responses by authorities in these respective countries.

3.6 Robustness

The robustness checks in this chapter include an announcement classification using intra-day data on monetary surprises as well as controls for volatility, liquidity, global commodity prices, and fundamentals in the regressions. The first robustness check compares the announcement classification using daily interest rate expectations

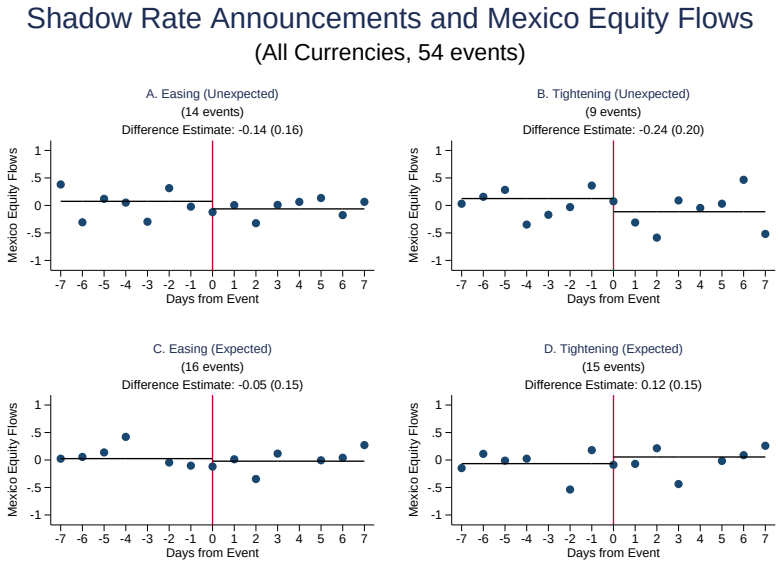


Figure 3.13: Standardized effects of Federal Reserve announcements classified by the Shadow Rate Model on equity flows to Mexico.

with intra-day data on interest rate expectations. The second set of robustness checks introduce control variables into the regressions for uncertainty measured by the VIX, liquidity in the U.S. Treasury market, oil and commodity prices measured from Bloomberg, and fundamentals measured by J.P. Morgan EMBI and the MSCI equity index.

3.6.1 Intra-day Monetary Surprise Announcement Classification

One robustness check is to classify the Federal Reserve announcements using intra-day monetary surprises instead of daily changes in interest rate expectations. Recall, this chapter used daily frequency expectations from a shadow rate term structure model to classify the Federal Reserve announcements as easing (unexpected), tightening

(unexpected), easing (expected), and tightening (expected). However, this classification could be biased if other events occur on Federal Reserve announcement days that systematically influence the market expectations, either domestically or internationally. Intra-day data on monetary surprises are calculated from taking the first principal component of the change in future yields for 2 year, 5 year, 10 year, and 30 year Treasury futures in the 15 minutes before and 105 minutes after a Federal Reserve announcement (Rogers et. al. (2014 and 2015), Curcuru et. al. (2015)).

Table 3.2: Intra-day Classification of Federal Reserve Announcements

	Rogers et. al. (2014)
Easing	27
Tightening	25
Unclassified	2
Total	54

The intra-day monetary surprises are used to classify announcements where there is a positive interest rate change as a tightening announcement, announcements where there is a negative interest rate change as an easing announcement, and announcements where there is no change as unclassified. As seen in Table 3.2 the intra-day data on monetary surprises classifies 27 announcements as easing, 25 announcements as tightening, and leaves 2 announcements unclassified. Appendix Table 3.6 shows a complete list and comparison of all 54 Federal Reserve announcements from October 2008 until October 2014 using the shadow rate model and the intra-day monetary surprises. The intra-daily monetary surprise announcement classification matches the daily shadow rate model classification for most of the Federal Reserve announcements

during this time period. The only other differences between the intra-daily announcement classification and the shadow rate model announcement classification are that the intra-daily classification leaves two announcements unclassified and that the intra-daily classification cannot be used to determine if it is expected or unexpected.

3.6.2 Control Variables

Another set of robustness checks involves including control variables into the regression specification (1) to see whether this changes the statistical significance for the coefficient for the shadow rate announcements. For both the debt flows and the equity flows the uncertainty as measured by the VIX, market liquidity in the U.S. Treasury market as measured by Hu, Pan, Wang (2013), and commodity prices as measured by Bloomberg are included in the regression specifications. For the debt flow regressions a control for the J.P. Morgan Emerging Market Bond Index is included as a proxy for fundamentals and for the equity flow regressions a control for the MSCI as proxy for fundamentals.

VIX

Previous literature has shown that global risk aversion, measured by the VIX, may help explain portfolio flows to emerging markets (Ahmed and Zlate (2013), Nier, Sedik, and Mondino (2014), Rey (2014), Ananchotikul and Zhang (2014), Koepke (2014)). When global risk aversion is high, for example, global investors are more likely to put their money into "safe" assets such as U.S. Treasuries and less likely to put

their money into emerging markets. The VIX is added to the regression in order to make sure that the portfolio flows to Latin America are responding to Federal Reserve announcements and not to changes in global risk aversion as measured by the VIX. The VIX measures the implied volatility of the S&P 500 index options calculated by the Chicago Board Options Exchange (CBOE) and measures the stock market's expectations of stock market volatility over the next 30 day period. The results from this robustness check, shown in Appendix Table 3.7 and Appendix Table 3.8, indicate that adding the VIX to the specification does not change the results for portfolio flows to Latin America or to Brazil and Mexico.

Liquidity

The measure of market liquidity, a measure developed by Hu, Pan, Wang (2013), is used as a control variable that may help explain the investment behavior of global financial flows to Latin America. This measure of market liquidity, available at daily frequency, captures the spread between seasoned and recently issued comparable Treasury securities and weekly average trading volume in the secondary market for Treasury Inflation Protected Securities (TIPS) as reported by the Federal Reserve Bank of New York. When this market is illiquid this suggests a shortage of arbitrage capital and tightening of liquidity in the overall market. This market liquidity measure has been shown to capture major financial events such as the 1987 stock market crash, the near collapse of LTCM, 9/11, the GM credit crisis, and the fall of Bear Sterns and Lehman Brothers. When this measure is low, this suggests there is sufficient arbitrage capital.

Including a market liquidity variable tests to see if the Federal Reserve announcements are driving these portfolio flows to Latin America despite changes in overall market liquidity. The results from this robustness check, in Table 3.10 and Table 3.15, indicate that adding the this measure does not change the results for portfolio flows to Latin America, Brazil, or Mexico.

Commodity Prices

The oil price, West Texas Intermediate (WTI), is used another separate control variable that may explain portfolio flows to Latin America. Latin American countries that are net oil exporters reliant on petroleum export receipts will be negatively affected by lower oil prices while Latin American countries that are net oil importers benefit from decline in oil price. Adding a control for oil prices before and after Federal Reserve announcements ensures that the portfolio flows are responding to the announcements and not the oil prices. The results from this robustness check, shown in Appendix Table 3.11 and Appendix Table 3.16, indicate that adding the oil price into the specification does not invalidate the results for portfolio flows to Latin America or to Brazil and Mexico.

A combination of commodity prices, Bloomberg Commodity Index, is added as a separate control variable that may explain portfolio flows to Latin America. Similar to the case of oil prices, countries in Latin America that are net commodity exporters will be negatively affected from lower commodity prices and Latin American countries that are net importers of commodities will benefit from the decline in the commodity

price. Adding a control variable for commodity prices before and after Federal Reserve announcements ensures that the portfolio flows are responding to the announcements and not the changes in commodity prices. The result from this robustness check, shown in Appendix Table 3.12 and Appendix Table 3.17 indicate that adding commodity prices to the specification does not change the results for portfolio flows to Latin America or to Brazil and Mexico.

Fundamentals

The debt market fundamentals, measured by the J.P. Morgan Emerging Market Bond Index (EMBI) Global is used as a control variable to explain portfolio debt flows to Latin America. The EMBI Global covers 32 countries and is the most comprehensive emerging markets debt benchmark covering U.S. dollar denominated Brady bonds, Eurobonds, traded loans and local market debt instruments issued by sovereign and quasi-sovereign entities. Instead of selecting countries according to a sovereign-credit rating level, this index defines emerging markets with a combination of World Bank defined per capita income brackets and each country's debt-restructuring history. The EMBI Global only considers emerging markets issues denominated in U.S. dollars with a minimum current face outstanding of $500 million and at least 2.5 years to maturity but relaxes some of the EMBI+ limits on secondary market trading.[18] The exact

[18]The EMBI Global is more commonly used than the EMBI Global Diversified and the EMBI+. The EMBI Global Diversified is a uniquely-weighted version of the EMBI Global that limits the weights of those index countries with larger debt stocks by only including specified portions of these countries' eligible current face amounts of debt outstanding. It also applies larger weights to less liquid issues from countries with smaller debt stocks. The EMBI+ covers 17 countries (including Brazil and Mexico) and comprises a set of broker-traded external debt instruments widely followed and quoted by several market makers. However, the EMBI+ only considers emerging markets issues denominated in U.S.

ticker symbol for EMBI Global Latin America is JPMGLAT, for EMBI Global Brazil is JPMGBRA, and for EMBI Global Mexico is JPMGMEX.

The equity market market fundamentals, proxied by the MSCI Emerging Market Index is used as a control variable to explain portfolio equity flows to Latin America. The MSCI EM Latin America Index, with Bloomberg ticker symbol MXLA, is a free-float weighted index that captures large and mid cap representation across five emerging market countries in Latin America: Brazil, Chile, Colombia, Mexico, and Peru. The index covers approximately 85 percent of the free float-adjusted market capitalization in each country. The MSCI Brazil Index, with Bloomberg ticker symbol MXBR Index, measures the performance of 61 large and mid cap Brazilian companies and covers approximately 85 percent of the equity market in Brazil. The MSCI Mexico Index, with Bloomberg ticker symbol MXMX Index, measures the performance of 27 large and mid cap companies in Mexico and covers 85 percent of the equity market in Mexico.

The results from including the EMBI and the MSCI in the regression (1) as a robustness check, shown in Appendix Table 3.13 and Appendix Table 3.18, indicate these variables do not change the results. The only exception is that both the easing (unexpected) and tightening (unexpected) announcements become statistically significant for the specification that includes the EMBI a control variable whereas only the easing (unexpected) announcements were statistically significant without the EMBI.

dollars with a minimum current face outstanding of $500 million and at least 2.5 years to maturity and must meet strict criteria for secondary market trading liquidity.

3.7 Conclusion

This chapter examined the effects of Federal Reserve announcements on portfolio flows to Latin America since the Global Financial Crisis. First, the chapter classified all the Federal Reserve announcements from October 8, 2008 until October 29, 2014 as either easing (unexpected), tightening (unexpected), easing (expected), or tightening (expected). Second, this Federal Reserve announcement classification using the shadow rate model was used for an event study on debt flows and equity flows to Latin America as well as to Brazil and Mexico. The results showed that both easing (unexpected) and tightening (unexpected) announcements cause debt outflows from Latin America but that it only had an effect on local currency and not hard currency debt flows. These announcements did not have a statistically significant effect on equity flows. The easing (unexpected) Federal Reserve announcements had an effect on local currency debt flows to Brazil but had no effect on hard currency debt flows to Brazil or to equity flows to Brazil. There was no announcement classification that had an effect on equity flows to Mexico and data limitations for debt flows to Mexico made it impossible to estimate the effect of announcements on these flows using EPFR Global data. These results were robust to controlling for uncertainty measured by the VIX, liquidity measured from lack of arbitrage in the U.S. Treasury debt market, oil and commodity prices, and fundamentals measured by the J.P. Morgan EMBI bond index and the MSCI equity index.

These results are in contrast to some of the portfolio flow effects found in Fis-

cher (2016) that only tightening (unexpected) announcements caused emerging market debt outflows. In this chapter, using the same shadow rate announcement classification of Federal Reserve announcements, both the easing (unexpected) announcements and the tightening (unexpected) announcements caused Latin America debt outflows but had not effect on equity flows. This result suggests that foreign debt portfolio investors to Latin America perceive any unexpected Federal Reserve announcement, regardless of whether it is an easing or tightening announcement, as an indication that it might be best to take the money out of Latin America. Second, a look at the subgroups of debt flows found that it was the local currency debt flows and not the hard currency debt flows that responded to these easing (unexpected) and tightening (unexpected) Federal Reserve announcements. This too was in contrast to the result that tightening (unexpected) announcements had a larger effect on hard currency debt flows than on local currency debt flows from Fischer (2016). The analysis of Brazil and Mexico indicated that Brazil was more sensitive to the Federal Reserve announcements. In particular, the easing (unexpected) Federal Reserve announcements caused local currency debt outflows from Brazil. The results for Mexico debt flows are inconclusive because there are fewer funds that are tracked by EPFR Global to Mexico than there are for Brazil. A more comprehensive data set for Mexico, that includes a richer set of funds, would enable an estimation of the effects of Federal Reserve announcements on portfolio flows to Mexico.[19]

[19]One possibility would be to use daily frequency foreign portfolio data series released by the Banco de Mexico called GUBERNAMENTAL, Residentes en el Extranjero (II) or the daily frequency EM Portfolio Flows tracker data compiled by Robin Koepke and Scott Farnham at the Institute of International Finance.

