ESSAYS ON PRICING ANOMALIES AND THE LIMITS OF ARBITRAGE IN EMERGING MARKETS

A Thesis

by

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To my family for their constant support and unconditional love.

ABSTRACT

It is a difficult task to explain market anomalies in standard models of asset pricing, as they are all based on the core idea of the law of one price: two assets with equal expected returns have equal values. Otherwise, there is an arbitrage opportunity. However, arbitrage opportunities should not last for an extended period, as arbitrageurs should eventually locate the apparent mispricing, provide liquidity to markets, and keep prices in line with the asset's fundamentals. The Lehman crisis gives an opportunity to investigate both the behavioral and economic causes of deviations from the law of one price parity. Therefore, this dissertation thesis is focused on the empirical analysis of deviations from the law of one price parity using covered interest rate parity (CIRP) metric. It consists of three parts; the first two parts deal with the analysis of CIRP from different angles. The third part focused on finding an answer to the question, whether a market-based indicator created by the country-specific risk factors of CIRP deviations would be a major sign that can produce early warnings for the Turkish market.

In the first chapter, I use the covered interest rate parity metric to measure violations of the law of one price parity (LOP) for currencies of developed and emerging economies. Across the five maturity point, I investigate both the time-series and cross-sectional variation of this LOP metric which severely violated during periods of financial distress. Dynamic factor analysis reveals that LOP deviations are time varying and state dependent for both markets and driven by two factors, namely: Global and Local factors. I construct empirical proxies for these factors and run a comprehensive investigation about economic drivers of this anomaly in three separate phases, pre-crisis, crisis (liquidity and credit crisis) and post crisis. My findings show

that CIRP deviations on the global risk component and the country-specific risk components show distinct dynamics across developed and emerging countries. During the first phase of the crises, the global funding and liquidity factors are significant and shared to both markets, however, after the Lehman collapse while sentiment factors have a considerable impact on developed markets, the country-specific risk factors turn to be the main factors for emerging markets. In addition, financial contagion in developed markets, in terms of one way price discovery and volatility spillover does not appear to be valid for emerging markets CIRP deviations. Therefore, in the return and volatility levels, contagion in emerging countries indicate different local characteristics.

The collapse of the recent housing price bubble brought the global economy to its knees and caused international funding liquidity to dry up. In the second chapter, I investigate how economic policies during the crisis impacted global liquidity by examining the covered interest rate parity condition. I find that swap lines orchestrated by the Federal Reserve, stress test announcements, and other governmental policies and news events had a significant impact on CIRP violations. My findings indicate that policies pursued during the crisis helped relieve market frictions in foreign exchange markets and that the result of these policies differed for developed and emerging markets.

Most economists would argue that the seeds of the financial crisis were planted some time before the onset of the crisis. Hence, in the third chapter, I investigate whether the country-specific risk factors of CIRP deviations can be used as an early warning indicator for a local economy, namely Turkey, and create a blended index, so that regulators can be increasingly forward-looking hence pre-emptive rather than reactive in the century of high-speed information flow.

ÖZETÇE

Standart varlık fiyatlama modelleri ile piyasa anomalilerini açıklamak zordur, zira hepsi esas olarak tek fiyat teorisine dayanır; eşit getiri beklentileri olan varlıklar eşit değerlere sahip olmalıdır. Aksi takdirde, bir arbitraj fırsatı doğar. Ancak, arbitraj imkânı normal şartlarda uzun sürmemelidir, çünkü teorik olarak arbitrajörler gerekli likiditeyi sağlayarak yanlış fiyatlandırmayı sonlandırırlar. Yaşanılan son finansal kriz ise tek fiyat teorisini tekrar tartışmaya açmış ve oluşan sapmaların davranışsal ve ekonomik nedenlerini araştırmak için bir fırsat vermiştir. Bu tez, tek fiyat teorisinde oluşan sapmalara deneysel olarak Güvenceli Faiz Paritesi üzerinden odaklanmıştır. Tez üç bölümden oluşmaktadır, ilk iki bölüm Güvenceli Faiz Paritesinden sapmaların farklı açılardan analizini içerirken, son bölüm Türkiye finansal sistemi için piyasa tabanlı erken uyarı üretebilecek bir endeksin bu sapmalar kullanılarak oluşturulup oluşturulamayacağını araştırmaktadır.

İlk bölümde, gelişmiş ve gelişmekte olan piyasalarda Güvenceli Faiz Paritesi analizi üzerinden tek fiyat teorisinin bozulmaları getiri eğrisinin beş ayrı vadesinde incelenmiştir. Dinamik faktör analizi sonucu tek fiyat teorisindeki bozulmaların her iki piyasa için zamana ve duruma bağlı olduğu, diğer taraftan küresel ve lokal olmak üzere iki faktörün etkinliği tartışılmıştır. Takas (swap) marketlerindeki derinleşen bozulmaların ekonomik sebepleri kriz öncesi, kriz ve kriz sonrası olmak üzere dönemlere ayrıştırılarak araştırılmış, küresel ve ülke özel sebeplerin etkinliği tartışılmıştır. Sonuçlar, parite düzensizliklerini açıklamada gelişmiş ülkelerde küresel faktörlerin –fonlama, likidite, davranışsal- önemini; gelişmekte olan ülkelerin ise küresel faktörlerin yanında; lokal faktörlerin - kurun ani değişiklik riski ve kredi riski - önemini ortaya koymuştur. Ayrıca gelişmiş marketlerde görünen finansal bulaşıcılık, varlıkların

değerlerinin oluştuğu vade ve vadeler arası tek yönlü bilgi geçişkenliği, gelişmekte olan ülke faiz parite bozulmaları verisinde gözükmemektedir. Bu durum, gelişmekte olan ülkeler için seviye ve oynaklıkta bulaşıcılık etkisinin de lokal düzeyde farklılık taşıdığını göstermektedir.