This chapter examined the effects of Federal Reserve announcement days on portfolio flows to Latin America since the Global Financial Crisis. Future work could use this same methodology and data to examine the effect of future Federal Reserve announcements on portfolio flows to Latin America when short term interest rate is no longer at the zero lower bound. Another possible idea would be to use this methodology and data to examine how these Federal Reserve announcements affect domestic investors in Latin America, Brazil, and Mexico. This chapter used a portfolio data that are globally domiciled but most of which are based in the United States. Perhaps domestic and foreign investors respond differently to the same Federal Reserve announcements. Along those same lines, it would be interesting to examine the effect of these announcements on hedge funds, sovereign wealth funds, and central banks to see whether these other market participants and international financial flows respond similarly or differently to the regulated mutual funds and exchange traded funds examined in this chapter. Finally, one could examine how the announcements by central banks in Latin America, such as the Banco de Mexico and the Banco do Brazil, affect market expectations and global financial flows.

3.8 Appendix Figures and Tables

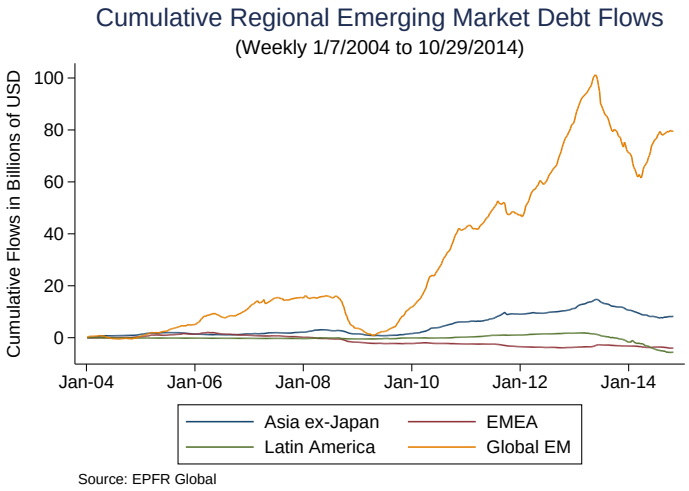


Figure 3.14: Cumulative Regional Emerging Market Debt Flows.

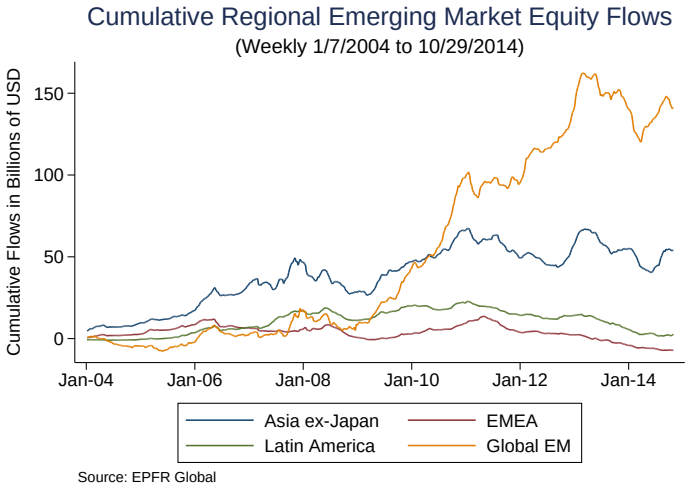


Figure 3.15: Cumulative Regional Emerging Market Equity Flows.

Table 3.3: Summary Statistics

	Obs	Mean	Std. Dev.	Min	Max
Latin America, Debt (All Currencies)	1573	-3.49	39.61	-420.60	458.93
Latin America, Debt (Hard Currency)	1573	0.37	5.26	-36.96	33.66
Latin America, Debt (Local Currency)	1573	-3.80	38.73	-418.31	458.21
Latin America, Debt (Mixed Currency)	1554	-0.07	1.29	-32.72	18.50
Brazil, Debt (Hard Currency)	1573	-0.05	2.91	-33.20	14.96
Brazil, Debt (Local Currency)	1305	0.20	4.36	-92.39	42.26
Mexico, Debt (Local Currency)	1573	-5.55	80.39	-603.10	644.36
Latin America, Equity	1573	-5.55	80.39	-603.10	644.36
Brazil, Equity	1573	-0.96	60.88	-363.55	629.91
Mexico, Equity	1573	-2.02	32.68	-247.83	231.78
VIX Index	1581	22.37	11.22	10.32	80.86
Liquidity	1516	3.39	3.77	0.72	20.47
WTI Oil Price	1581	86.25	16.76	31.41	113.93
Bloomberg Commodity Index	1581	136.16	14.08	102.00	175.42
JP Morgan EMBI Latin America	1581	499.91	94.96	265.62	642.00
JP Morgan EMBI Brazil	1581	870.10	127.87	495.63	1049.96
JP Morgan EMBI Mexico	1581	506.81	78.68	296.65	627.31
MSCI Latin America	1581	3579.76	647.87	1659.16	4729.96
MSCI Brazil	1581	2803.30	609.47	1286.54	3923.12
MSCI Mexico	1581	5826.92	1237.14	2335.10	7771.69

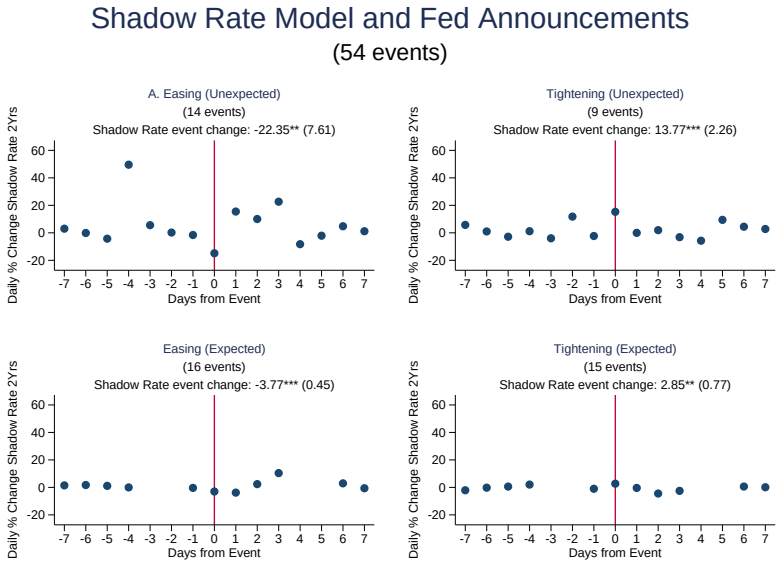


Figure 3.16: Significance test of the daily percentage change in Shadow Rate Model two year short rate expectations on the Fed announcement day relative to the previous seven days.

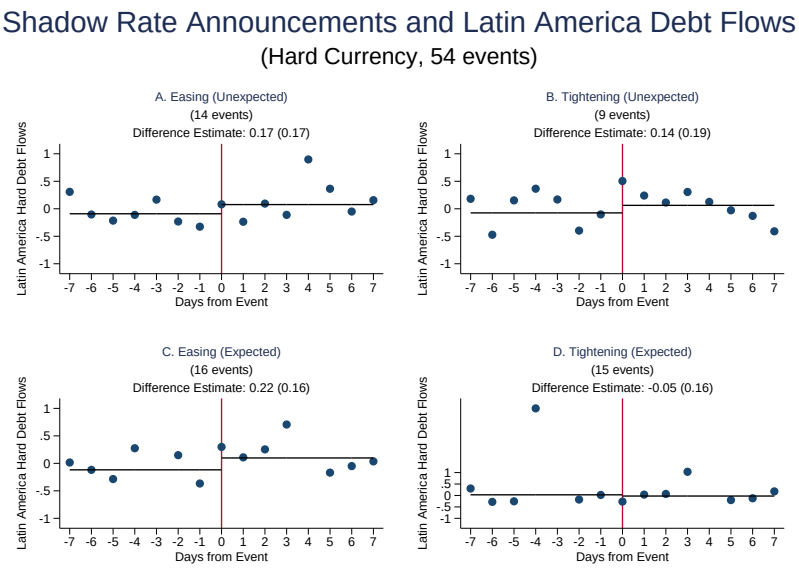


Figure 3.17: Standardized effects of Federal Reserve announcements classified by the Shadow Rate Model on Latin America debt flows in hard currency.

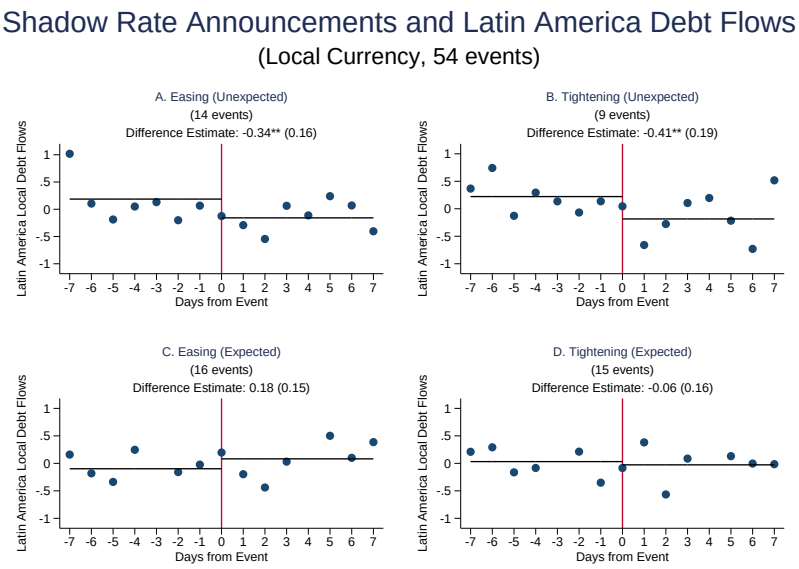


Figure 3.18: Standardized effects of Federal Reserve announcements classified by the Shadow Rate Model on Latin America debt flows in local currency.

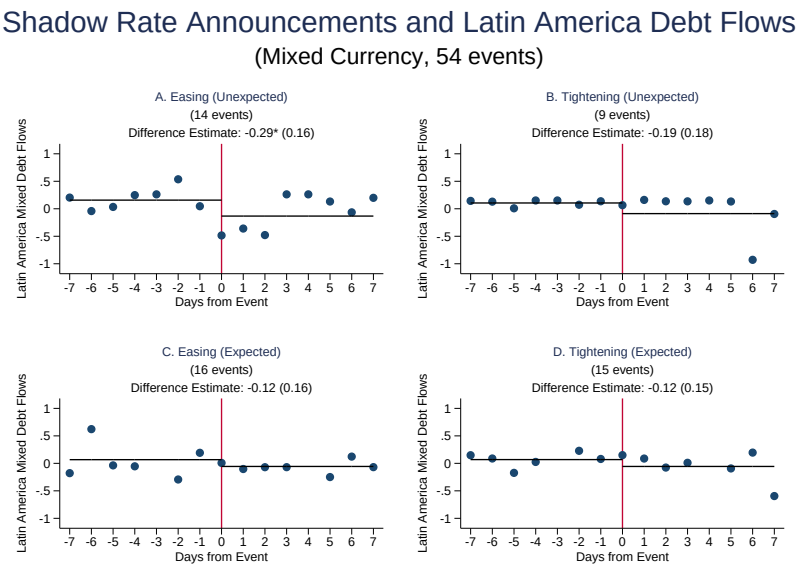


Figure 3.19: Standardized effects of Federal Reserve announcements classified by the Shadow Rate Model on Latin America debt flows in mixed currency.

Table 3.4: EPFR Global Equity Flow Coverage

	Daily Frequency		Weekly Frequency		Monthly Frequency	
Fund Group	# of Funds	$US Billions	# of Funds	$US Billions	# of Funds	$US billions
	(1)	(2)	(3)	(4)	(5)	(6)
Asia ex-Japan	2,486	304	2,500	303	2,932	375
EMEA	691	40	693	40	803	51
GEM	1,878	405	1,897	414	2,241	537
Global	7,194	1,675	7,278	1,702	9,591	3,323
Japan	1,001	206	1,005	207	1,081	213
Latin America	471	34	472	48	465	77
Pacific	367	48	366	48	465	77
USA	8,801	3,333	9,057	3,404	11,022	6,676
Western Europe	4,672	970	4,669	974	5,074	1,091
Total	27,561	7,015	27,937	7,125	33,735	12,396

Source: EPFR Global

Table 3.5: EPFR Global Debt Flow Coverage

	Daily Frequency		Weekly Frequency		Monthly Frequency	
Fund Group	# of Funds	$US Billions	# of Funds	$US Billions	# of Funds	$US billions
	(1)	(2)	(3)	(4)	(5)	(6)
Balanced	1,657	590	1,676	591	2,354	1,321
Emerging Markets	2,728	227	2,735	228	3,029	314
Global	5,030	923	5,051	930	6,045	1,458
High Yield	2,112	451	2,134	461	2,437	627
Money Market	2,400	3,505	2,411	3,528	2,650	3,793
USA	3,935	1,305	4,174	1,358	5,201	2,653
Total	17,862	7,001	18,181	7,096	21,716	10,166

Source: EPFR Global

Table 3.6: Federal Reserve Announcements Classification Results

Date	Event	Shadow Rate Model	Rogers et.al. (2014)	Shadow Rate Model	Rogers et. al. (2014)
		(1)	(2)	(3)	(4)
10/8/2008	FOMC/Joint CB Statement				
10/29/2008	FOMC Meeting	Tightening (Expected)	Easing	1.72	-0.009
LSAP 1					
11/25/2008	Fed MBS/Agency Purchases	Easing (Unexpected)	Easing	-23.48	-0.061
12/16/2008	FOMC Meeting	Easing (Unexpected)	Easing	-38.97	-0.270
1/28/2009	FOMC Meeting	Tightening (Unexpected)	Tightening	14.27	0.020
3/18/2009	FOMC Meeting	Easing (Unexpected)	Easing	-17.90	-0.370
4/29/2009	FOMC Meeting	Tightening (Expected)	Tightening	0.56	0.053
6/24/2009	FOMC Meeting	Tightening (Expected)	Tightening	3.02	0.109
8/12/2009	FOMC Meeting	Easing (Expected)	Easing	-2.83	-0.026
9/23/2009	FOMC Meeting	Easing (Expected)	Easing	-3.89	-0.099
11/4/2009	FOMC Meeting	Easing (Expected)	Easing	-3.93	-0.024
12/16/2009	FOMC Meeting	Easing (Expected)	Tightening	-2.70	0.028
1/27/2010	FOMC Meeting	Tightening (Expected)	Tightening	5.34	0.064
3/16/2010	FOMC Meeting	Easing (Expected)	Easing	-2.58	-0.043
4/28/2010	FOMC Meeting	Tightening (Expected)	Easing	4.01	-0.009
6/23/2010	FOMC Meeting	Easing (Unexpected)	Easing	-6.93	-0.025
LSAP 2					
8/10/2010	FOMC Meeting	Easing (Expected)	Easing	-3.63	-0.085
8/27/2010	Bernanke at Jackson Hole	Tightening (Unexpected)	Tightening	13.20	0.086
9/21/2010	FOMC Meeting	Easing (Unexpected)	Easing	-10.53	-0.071
10/15/2010	Bernanke at Boston Fed	Easing (Unexpected)	Unclassified	-6.66	0.000
11/3/2010	FOMC Meeting	Easing (Unexpected)	Easing	-11.46	-0.057
12/14/2010	FOMC Meeting	Tightening (Unexpected)	Tightening	6.49	0.032
1/26/2011	FOMC Meeting	Tightening (Unexpected)	Easing	6.87	-0.019
3/15/2011	FOMC Meeting	Tightening (Unexpected)	Tightening	5.82	0.068
4/27/2011	FOMC Meeting	Easing (Expected)	Easing	-1.53	-0.034
6/22/2011	FOMC Meeting	Tightening (Expected)	Tightening	0.12	0.037
MEP					
8/9/2011	FOMC Meeting	Easing (Unexpected)	Easing	-31.48	-0.142
8/26/2011	Bernanke at Jackson Hole	Easing (Unexpected)	Easing	-14.39	-0.008
9/21/2011	FOMC Meeting	Tightening (Unexpected)	Tightening	31.38	0.032
11/2/2011	FOMC Meeting	Tightening (Expected)	Unclassified	0.31	0.000
12/13/2011	FOMC Meeting	Tightening (Expected)	Tightening	1.06	0.007
1/25/2012	FOMC Meeting	Easing (Unexpected)	Easing	-14.76	-0.057
3/13/2012	FOMC Meeting	Tightening (Unexpected)	Tightening	4.42	0.047
4/25/2012	FOMC Meeting	Easing (Expected)	Tightening	-2.37	0.015
6/20/2012	FOMC Meeting	Tightening (Expected)	Tightening	3.18	0.015
8/1/2012	FOMC Meeting	Tightening (Expected)	Tightening	2.33	0.053
LSAP 3					
9/13/2012	FOMC Meeting	Easing (Unexpected)	Tightening	-6.51	0.016
10/24/2012	FOMC Meeting	Easing (Expected)	Easing	-2.04	-0.002
12/12/2012	FOMC Meeting	Easing (Expected)	Tightening	-1.46	0.005
1/30/2013	FOMC Meeting	Easing (Unexpected)	Easing	-5.91	-0.024
3/20/2013	FOMC Meeting	Tightening (Expected)	Tightening	4.30	0.011
5/1/2013	FOMC Meeting	Easing (Expected)	Tightening	-2.00	0.003
5/22/2013	Bernanke Testimony	Tightening (Expected)	Tightening	4.96	0.031
6/19/2013	FOMC Meeting	Tightening (Unexpected)	Tightening	16.29	0.198
7/31/2013	FOMC Meeting	Easing (Expected)	Easing	-3.16	-0.054
9/18/2013	FOMC Meeting	Easing (Unexpected)	Easing	-13.56	-0.223
10/30/2013	FOMC Meeting	Easing (Expected)	Tightening	-1.13	0.048
12/18/2013	FOMC Meeting	Easing (Unexpected)	Easing	-5.53	-0.020
1/29/2014	FOMC Meeting	Easing (Expected)	Easing	-3.50	-0.013
3/19/2014	FOMC Meeting	Tightening (Unexpected)	Tightening	32.20	0.147
4/30/2014	FOMC Meeting	Easing (Expected)	Easing	-4.21	-0.017
6/18/2014	FOMC Meeting	Easing (Expected)	Easing	-1.70	-0.022
7/30/2014	FOMC Meeting	Tightening (Expected)	Easing	2.89	-0.012
9/17/2014	FOMC Meeting	Tightening (Expected)	Tightening	2.80	0.078
10/29/2014	FOMC Meeting	Tightening (Unexpected)	Tightening	11.12	0.055

Table 3.7: Shadow Rate Announcements and Latin America Flows

	Debt Flows				Equity Flows
	All	Hard	Local	Mixed	All
	(1)	(2)	(3)	(4)	(5)
Easing (Unexpected)	-0.32*	0.17	-0.34*	-0.29*	0.16
	(0.16)	(0.17)	(0.16)	(0.16)	(0.16)
Observations	153	153	153	153	153
Tightening (Unexpected)	-0.41**	0.19	-0.46**	-0.22	-0.15
	(0.20)	(0.20)	(0.20)	(0.20)	(0.20)
Observations	94	94	94	94	94
Easing (Expected)	0.20	0.22	0.18	-0.12	-0.18
	(0.15)	(0.16)	(0.15)	(0.16)	(0.15)
Observations	176	176	176	176	176
Tightening (Expected)	-0.07	-0.05	-0.06	-0.12	0.13
	(0.16)	(0.16)	(0.16)	(0.15)	(0.15)
Observations	165	165	165	156	165

Robust standard errors in parentheses ***p<0.01, **p<0.05,*p<0.1

Table 3.8: Shadow Rate Announcements and Brazil and Mexico Flows

	Brazil Debt Flows		Brazil Equity Flows	Mexico Equity Flows
	Hard	Local	All	All
	(1)	(2)	(3)	(4)
Easing (Unexpected)	0.01	-0.30*	0.2	-0.14
	(0.17)	(0.16)	(0.16)	(0.16)
Observations	153	153	153	153
Tightening (Unexpected)	0.09	-0.31	0	-0.24
	(0.21)	(0.20)	(0.21)	(0.20)
Observations	94	94	94	94
Easing (Expected)	0.21	0.22	-0.2	-0.05
	(0.16)	(0.15)	(0.15)	(0.15)
Observations	176	176	176	176
Tightening (Expected)	-0.04	-0.09	0.00	0.12
	(0.16)	(0.16)	(0.15)	(0.15)
Observations	165	165	165	165

Robust standard errors in parentheses ***p<0.01, **p<0.05,*p<0.1

Table 3.9: Latin America Flows Controlling for the VIX

	Debt Flows				Equity Flows
	All	Hard	Local	Mixed	All
	(1)	(2)	(3)	(4)	(5)
Easing (Unexpected)	-0.32*	0.16	-0.34*	-0.27*	0.15
	(0.16)	(0.17)	(0.16)	(0.15)	(0.16)
Observations	153	153	153	153	153
Tightening (Unexpected)	-0.42*	0.20	-0.47*	-0.23	-0.16
	(0.21)	(0.21)	(0.20)	(0.21)	(0.21)
Observations	94	94	94	94	94
Easing (Expected)	0.20	0.22	0.18	-0.12	-0.19
	(0.15)	(0.16)	(0.15)	(0.16)	(0.15)
Observations	176	176	176	176	176
Tightening (Expected)	-0.07	-0.06	-0.05	-0.12	0.13
	(0.16)	(0.16)	(0.16)	(0.15)	(0.16)
Observations	165	165	165	156	165

Robust standard errors in parentheses ***p<0.01, **p<0.05,*p<0.1

Table 3.10: Latin America Flows Controlling for Liquidity

	Debt Flows				Equity Flows
	All	Hard	Local	Mixed	All
	(1)	(2)	(3)	(4)	(5)
Easing (Unexpected)	-0.32*	0.19	-0.35*	-0.29*	0.16
	(0.17)	(0.17)	(0.17)	(0.16)	(0.16)
Observations	151	151	151	151	151
Tightening (Unexpected)	-0.41*	0.19	-0.46*	-0.22	-0.16
	(0.20)	(0.20)	(0.20)	(0.20)	(0.20)
Observations	94	94	94	94	94
Easing (Expected)	0.20	0.22	0.18	-0.12	-0.2
	(0.15)	(0.16)	(0.15)	(0.17)	(0.15)
Observations	173	173	173	173	173
Tightening (Expected)	-0.04	-0.03	-0.03	-0.10	0.13
	(0.15)	(0.16)	(0.16)	(0.16)	(0.15)
Observations	164	164	164	155	164

Robust standard errors in parentheses ***p<0.01, **p<0.05,*p<0.1

Table 3.11: Latin America Flows Controlling for the Oil Price

	Debt Flows				Equity Flows
	All	Hard	Local	Mixed	All
	(1)	(2)	(3)	(4)	(5)
Easing (Unexpected)	-0.32*	0.17	-0.34*	-0.30*	0.16
	(0.16)	(0.17)	(0.16)	(0.15)	(0.16)
Observations	153	153	153	153	153
Tightening (Unexpected)	-0.41*	0.19	-0.46*	-0.22	-0.16
	(0.20)	(0.20)	(0.20)	(0.20)	(0.20)
Observations	94	94	94	94	94
Easing (Expected)	0.19	0.22	0.17	-0.12	-0.19
	0.15	(0.16)	(0.15)	(0.16)	(0.15)
Observations	176	176	176	176	176
Tightening (Expected)	-0.07	-0.05	-0.06	-0.12	0.13
	0.16	(0.16)	(0.16)	(0.15)	(0.15)
Observations	165	165	165	156	165

Robust standard errors in parentheses ***p<0.01, **p<0.05,*p<0.1

Table 3.12: Latin America Flows Controlling for Commodity Prices

	Debt Flows				Equity Flows
	All	Hard	Local	Mixed	All
	(1)	(2)	(3)	(4)	(5)
Easing (Unexpected)	-0.33*	0.14	-0.35*	-0.30*	0.16
	(0.16)	(0.16)	(0.16)	(0.16)	(0.16)
Observations	153	153	153	153	153
Tightening (Unexpected)	-0.42*	0.18	-0.46*	-0.22	-0.14
	(0.20)	(0.19)	(0.20)	(0.20)	(0.19)
Observations	94	94	94	94	94
Easing (Expected)	0.20	0.23	0.18	-0.12	-0.18
	0.15	(0.15)	(0.15)	(0.17)	(0.15)
Observations	176	176	176	176	176
Tightening (Expected)	-0.07	-0.05	-0.06	-0.13	0.12
	(0.16)	(0.16)	(0.16)	(0.15)	(0.15)
Observations	165	165	165	156	165

Robust standard errors in parentheses ***p<0.01, **p<0.05,*p<0.1

Table 3.13: Latin America Flows Controlling for the EMBI and MSCI

	Debt Flows				Equity Flows
	All	Hard	Local	Mixed	All
	(1)	(2)	(3)	(4)	(5)
Easing (Unexpected)	-0.32*	0.17	-0.34*	-0.29*	0.15
	(0.16)	(0.17)	(0.16)	(0.15)	(0.16)
Observations	153	153	153	153	94
Tightening (Unexpected)	-0.44*	0.16	-0.48*	-0.25	-0.15
	(0.21)	(0.21)	(0.21)	(0.22)	(0.20)
Observations	94	94	94	94	94
Easing (Expected)	0.20	0.22	0.18	-0.12	-0.18
	(0.14)	(0.16)	(0.14)	(0.16)	(0.15)
Observations	176	176	176	176	176
Tightening (Expected)	-0.07	-0.06	-0.06	-0.12	0.13
	(0.16)	(0.16)	(0.16)	(0.15)	(0.15)
Observations	165	165	165	156	165

Robust standard errors in parentheses ***p<0.01, **p<0.05,*p<0.1

Table 3.14: Brazil and Mexico Flows Controlling for the VIX

	Brazil Debt Flows		Brazil Equity Flows	Mexico Equity Flows
	Hard	Local	All	All
	(1)	(2)	(3)	(4)
Easing (Unexpected)	0.02	-0.28*	0.19	-0.13
	(0.17)	(0.16)	(0.16)	(0.16)
Observations	153	153	153	153
Tightening (Unexpected)	0.11	-0.32	-0.01	-0.25
	(0.21)	(0.21)	(0.21)	(0.21)
Observations	94	94	94	94
Easing (Expected)	0.21	0.22	-0.20	-0.05
	(0.15)	(0.15)	(0.15)	(0.15)
Observations	176	176	176	176
Tightening (Expected)	-0.03	-0.07	0.01	0.11
	(0.16)	(0.16)	(0.15)	(0.15)
Observations	165	165	165	165

Robust standard errors in parentheses ***p<0.01, **p<0.05,*p<0.1

Table 3.15: Brazil and Mexico Flows Controlling for Liquidity

	Brazil Debt Flows		Brazil Equity Flows	Mexico Equity Flows
	Hard	Local	All	All
	(1)	(2)	(3)	(4)
Easing (Unexpected)	0.01	-0.30*	0.2	-0.13
	(0.17)	(0.16)	(0.16)	(0.17)
Observations	151	151	151	151
Tightening (Unexpected)	0.09	-0.31	-0.01	-0.24
	(0.21)	(0.20)	(0.21)	(0.20)
Observations	94	94	94	94
Easing (Expected)	0.21	0.22	-0.21	-0.25
	(0.16)	(0.15)	(0.15)	(0.21)
Observations	173	173	173	94
Tightening (Expected)	-0.03	-0.04	0.00	0.12
	(0.16)	(0.15)	(0.15)	(0.15)
Observations	164	164	164	164

Robust standard errors in parentheses ***p<0.01, **p<0.05,*p<0.1

Table 3.16: Brazil and Mexico Flows Controlling for the Oil Price

	Brazil Debt Flows		Brazil Equity Flows	Mexico Equity Flows
	Hard	Local	All	All
	(1)	(2)	(3)	(4)
Easing (Unexpected)	0	-0.30*	0.2	-0.14
	(0.17)	(0.16)	(0.16)	(0.16)
Observations	153	153	153	153
Tightening (Unexpected)	0.09	-0.31	-0.01	-0.24
	(0.21)	(0.20)	(0.20)	(0.20)
Observations	94	94	94	94
Easing (Expected)	0.21	0.21	-0.21	-0.05
	(0.16)	(0.15)	(0.15)	(0.15)
Observations	176	176	173	176
Tightening (Expected)	-0.05	-0.10	0.00	0.11
	(0.16)	(0.16)	(0.15)	(0.15)
Observations	165	165	165	165

Robust standard errors in parentheses ***p<0.01, **p<0.05,*p<0.1

Table 3.17: Brazil and Mexico Flows Controlling for Commodity Prices

	Brazil Debt Flows		Brazil Equity Flows	Mexico Equity Flows
	Hard	Local	All	All
	(1)	(2)	(3)	(4)
Easing (Unexpected)	-0.01	-0.30*	0.18	-0.13
	(0.17)	(0.16)	(0.15)	(0.17)
Observations	153	153	153	153
Tightening (Unexpected)	0.07	-0.31	0.01	-0.24
	(0.19)	(0.20)	(0.20)	(0.20)
Observations	94	94	94	94
Easing (Expected)	0.23	0.23	-0.2	-0.05
	(0.16)	(0.15)	(0.15)	(0.15)
Observations	176	176	176	176
Tightening (Expected)	-0.04	-0.09	0.00	0.12
	(0.16)	(0.16)	(0.15)	(0.15)
Observations	165	165	165	165

Robust standard errors in parentheses ***p<0.01, **p<0.05,*p<0.1

Table 3.18: Brazil and Mexico Flows Controlling for the EMBI and MSCI

	Brazil Debt Flows		Brazil Equity Flows	Mexico Equity Flows
	Hard	Local	All	All
	(1)	(2)	(3)	(4)
Easing (Unexpected)	0.01	-0.30*	0.19	-0.13
	(0.17)	(0.16)	(0.16)	(0.16)
Observations	153	153	153	153
Tightening (Unexpected)	0.03	-0.35*	0.01	-0.25
	(0.20)	(0.21)	(0.20)	(0.21)
Observations	94	94	94	94
Easing (Expected)	0.22	0.22	-0.2	-0.05
	(0.15)	(0.15)	(0.15)	(0.15)
Observations	176	176	176	176
Tightening (Expected)	-0.04	-0.08	0.00	0.12
	(0.16)	(0.15)	(0.15)	(0.15)
Observations	165	165	165	165

Robust standard errors in parentheses ***p<0.01, **p<0.05,*p<0.1

Chapter 4

Bank Avalanche Model of Systemic Risk

4.1 Introduction

The modern financial system is a complex web of interactions in which market participants engage in a diverse set of transactions and relationships with other market participants. When this global financial system functions properly, financial intermediaries move capital from savers towards productive investments. The network gives the financial intermediaries access to the full set of capital and investment opportunities. This complex and interconnected financial system can also reach a critical state as systemic risk emerges undetected and serve to transmit financial shocks across the system. This chapter provides a theoretical agent based model of systemic risk with banks and non-financial transactors in a complete network, unconnected network, circle network, and star network that is calibrated with good and bad economic conditions and tested for bank lifespan, profitability, and bank avalanches.

A growing body of financial stability research and a new set of regulatory policies to address systemic risk has emerged since the Global Financial Crisis.[1] Systemic risk in the financial system can be difficult to detect as it can emerge even when each individual bank appears to be stable according to traditional metrics such as bank assets, market capitalization, price to earnings ratios, and assets.[2] Stress tests such as the Dodd-Frank Act stress test mandated by the Dodd-Frank Wall Street Reform and Consumer Protection Act of 2010 and the Comprehensive Capital Analysis and Review are designed to focus on the capital adequacy of the largest firms and both the Financial Stability Oversight Council and the Office of Financial Research were created to monitor financial stability.[3] The Federal Reserve has also established rules for strengthening the capital positions of global systemically important bank holding companies as they pose a greater threat to financial stability of the United States.[4] Despite these research

[1]Authors Daniel Friedman and Daniel McNeil in their nontechnical book *Morals and Markets: The Dangerous Balance (2nd Edition)* describe systemic risk as arising when "broken promises spread, as with excessive leverage, where node A defaulting on node B can cause B to default on nodes C and D, in turn causing defaults further along the links. Thus, a financial bankruptcy may bring innocent people down, even if they don't seem nearby, and they in turn can undermine more people. That's what happened in September and October 2008. The damage ripples outward, and it can take years to restore the network to health."

[2]Neil Kashkari, the president of the Federal Reserve Bank of Minneapolis, in a speech at the Brookings Institution on February 16, 2016 titled *"Lessons from the Crisis: Ending Too Big to Fail"* explained "A second lesson for me from the 2008 crisis is that almost by definition, we won't see the next crisis coming, and it won't look like what we might be expecting. If we, or markets, recognized an imbalance in the economy, market participants would likely take action to protect themselves. When I first went to Treasury in 2006, Treasury Secretary Henry Paulson directed his staff to work with financial regulators at the Federal Reserve and the Securities and Exchange Commission to look for what might trigger the next crisis. Based on his experience, we were due for a crisis because markets had been stable for several years. We looked at a number of scenarios, including an individual large bank running into trouble or a hedge fund suffering large losses, among others. We didn't consider a nationwide housing downturn. It seems so obvious now, but we didn't see it, and we were looking. We must assume that policymakers will not foresee future crises, either."

[3]For even more detail on bank stress-tests please refer to Bookstaber et. al. (2014), Tarullo (2014), and Fischer (2015).

[4]The Board of Governors of the Federal Reserve System approved a final rule requiring the largest and most systemically important U.S. bank holding companies to further strengthen their capital positions on June 20, 2015. Eight banks were designated GSIBs: Bank of America Corporation; The Bank of

and regulatory initiatives, there is room for more research that combines complexity theory with agent based modeling to understand how systemic risk emerges through the interactions between banks and other financial market participants (Bisias et. al. (2012), Bookstaber (2014), and Battiston et. al. (2016)).

This chapter investigates the ways in which financial network architecture affects financial system performance and financial stability. The first part of the chapter outlines the behavioral rules of the banks, non-financial transactors, and related aspects of the agent based model. The second part of the chapter analyzes the financial stability of this agent based model in a complete network, unconnected network, circle network, and star network using computer simulations. The simulations are conducted for all of the financial networks with a model calibrated for good economic conditions and for bad economic conditions. The results indicate that the circle network performs best in terms of bank lifespan and profitability among all the other networks. There is greater dispersion in profitability and financial stability when there are good economic conditions than when there are bad economic conditions.

This chapter proceeds with a review of the related literature on systemic risk and financial networks in Section 2. Section 3 explains the behavioral rules of the banks and non-financial transactors. Section 4 presents and explains the model simulation results. Section 5 concludes with suggestions for future research.

New York Mellon Corporation; Citigroup, Inc.; The Goldman Sachs Group, Inc.; JPMorgan Chase & Co.; Morgan Stanley; State Street Corporation; and Wells Fargo & Company.

4.2 Related Literature

This chapter uses agent based modeling to examine the financial stability of bank networks and contributes to the literature on bank stability, networks, and agent based modeling. The ideas for the agent based model in this chapter draw upon the bank avalanche model by Friedman (1998 and 2012) and the concept of self-criticality from Bak et. al. (1988). Although progress has been made to better understand systemic risk since the Global Financial Crisis there is still more work to be done (Bisias et. al. (2012), Yellen (2013), Handbook on Systemic Risk (2013), IMF Guide to Stress Testing (2014), Bookstaber (2014), Freixas et. al. (2015), and Battiston et. al. (2016)).

This chapter contributes to the theoretical literature on banking stability with a model in which systemic risk and financial contagion originates from the behavior of non-financial transactors and spreads through the interbank network. Early theoretical work on bank stability by Diamond and Dybvig (1983) examines how a rational and prudent actions by individual depositors to limit their own risks may be highly destabilizing to an institution designed to transform short-term liabilities into long-term assets. Allen and Gale (2002) develop a model of how financial networks influence systemic risk and in which systemic risk arises through liquidity shocks that spread from one bank to another and cause the whole system to collapse. Allen and Gale (2002) find that a complete interbank network limits the severity of a financial crisis whereas an incomplete interbank network transmits the shock more strongly across regions. In this chapter, the systemic risk emerges from within the system similar to a sandpile model

and self-criticality developed by Bak et. al. (1988) in which the natural dynamics of a system can lead to avalanches of bank failures.[5] This chapter, unlike Diamond and Dybvig (1983) and Allen and Gale (2002), simulates and provides analysis of the bank avalanche model of systemic risk.

This chapter also contributes to a growing literature on the role of interconnectedness and financial stability by testing the behavior of different bank network architectures. Several economists have used game theory and networks to explain economic behavior (Goyal (2007) and Jackson (2010)). Caballero and Simsek (2011) build upon the interconnected bank network of Allen and Gale (2011) but limit the amount of information that banks know about their counterparties. Banks know their own counterparties but not the counterparty of their counterparties. In this context, an increase in network complexity increases payoff uncertainty and a small shock relative to agent resources leads to large fire sales. Gai, Haldane, and Capadia (2011) show that the simplest network, rather than the complex network, survives the longest. They find that contagion from shocks is less frequent and less severe for lower levels than for higher levels of interconnectedness. Acemoglu, Ozdaglar, Tahbaz-Salehi (2013) show how systemic risk in financial networks arises due to counterparty risk and find that a complete financial network is more stable than the incomplete network as long as the

[5]Bak et. al. (1988) describe the principle of self-criticality using a sandpile model as "To demonstrate self-organized criticality, one needs a shoebox and a cup or two of sand - sugar or salt will do in a pinch. Wet the sand with a small amount of water, mix, and gather the sand into the steepest possible pile in one corner of the box. The angle of repose (i.e., the threshold slope) is larger for wet sand, so as the water evaporates, one observes a sequence of slides - some very small, others quite large - occurring at random places on the pile. (The evaporation process can be sped up by placing the box on a warm surface, or under direct sunlight.) This experiment is also exceptionally portable, and is best done on a sunny day at the beach."

shocks are small. However, when the shocks reach a certain level then bank interconnectedness serves as a propagation mechanism and leads to a more fragile financial system. Glaesserman and Young (2013) develop a model of financial contagion and examine how interconnections increase expected losses, with minimal information about network architecture, under a range of shock distributions. This chapter examines the degree to which different interbank network architectures change the profitability and financial stability of the system and tracks systemic risk in the form of bank avalanches.

Finally, this chapter contributes to the literature by using complexity economics and agent based modeling (ABM) to examine bank avalanches and systemic risk within an interconnected financial system. This chapter uses an ABM with behavioral rules for banks and non-financial transactors as in Friedman (1998 and 2012) to analyze systemic risk in a complete network, unconnected network, circle network, and star network. The systemic risk in this ABM emerges as a critical state as a result of the system dynamics and the interactions between agents Bak et. al (1988). ABMs are well suited to examine systemic risk as they allow agents to be unique and different, interact locally, and exhibit adaptive behavior (Grimm et. al. (2010)). Furthermore, ABMs are evolving complex systems in which shocks come endogenously from the behavior and interactions of individual agents rather than coming from exogenous shocks outside of the system (Bookstaber (2012), Bookstaber et. al. (2014), Battiston et. al. (2016)). Recently, Leduc et. al. (2016) use an agent based model to examine systemic risk in financial networks with credit default swaps (CDS) and find that the CDS market improves resiliency to insolvency cascades.

4.3 Model Description

4.3.1 Overview

The purpose of this agent based model (ABM) is to examine the emergence of systemic risk in a financial network that has banks and non-financial transactors. ABMs are used for explaining systems level behavior because of their unique ability to include heterogeneity of and among agents, local interactions and learning among agents, and adaptive behavior of agents. This bank avalanche model of systemic risk has banks and non-financial transactors that follow behavioral rules from Friedman (1998) with different network architectures. The systemic risk in this model leads to bank avalanches as the failure of one bank impacts the failure of other banks in the financial system. A better understanding of these dynamics can provide insights into how the interconnected actions of bank operations leads to systemic risk, the ways in which financial network topography affect financial stability, and possibly assist in developing policies to mitigate these risks. This model description proceeds covers three main areas: overview, design concepts, and details (Grimm et. al. (2010)).

Entities

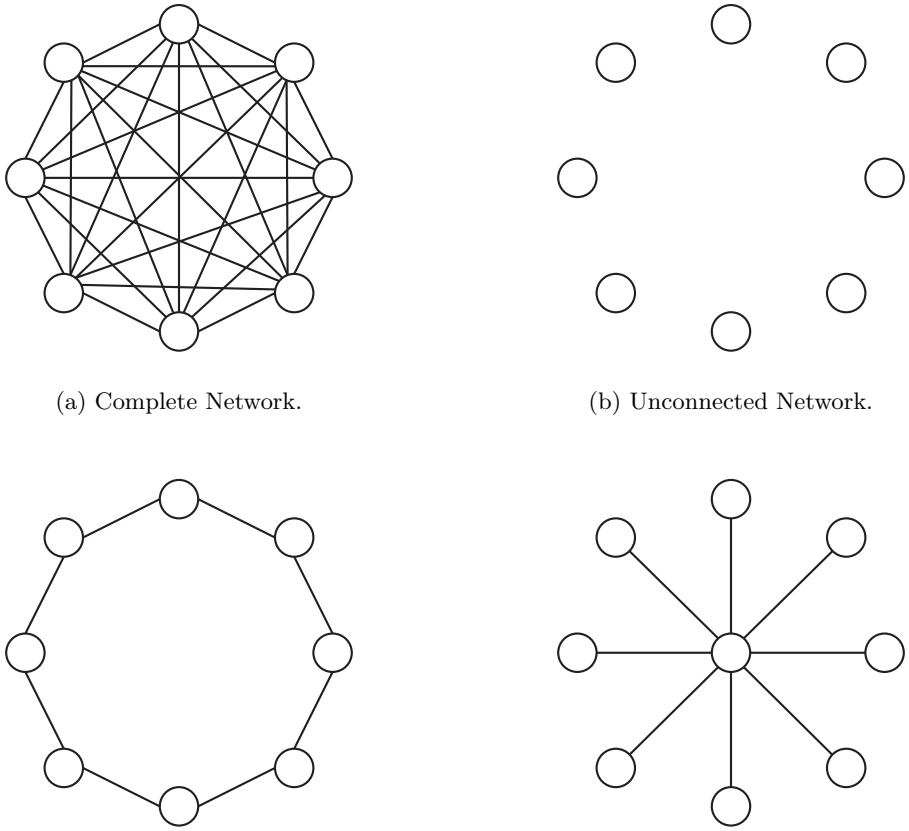
The two entities in this ABM are the banks and non-financial transactors (NFTs). Bank avalanches occur when more than one bank becomes insolvent and defaults at the same time in a simulation. The banks interact directly with NFTs and through the interbank market with other banks. Each bank maximizes their net

interest revenue by taking deposits D, making loans L, and making interbank loans I_L while making sure to maintain the minimum reserve requirement R. The non-financial transactors in this ABM use the financial system to make deposits D and apply for loans L. The non-financial transactors affect the interactions and activities of the banks.

State Variables and Scales

This ABM has several system level state variables. The first state variable is the interbank network architecture through which the banks can borrow and lend to other banks. As seen in Figure 4.1, we consider the following architectures: complete network, unconnected network, circle network, or star network. In the complete network, each bank trades interbank deposits I_D and interbank loans I_L with all the other banks in the network. In the unconnected network, banks cannot trade interbank deposits I_D and interbank loans I_L in the network. In the circle network, each bank makes interbank deposits I_D and loans with neighboring banks. In the star network, each bank has a centrally cleared transaction of interbank deposits I_D and interbank loans I_L. The other system state variable is the total number of banks in the network.

There are state variables specific to the banks and to the NFTs. The state variables specific to the banks are the bank loan rate to the NFTs p_{loan} and the bank reserve requirement R, which is a percentage of bank assets in reserves. The state variables specific to the NFTs include: the deposit rate $p_{deposit}$ (the rate the NFT makes a deposit to the bank), the withdrawal rate $p_{withdrawal}$ (the rate the NFT withdraws a bank deposit), the repayment rate $p_{repayment}$ (the rate the NFT repays a loan), and the



(a) Complete Network.

(b) Unconnected Network.

(c) Circle Network.

(d) Star Network.

Figure 4.1: Interbank Networks of the Bank Avalanche Model of Systemic Risk.

default rate $p_{default}$ (the rate the NFT defaults on a bank loan).

This ABM operates on a daily frequency time scale where each tick in the simulation represents a day. The ABM can be setup to run any number of simulations and restarts to a new simulation once all of the banks in the network become insolvent. The simulation ends once all of them have been completed.

Process Overview and Scheduling

This ABM has several steps at each period of the simulation which are outlined in the flow diagram of the bank avalanche model in Figure 4.1. When the simulation begins, the NFT engages in retail activity by making a deposit or a withdrawal as well as commercial activity to engage in a loan application, loan repayment, or default on a loan. Once the NFTs have completed their actions each bank examines their level of reserves relative to the reserve requirement. If a bank has a level reserves greater than their reserve requirement then the bank can provide a loan to an NFT or an interbank loan to another bank. If the level of reserves equals the reserve requirement then the bank does not take any additional actions. When reserves are less than the reserve requirement then the bank uses its deposits to replenish its reserves, uses the interbank deposits to replenish its reserves, recalls loans from other banks, or recalls loans from NFTs. Once the bank has an appropriate level of reserves it must check to see its level of capital. When bank capital is positive the bank is solvent and continues to the next period otherwise the bank is insolvent and must be removed from the simulation.

4.3.2 Design Concepts

Basic principles

The basic principle for the banks in this model is to maximize their net interest revenue. Bank net worth is measured by its capital $K = R + L + I_L - D - I_D$, which is the sum of assets (reserves R, loans to NFTs L, and interbank loans I_L) less liabilities

(deposits from NFTs D and interbank deposits I_D). The banks maximize net interest revenue by minimizing their reserves R by making loans to loan applicants L and to other banks I_L. In particular, each bank attempts to keep its reserves R equal to the reserve requirement R^* by using deposits D, interbank deposits I_D, and calling in loans L. A bank without sufficient deposits from NFTs to meet its requirements will access the interbank market to make this funding available from another bank in their network. When R_i falls below 0 and the number of interbank loans outstanding $I_L = 0$ then bank is illiquid. The bank i can increment reserves R by recalling loans L_i, increasing its deposits D_i and interbank deposits I_D. A bank reaches a critical state and becomes insolvent when bank capital $K < 0$ and becomes bankrupt and must be liquidated. The increased market stress as a result of this insolvency and liquidation of loans L and interbank loans I_L can affect neighboring banks that are counterparties of these transactions because of reduced overall market liquidity.

The basic principle for the NFTs is to make deposits and apply for loans at the banks which in turn affect the financial position of the banks. An NFT makes a a new deposit or loan with some positive probability $p_{deposit}$ and p_{loan} according to a Poisson distribution process. An NFT deposit leads to a deposit $D_i + 1$ and new loan $L_i + 1$ events at a bank i. Withdrawal $D_i - 1$ and repayment $L_i - 1$ events at a bank and are also initiated by NFTs randomly with probability $p_{withdrawal}$ and $p_{repayment}$ per unit of D and L every time period. There is a probability $p_{default}$ of a loan default at bank i causing $L_i - 1^*$ that induces a lower value of capital $K_i - 1$ but no change in reserves R_i.

The basic principle of the interbank market is to allow each bank to make interbank loans I_L and interbank deposits I_D with other banks in their network. At every point in time during the simulation, the ABM tracks the reserves R_i that each bank has on hand, amount of deposits D_i that each bank has from NFTs, and the number of loans L_i to NFTs. Each deposit and loan in this model have a value of 1 which makes reserves, deposits, and loans all integer values. In the model, there are interbank loans I_L and interbank deposits I_D between the banks in the network. In the real world, these connections could also represent the interbank market for CDs, credit default swaps, and FX contracts. The interbank assets for bank i are the sum of interbank loans and interbank deposits $A_i = I_{i+1} - I_i = I_L - I_D$. There is a balance so that the total bank deposits in the financial system is equal to the sum of the deposits at each individual bank $D_T = \sum_{i=1}^{N} D_i$ and the total loans by the banks in the financial system equals the sum of the loans at each individual bank $L_T = \sum_{i=1}^{N} L_i$. Although the total interbank deposits I_D and interbank loans I_L balance on the system level, the I_D and I_L may not balance at an individual bank. In this way, it is possible that an individual bank will not have the sum of its deposits equal the sum of its loans. When an individual bank does not have sufficient deposits from NFTs to meet its reserve requirement or has insufficient loans applications to satisfy the deposits then the bank will access the interbank market to request funds from another bank.

Adaptation

The banks make decisions and adapt behavior in each period to meet regulatory requirements for bank reserves, to remain competitive relative to other banks, and to respond to the market environment. The model uses a fixed Poisson distirbution process for the loan rate p_{loan} and bank reserve requirements R^* that provide baseline parameters for the bank behavior. The market environment is described by the Poisson distribution process for the deposit rate $p_{deposit}$, withdrawal rate $p_{withdrawal}$, repayment rate $p_{repayment}$, and default rate $p_{default}$. At each period every bank makes decisions about their strategy to maximize their net interest revenue through their operations with NFTs and with other banks. The banks engage in use their interbank network and through these relationships observe the strategies, profitability, and insolvency of neighboring banks. Banks can change their strategies by changing their reserve holdings. Although a bank must meet the minimum reserve requirement they can decide to increase or change their reserves so long as the amount of capital that they have is positive.

Objectives

The objective of the banks is to maximize their profits as measured by their net interest revenue. The success of the banks will depend on their profitability which is linked to the degree to which they are lending and their leverage. Profitability is the net interest revenue in each period. Recall that bank net worth is its capital K which is the sum of reserves, loans, interbank loans and less deposits and interbank deposits

$K = R + L + I_L - D - I_D$. It is implicitly assumed that interest rate paid on loans L is higher than interbank loans I_L which is higher than the interest rate paid on reserves R. Furthermore, banks do not want to be illiquid or become insolvent but do not have information on the entire banking system. Throughout the simulation the banks will increasingly increase their profitability by reducing their reserves which increases the possibility of a liquidty or insolvency event in the future.

Sensing

The banks in this model sense the state of the economy and the behaviors of the other banks in their network. When the economy is doing well, the banks are receiving deposits and withdrawals as NFTs have to satisfy their retail banking needs. In addition, as the economy performs well, the banks sense an increased demand for loans, an increase in loan repayment rates, and a decrease in the loan default rates. On the other hand, when the economy is doing poorly, then the banks will sense a decreased demand for loans, a decreased demand for loans, a decrease in loan repayment rates, and an increase in loan default rates. The banks also sense the behaviors of the other banks in their network through their dealings with other banks. For example, when the economy is performing well, banks on average will have a higher rate of deposit from NFTs and a higher demand for loans. Banks can use the interbank market to either lend excess deposits or to borrow money to meet the demand from loan applicants. Because a bank can only use the interbank market if it has a connection with another bank the more connected bank networks are better able to borrow and lend excess deposits on

the interbank market.

Interaction

The banks in this model interact with the non-financial transactors (NFTs) directly and interact with other banks in their network according to the behavioral rules. This ABM assumes a Poisson probability distribution of behavior that the NFTs interact with the banks to make deposits and withdrawals, apply for loans, and default with some probability and then examines how the banks react to these behaviors to make interbank loans and deposits. The banks interact with other banks in the system in order to gain competitive advantage.

The interbank transactions is a main interaction element in this ABM. When an NFT deposits or applies for a loan at a bank then this bank has the opportunity to conduct interbank transactions other banks in the network. A transaction of 1 dollar from bank i to bank j could have one of the following effects. First, $R_{i,t} - 1 \rightarrow R_{i,t+1}$ implies that a bank experiences a withdrawal in the form of a deposit or a loan with either an NFT or another bank at time t and therefore has a change in the value of reserves R_i at time $t+1$ from what it had at time t. Whenever this type of interaction occurs at bank i there is a counterparty bank j which experiences $R_{j,t} + 1 \rightarrow R_{j,t+1}$ which is an increase in the level of reserves by 1 at time t to time $t+1$. The simulation keeps track of interbank loans and deposits. Therefore, if we suppose NFTs initiate deposit at bank j but then a loan at bank k, assume that $j = i-1$ and $k = i+1$, bank j reacts to this by increasing its interbank loans I_L at neighboring bank i. Note that

the assets A_i is unaffected and R_i and K_i also remain unchanged.

The banks in this financial system also can experience a liquidity crisis as internal forces push the financial system to a critical state. Suppose that each bank has a target level of reserves R^*. In this financial system, when bank i has just enough deposits to meet its reserve requirement target R^* and an NFT deposit withdrawal or loan request that renders bank i illiquid. When bank i becomes illiquid the system can go into a critical state as this withdrawal from bank i goes to the neighboring bank j. This neighboring bank j can then become illiquid and this can spread the local episode to other banks in the system. Similarly, when a bank decides to have larger reserves and to change its reserve target it then can call in the loans that it has made to the other banks. Therefore, the NFTs see a critical state and rationally accelerate the crisis.

The banks in this financial system can experience a solvency crisis in the course of their every day interactions. A bank solvency crisis happens because the professional bank managers lower the capital K that they hold at the bank relative to bank assets over time. First, the banks managers lower the capital K because the banks that have higher K will lower K to be competitive with other banks. Banks with a lower K will be able, all else equal, to pay out more to shareholders and to show a higher return on equity. Banks with higher K will come under pressure to emulate the banks with the apparently lower K. Second, the bank manager compensation typically depends on relative performance. While bank managers are not penalized for poor performance in bad times they have an incentive to show the same profitability as other banks in good

times. Therefore, until a state of criticality is reached the bank managers will have an incentive to reduce the K of their bank relative to the other banks. Loan default causes bank i to become insolvent. This spreads and causes other connected banks to become insolvent. Moral hazard of government intervention is not part of this model.

4.3.3 Design Details

Initialization

The model initialization includes calibration parameters for the banking network and system dynamics as well as a set of initial economic conditions for good economic times and bad economic times. The bank network is either a complete network, unconnnected network, circle network, or star network. The most up to date data on banks and other bank holding companies is used to initialize the ABM at 8 banks.[6] In addition, the bank reserve ratio is 30 percent, starting deposits are 100, starting reserves are 303, starting loans are 700, the loan interest rate is 5 percent, and the deposit interest rate is 1 percent. The intuition for the starting level of reserves is that all banks start the simulation just slightly above the reserve requirement. For the simulations with good economic conditions the deposit rate is 3 per period, withdrawal rate is 2 per period, loan rate is 3 per period, repayment rate is 2 per period, and the default probability is 1 percent. For the simulations with bad economic conditions the

[6]Both the Federal Reserve Board of Governors and the Financial Stability Oversight Council (FSOC) provide public information on the following eight global systemically important bank holding companies (GSIBs): Bank of America Corporation; The Bank of New York Mellon Corporation; Citigroup, Inc.; The Goldman Sachs Group, Inc.; JPMorgan Chase & Co.; Morgan Stanley; State Street Corporation; and Wells Fargo & Company.

deposit rate is 3 per period, withdrawal rate is 3 per period, loan rate is 2 per period, repayment rate is 2 per period, and the default probability is 10 percent.

Input data

The current version of this ABM uses reasonable parameter values and initial conditions. Future versions could incorporate other model parameter values and initial conditions.

4.4 Results

The simulation results indicate that more interconnected bank networks have longer bank lifespans, are more profitable, but are also more likely to experience a bank avalanche than less interconnected bank networks. Furthermore, the profitability and the financial stability of the bank networks depends on the economic conditions. Simulations are conducted across all of the networks using a model calibration with good economic conditions and using a model calibration with bad economic conditions. The results indicate that there is greater dispersion in profitability and financial stability across the networks when there are good economic conditions than when there are bad economic conditions. Furthermore, the circle network performs best of all the networks in terms of bank lifespan, profitability, and also has less bank avalanches than the complete network.

When the model is calibrated with good economic conditions the mean simulation results indicate that the circle network performs the best of all the financial

networks in terms of bank lifespan and profitability. For the simulations with good economic conditions the deposit rate is 3 per period, withdrawal rate is 2 per period, loan rate is 3 per period, repayment rate is 2 per period, and the default probability is 1 percent. As seen from Table 4.1, the mean bank lifespan is longest for the circle network with 9,460, for the star network is 2,668, for the complete network is 1,499, and the unconnected network is 726. The average profitability is highest for the circle network with 3,794,223 followed by the star network with 1,693,435, the complete network with 791,983, and the unconnected network with 152,019. The bank avalanche statistics indicate that they are highest for the complete network with a mean of 0.56, followed by circle network with 0.01, and no bank avalanches for the star network or the unconnected network. Appendix Table 4.3 provides even more detailed summary statistics on model simulations calibrated using good economic conditions.

Table 4.1: Mean of Simulation Results (Good Economy)

	Complete Network	Unconnected Network	Circle Network	Star Network
Bank Lifespan	1,499	726	9,460	2,668
Profitability	791,983	152,019	3,794,223	1,693,435
Bank Avalanche	0.56	0.00	0.01	0.00

The cumulative density functions of bank lifespan and profitability under good economic conditions provide additional insights into the results. Appendix Figure 4.3 shows that the bank lifespan for the circle network in good economic conditions is very different from the other financial networks. The bank lifespan for the unconnected network is the shortest and ends at about 2000. The bank lifespan for the complete network and the star network stabilize at 2000 with about 20 percent of the banks then

continuing on until 10,000. The circle network, however, loses about 5 percent of the banks in the very beginning but then about 95 percent of the banks have a lifespan until 10,000. Appendix Figure 4.5 shows very different profitability cumulative density functions for the different financial networks. Almost 90 percent of the banks in the circle network make a profit over 3 million. In the complete network about 70 percent of the banks earn a profit of less than 1 million and 30 percent of the banks make a profit of over 2 million, but none over 3 million in profits. About 25 percent of the banks in the star network make less than 2 million and the other 75 percent of the banks earn a little over 2 million. Appendix Figure 4.7 shows that the complete network has by far the most bank avalanches of any of the other networks.

When the model is calibrated with bad economic conditions the simulation results also indicate that the circle network performs best of all the financial networks in terms of bank lifespan and profitability. As seen from Table 4.2, the average bank lifespan is longest for the circle network with 95 and followed by the star network with 94, the complete network with 81, and the unconnected network with 70. The average profitability is highest for the circle network with 19,004, the star network with 18,653, the complete network with 16,093, and the unconnected network with 13,796. The bank avalanche statistics indicate that the complete network has the highest amount of bank avalanches with a mean of 0.24, followed by the circle network with 0.09, the star network with 0.03, and no bank avalanches for the unconnected network.

The cumulative density functions of bank lifespan and profitability under bad economic conditions indicate less variation across the different networks than was present

Table 4.2: Mean of Simulation Results (Bad Economy)

	Complete Network	Unconnected Network	Circle Network	Star Network
Bank Lifespan	81	70	95	94
Profitability	16,093	13,796	19,004	18,653
Bank Avalanche	0.24	0.00	0.09	0.03

under good economic conditions. Appendix Figure 4.4 show that cumulative density functions for bank lifespan is relatively the same across the different network. The bank lifespan for the unconnected network is the shortest and ends at about 160. However, the bank lifespans for the complete, circle, and star network converge to the same place at over 500. Appendix Figure 4.6 indicate that similar cumulative density functions of profitability for the different financial networks. The profitability of the unconnected network is the lowest of all the other networks and ends at 30,000. The cumulative density functions for profitability show no noticeable differences for the the complete network, circle network, and star network. The maximum profitability for the unconnected network is much lower than the other networks but only about 1 percent of banks earn more than 75,000 in the complete network, circle network, and star network. The Appendix Figure 4.8 shows that the complete network has by far the most bank avalanches of any of the other networks. The complete network has 176 instances with 1 bank avalanche, 31 instances with 2 bank avalanches. The circle network has 58 instances of 1 avalanche and 16 instances of 2 avalanches. The star network has 32 instances with 1 avalanche while the unconnected network, by definition because it does not have an interbank network, does not have any avalanches.

The two main results are that the circle network exhibits the best performance

of all the networks and that network matters much more when there are good economic conditions than when there are bad economic conditions. One possible explanation for why the circle network does so well relative to the other networks in terms of bank lifespan, profitability, and bank avalanches is that a few of the banks become insolvent at the beginning of the simulation but because they are not connected to the entire system it does not bring down the other banks. In the complete network there is less of a change for bank failures for the bad banks to occur but then when they do the financial contagion spreads to the healthy banks too. In the unconnected and the star networks the banks are unable to take full advantage of the interbank network even if they are less likely to experience financial contagion. There is a much greater dispersion in the performance of the financial networks when there are good economic conditions than when there are bad economic conditions. More work must be done to explore the role of economic conditions on network performance.

4.5 Conclusion

This chapter developed a model of systemic risk to examine the emergence of profitability and financial stability of different bank networks. This agent based model (ABM) introduced behavioral rules for banks and non-financial transactors with an interbank market that included a complete network, unconnected network, circle network, and a star network. Simulations were used to examine the behavior of the model using good economic conditions and bad economic conditions in the different interbank net-

works. These simulation results for the good economic conditions indicated that more interconnected interbank networks had longer bank lifespan and higher profitability but also a higher incidence of a bank avalanche or financial contagion. Interestingly, the circle network performed better than all of the other interbank networks, including even the complete network, suggesting that there are limits to the benefits of interconnections in good economic conditions. Whether the economic conditions were good or bad also appear to affect the bank lifespan, profitability, and incidence of bank avalanche.

This chapter showed that the structure of interbank connections can affect financial contagion and the emergence of systemic risk. The results in this chapter contrast with those of Allen and Gale (2002) that the complete network is the most stable and Acemoglu, Ozdaglar, Tahbaz-Salehi (2013) that incomplete networks are more stable than incomplete networks as long as shocks are small. Whereas in those models the shocks came from an external source the shocks in this model emerged through the interactions of the agents as the system reached a critical state which lead to bank avalanches. In this chapter the circle network, in which the banks are not fully connected but also not unconnected either, perform the best in terms of bank lifespan and profitability. Furthermore, in this chapter the performance of the various interbank networks depends also on the state of the economy and shows greater variation when there are good economic conditions than when there are bad economic conditions. In the future, the model calibration could possibly integrate real time data to monitor and stress test the global financial system. This chapter also assumed that all the banks in the system faced the same set of parameters and regulatory frameworks. Future

work could also explore financial stability dynamics in which the banks were not only different at the time of initialization but in which they actually faced different sets of regulations and how that would affect the system as a whole. This bank avalanche model of systemic risk can also be used to examine related issues in financial stability.

4.6 Appendix Figures and Tables

Figure 4.2: Flowchart of Bank Avalanche Model of Systemic Risk.

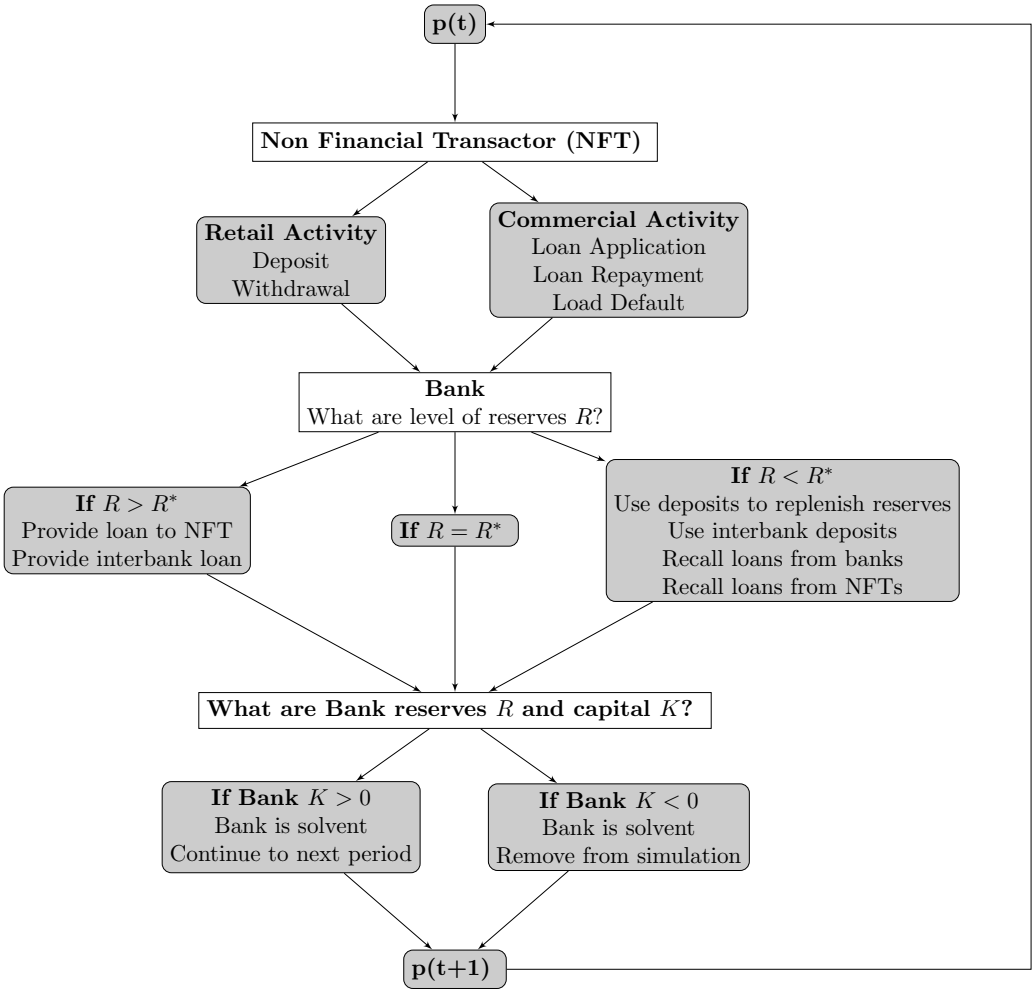


Table 4.3: Summary Statistics of Simulation Results (Good Economy)

		Complete Network	Unconnected Network	Circle Network	Star Network
Bank Lifespan					
	Mean	1,499	726	9,460	2,668
	Std. Dev.	2,546	291	2,198	3,665
	Min	12	15	25	35
	Max	10,080	1,938	10,101	10,093
	Obs.	1,000	1,000	1,000	1,000
Profitability					
	Mean	791,983	152,019	3,794,223	1,693,435
	Std. Dev.	912,118	36,537	786,974	712,499
	Min	14,618	64,971	8,379	63,132
	Max	4,029,960	323,740	4,191,759	2,220,368
	Obs.	1,000	1,000	1,000	1,000
Bank Avalanche					
	Mean	0.56	0.00	0.01	0.00
	Std. Dev.	0.69	0.00	0.13	0.00
	Min	0	0	0	0
	Max	3	0	3	0
	Obs.	1,000	1,000	1,000	1,000

Table 4.4: Summary Statistics of Simulation Results (Bad Economy)

		Complete Network	Unconnected Network	Circle Network	Star Network
Bank Lifespan					
	Mean	81	70	95	94
	Std. Dev.	91	29	116	71
	Min	2	1	3	4
	Max	2,205	188	1,834	1,649
	Obs.	1,000	1,000	1,000	1,000
Profitability					
	Mean	16,093	13,796	19,004	18,653
	Std. Dev.	9,410	3,381	20,122	6,960
	Min	3,072	5,845	3,823	3,768
	Max	127,685	29,964	358,212	92,745
	Obs.	1,000	1,000	1,000	1,000
Bank Avalanche					
	Mean	0.24	0.00	0.09	0.03
	Std. Dev.	0.49	0.00	0.34	0.18
	Min	0	0	0	0
	Max	2	0	2	1
	Obs.	1,000	1,000	1,000	1,000

Figure 4.3: Cumulative Density Function of Bank Lifespan (Good Economy)

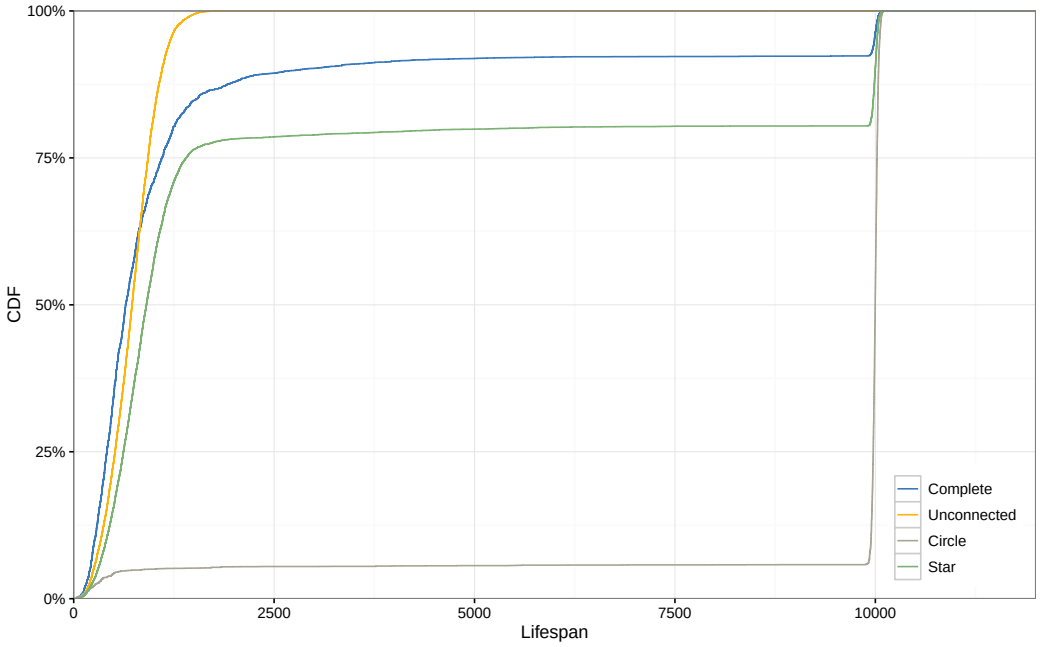


Figure 4.4: Cumulative Density Function of Bank Lifespan (Bad Economy)

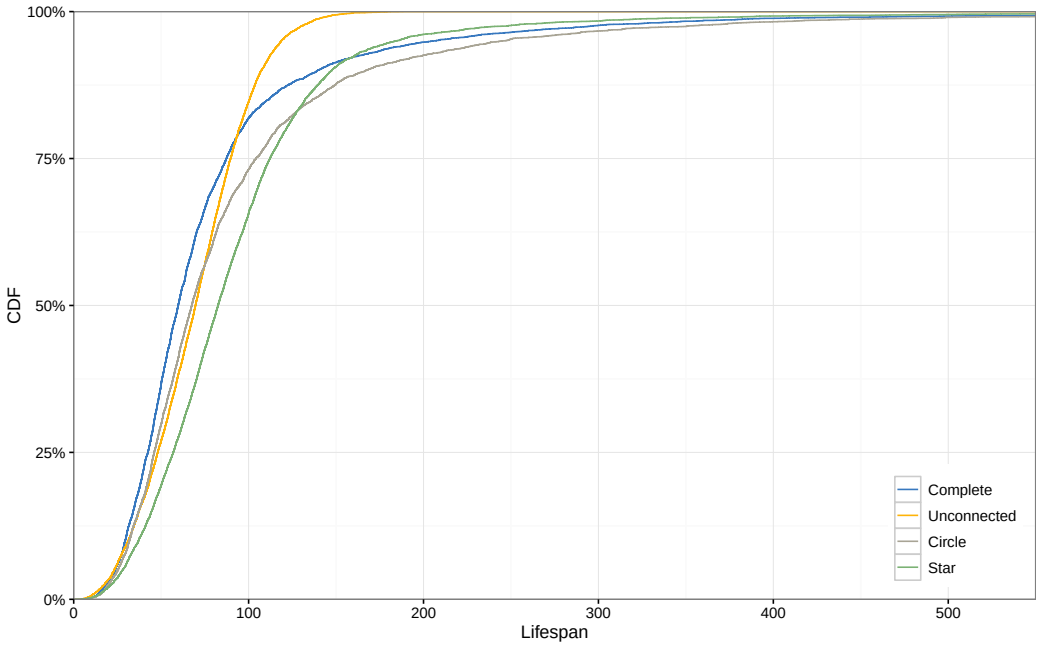


Figure 4.5: Cumulative Density Function of Profitability (Good Economy)

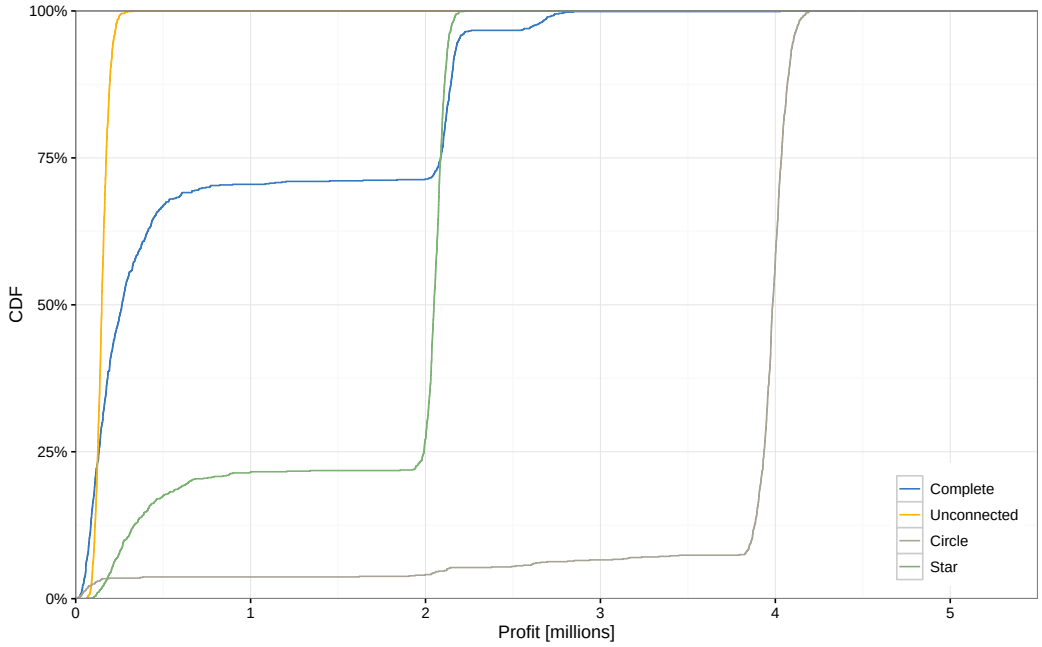


Figure 4.6: Cumulative Density Function of Profitability (Bad Economy)

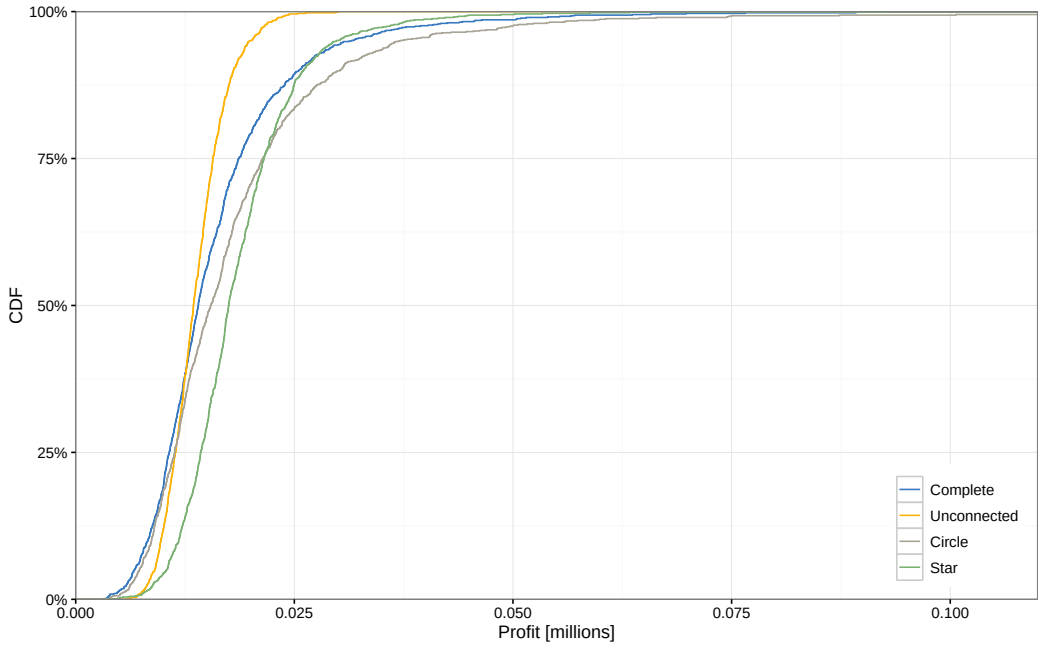


Figure 4.7: Summary Statistics of Bank Avalanches (Good Economy)

	Complete Network	Unconnected Network	Circle Network	Star Network
No Avalanches	547	1000	991	1000
1 Avalanche	346	0	8	0
2 Avalanches	103	0	0	0
3 Avalanches	4	0	1	0

Figure 4.8: Summary Statistics of Bank Avalanches (Bad Economy)

	Complete Network	Unconnected Network	Circle Network	Star Network
No Avalanches	793	1000	926	968
1 Avalanche	176	0	58	32
2 Avalanches	31	0	16	0
3 Avalanches	0	0	0	0

Appendix A

Chapters 2 and 3: AFNS and B-AFNS Model Descriptions

A.0.1 Arbitrage-Free Nelson Siegel (AFNS) Model

Term structure models decompose the debt yields into the average expected future short-term rate and the term premium for a given maturity. The yield curve at time t for a given maturity τ debt can be written to be the sum of the average market expectations of the short-rate and a term premium at time time for a given maturity τ bond:

$$y_t(\tau) = \frac{1}{\tau}\int_t^{t+\tau} E_t^P[r_s]ds + TP_t(\tau)$$

the average expectations of the short rate is sometimes referred to as the risk neutral yield and written as $RN_t(\tau) = \frac{1}{\tau}\int_t^{t+\tau} E_t^P[r_s]ds$ and is identical for all debt of that maturity. The term premium, $TP_t(\tau)$ is a residual term that captures information

about growth and inflation, changes in overall risk aversion, credit risk, and liquidity risk of the bond. The term premium $TP_t(\tau)$ can also be expressed in terms of the model $TP_t(\tau) = y_t(\tau) - \frac{1}{\tau}\int_t^{t+\tau} E_t^P[r_s]ds$. The forward short rates and forward term premia can be estimated from the the term structure model and will be compared to asset price measures of the short-rate.

The arbitrage-free Nelson-Siegel model (AFNS) by Christensen and Rudebusch (2012) is an affine Gaussian term structure model that builds off a representation introduced in Christensen et al. (2011) and contributes to a growing literature of dynamic term structure models.[1] Gaussian term structure models have risk-neutral Q-measure that captures factors in the short-term rate and a real world P-measure that captures factors in the term premium. This AFNS model has three latent state variables that represent the slope, level, and curvature of the yield curve $X_t = (L_t, S_t, C_t)$. The risk-neutral Q-measure is described by the following stochastic differential equations (SDEs):

$$\begin{pmatrix} dL_t \\ dS_t \\ dC_t \end{pmatrix} = \begin{pmatrix} 0 & 0 & 0 \\ 0 & \lambda & -\lambda \\ 0 & 0 & \lambda \end{pmatrix} \left[\begin{pmatrix} \theta_1^Q \\ \theta_2^Q \\ \theta_3^Q \end{pmatrix} - \begin{pmatrix} L_t \\ S_t \\ C_t \end{pmatrix} \right] dt + \sum \begin{pmatrix} dW_t^{L,Q} \\ dW_t^{S,Q} \\ dW_t^{C,Q} \end{pmatrix}, \qquad \lambda > 0 \tag{1}$$

The short-term rate is described by

[1] Other examples of term structures include Hamilton and Wu (2012), Andreasen and Christensen (2015).

$$r_t = L_t + S_t \tag{2}$$

This specification implies that zero-coupon bond yields are given by

$$y_t(\tau) = L_t + \left(\frac{1 - e^{-\lambda\tau}}{\lambda\tau}\right) S_t + \left(\frac{1 - e^{-\lambda\tau}}{\lambda\tau} - e^{-\lambda\tau}\right) C_t - \frac{A(\tau)}{\tau} \tag{3}$$

The factor loadings in the yield function are the level, slope, and curvature loadings introduced in Nelson and Siegel (1987). The $A(\tau)/\tau$ is a yield-adjustment term, which captures the convexity effects due to Jensen's inequality and ensures the absence of arbitrage. Diebold and Rudebusch (2011) explain that this adjustment term makes sure that the Nelson-Siegel bond prices are arbitrage-free and thus are not subject to the critique by Filipović (1999) that Nelson-Siegel models contain arbitrage opportunities.

The AFNS model is completed with a term premium specification that connects the measure of risk-free Q-factor dynamics with the measure of risk P-factor dynamics. The term premium is affine and implemented as in Duffee (2002). The factor dynamics of the maximally flexible specification of the AFNS model are then given by:

$$\begin{pmatrix} dL_t \\ dS_t \\ dC_t \end{pmatrix} = \begin{pmatrix} \kappa_{11}^P & \kappa_{12}^P & \kappa_{13}^P \\ \kappa_{21}^P & \kappa_{23}^P & \kappa_{23}^P \\ \kappa_{31}^P & \kappa_{32}^P & \kappa_{33}^P \end{pmatrix} \left[\begin{pmatrix} \theta_1^P \\ \theta_2^P \\ \theta_3^P \end{pmatrix} - \begin{pmatrix} L_t \\ S_t \\ C_t \end{pmatrix} \right] dt + \sum \begin{pmatrix} dW_t^{L,P} \\ dW_t^{S,P} \\ dW_t^{C,P} \end{pmatrix}, \qquad \lambda > 0 \tag{4}$$

The AFNS forward rate is described by the following equation:

$$f_t(\tau) = L_t + e^{-\lambda\tau} S_t + \lambda\tau e^{-\lambda\tau} C_t + A^f(\tau) \tag{5}$$

The yield data used to estimate the shadow rate model includes a large sample of nominal U.S. Treasury zero-coupon yields from January 4, 1985 until March 5, 2015. The yields consist of three- and six-month Treasury bill yields from the H.15 series from the Federal Reserve Board as well as the one year, two years, three years, five years, seven years, and ten years data from Gurkaynak et al. (2007). The longest maturity Treasury yields are not available prior to November 25, 1985 and so that is why the sample is restricted to starting at that time. A standard Kalman filter is used to analyze the data.

The AFNS model is used to estimate the standard zero-coupon yield and forward rate decompositions as described in Christensen and Rudebusch (2012) for the time period October 8, 2008 until October 29, 2014. The estimated yield curve data includes fitted zero-coupon yields, average expected short rates, and zero-coupon yield term premiums. The estimated forward rate curve data includes the fitted forward rates, expected short-rates, and forward rate term premiums. The maturities for this includes six months as well as the one year, two years, three years, four years, five years, six years, seven years, eight years, nine years, and ten years.

The standard Gaussian and AFNS term structure models are unable to capture two features of the term structure that arise at the zero lower bound. First, as a Gaussian model, the AFNS model assigns positive probabilities of negative interest

rates when the economy is near the zero lower bound. When the interest rate is negative, a loan is to be repaid with a lower amount than the original proceeds (Munk (2011)). This assumption does not stand up to economic theory (Black (1995)) nor does it stand up to empirical observation. Second, the AFNS model assumes that yields have constant volatility over time. This second assumption does not stand up to empirical reality because yields are less volatile when constrained at the zero lower bound (Christensen and Rudebusch (2014)).

A.0.2 Shadow Rate Arbitrage-Free Nelson-Siegel (B-AFNS) Model

The shadow rate (B-AFNS) model developed by Christensen and Rudebusch (2013) is an AFNS model except that it replaces the short-rate with a shadow rate that is truncated at zero and it also allows yields to become less volatile as the economy gets closer to the zero lower bound (Christensen and Rudebusch (2014)).[2] Otherwise, the B-AFNS model is the same as the standard three factor AFNS model.

The state variables follow the same risk neutral dynamic process for the Q-measure as the popular Nelson and Siegel (1987) model:

$$\begin{pmatrix} dL_t \\ dS_t \\ dC_t \end{pmatrix} = \begin{pmatrix} 0 & 0 & 0 \\ 0 & \lambda & -\lambda \\ 0 & 0 & \lambda \end{pmatrix} \left[\begin{pmatrix} \theta_1^Q \\ \theta_2^Q \\ \theta_3^Q \end{pmatrix} - \begin{pmatrix} L_t \\ S_t \\ C_t \end{pmatrix} \right] dt + \sum \begin{pmatrix} dW_t^{L,Q} \\ dW_t^{S,Q} \\ dW_t^{C,Q} \end{pmatrix}, \qquad \lambda > 0 \tag{6}$$

[2]Christensen and Rudebusch (2014) follow Kim and Singleton (2012) and refer to a world without physical currency by using the "B-" prefix in recognition of the work by Black (1995).

where $\sum$ is the constant covariance (or volatility) matrix.

The short-rate in the B-AFNS model is still the sum of the level and slope but constrained to be a non-negative process of the AFNS model:

$$s_t = L_t + S_t, \qquad r_t = \max\{0, s_t\} \tag{7}$$

The estimated bond yields in the B-AFNS models are allowed to be negative and follow the same popular level, slope and curvature factor loading Q-dynamics as the Nelson and Siegel (1987):

$$y_t(\tau) = L_t + \left(\frac{1 - e^{-\lambda\tau}}{\lambda\tau}\right) S_t + \left(\frac{1 - e^{-\lambda\tau}}{\lambda\tau} - e^{-\lambda\tau}\right) C_t - \frac{A(\tau)}{\tau} \tag{8}$$

where $A(\tau)/\tau$ is a maturity-dependent yield-adjustment term because of Jensen's inequality.

The risk factor P-measure dynamics of the B-AFNS follow the same process as in the AFNS model:

$$\begin{pmatrix} dL_t \\ dS_t \\ dC_t \end{pmatrix} = \begin{pmatrix} \kappa_{11}^P & \kappa_{12}^P & \kappa_{13}^P \\ \kappa_{21}^P & \kappa_{23}^P & \kappa_{23}^P \\ \kappa_{31}^P & \kappa_{32}^P & \kappa_{33}^P \end{pmatrix} \left[\begin{pmatrix} \theta_1^P \\ \theta_2^P \\ \theta_3^P \end{pmatrix} - \begin{pmatrix} L_t \\ S_t \\ C_t \end{pmatrix} \right] dt + \sum \begin{pmatrix} dW_t^{L,P} \\ dW_t^{S,P} \\ dW_t^{C,P} \end{pmatrix}, \qquad \lambda > 0 \tag{9}$$

The B-AFNS shadow forward rate equation is the same as the AFNS forward rate:

$$f_t(\tau) = L_t + e^{-\lambda\tau} S_t + \lambda\tau e^{-\lambda\tau} C_t + A^f(\tau) \tag{10}$$

where the final term is another maturity dependent yield-adjustment term due to Jensen's inequality.

The shadow-rate AFNS model is as flexible and empirically tractable as the standard AFNS model and is used to estimate the daily standard zero-coupon yield and forward rate decompositions as described in Christensen and Rudebusch (2013) for the time period October 8, 2008 until October 29, 2014. Similar to the AFNS model, the yield data used for the estimations comes the daily H.15 database and from Gürkaynak et.al. (2007). The model is estimated for fitted zero-coupon yields, average expected short rates, zero-coupon yield term premiums, fitted forward rates, expected short-rates, and forward rate term premiums at daily frequency. The expected short rates are estimated for 6 months to 10 year durations. This dissertation uses the B-AFNS model expected short rate at two year durations.

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