Emlak piyasasının çökmesi ile küresel ekonominin yaşadığı daralma uluslararası likiditenin kurumasına sebep olmuştur. Tezin ikinci bölümünde, kriz ile birlikte küresel likiditeyi yönetmede merkez bankalarının ve küresel ekonomi politikalarının etkinliğini Güvenceli Faiz Paritesi üzerinden araştıracağım. Bulgularım, Amerika Merkez Bankası (FED) öncülüğünde açılmış olan takas olanaklarının, stress test duyurularının ve diğer yapılan müdahalelerin Güvenceli Faiz Paritesi bozulmalarının normale döndürülmesinde etkili olmuştur. Ayrıca, müdahaleler kriz döneminde döviz marketlerinde yaşanan dalgalanmayı azaltmış, ancak sonuçları gelişmiş ve gelişmekte olan piyasalarda farklılık göstermiştir.

Birçok ekonomist finansal krizlerin tohumlarının krizlerden önce atıldığını ve bu sebeple fark edilebileceğini iddia eder. Tezimin üçüncü bölümünde, Güvenceli Faiz Paritesi sapmalarının tezimin ilk kısmında açıkladığım sebeplerinin gelişmekte olan ülke örneklerinden Türkiye için kriz öncesinde bir erken uyarı göstergesi olup olamayacağını bir endeks oluşturarak araştıracağım. Bu sayede Türkiye özelinde politika üretenler ve/veya regülatörler krizler karşısında reaktif olmak yerine proaktif hareket etme imkanı bulacaklardır.

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For the interwar period, "Covered interest rate parity arbitrage "should present itself only if the deviation is exceeded by at least 50 bps per annum and that large deviations should be persistent due to limited liquid capital.

John Maynard Keynes (1923)

Chapter I

EMPIRICAL INVESTIGATION OF COVERED INTEREST RATE PARITY

1.1 Introduction

Following the sub-prime crisis, as well as the collapse of Lehman Brothers, markets were driven into a critical level of uncertainty, resulting in severe and unsustainable deviations in CIRP[1] equilibrium. For the euro, for instance, the cross currency basis swap[2] spread - long term CIRP deviation - was around zero in November 2006. However, by October 2008, it was more than 80 bps. A similar economic phenomenon was observed in Turkey, where the cross currency basis swap spread was fluctuating around 35 bps in November 2006, but reached an unexpected level of 325 bps in December 2008. The effect was not confined to long-term maturities. For short-term euro swap markets, no deviations were observed before the crisis, but deviations hit 220 bps in September 2008. Similarly, in Turkey, the deviations reached up to 400 bps in October 2008.

In this paper, I investigate the potential determinants of violations of the law of one price (LOP) in currency swap markets for both developed and emerging countries. By addressing this issue, I hope to provide insight into how an "arbitrage-free" economy is influenced by specific market conditions and how certain risk factors may cause the same arbitrage opportunity to be limited in different economies.

[1] Covered Interest Rate Parity states that the difference between interest rates of two equivalent financial assets denominated in different currencies should be offset by the cost of compensating for currency risk in the spot/forward market. The term "covered" comes from the fact that investors are covered against uncertainty in forward markets.

[2] A basis swap is an agreement between two parties to exchange a principal denominated in different currencies and then to reverse the transaction at a later date by the initial spot rate.

The large deviations in short- and long-term swap markets around the crisis lead one to question whether the law of one price was temporarily impaired in these markets, and whether arbitrageurs were able to exploit these shocks through buying the cheaper currency and selling the more expensive one. If arbitrageurs were indeed able to take such positions, the anomaly in these markets would be expected to vanish quickly, as asset values would be driven back to fundamentals. However, for both emerging and developed markets, the deviations in short- and long-term swap markets continued to widen persistently for over two years. This gives support to the notion that Keynes's conjectures hold in modern financial markets. It also leads to many interesting questions. What economic reasons are behind the persistence of such a long-lasting disequilibrium? How widespread was this anomaly? Did the *same* risk factors constrain arbitrageurs in *different* economies?

It is a difficult task to explain market anomalies in standard models of asset pricing, as they are all based on the core idea of LOP: two assets with equal expected returns have equal values. Otherwise, there is an arbitrage opportunity. However, arbitrage opportunities should not last for an extended period, as arbitrageurs should eventually locate the apparent mispricing, provide liquidity to markets, and keep prices in line with the asset's fundamentals. Hence, when I investigate the currency swap markets during the recent financial turmoil (2007-2008), I realize arbitrageurs may not always be there to ensure price equilibrium.

To shed light on the unusual circumstances that surrounded the crisis, my paper uses short- and long-term CIRP deviations as proxies for disruptions in LOP. I proceed in four steps. First, I briefly discuss the theory behind CIRP equilibrium across five different maturity points, as it is crucial to justify the no-arbitrage relationship in frictionless economies during the three separate phases surrounding a financial crisis (pre-crisis, crisis, and post-crisis). I use CIRP violations in three developed markets (Japan, the United Kingdom and the combined European euro market) and three

emerging markets (Turkey, South Africa and Mexico) as examples for deviations from the LOP.

There are two main reasons why I focus on these emerging markets currencies. First, as highlighted by McCormick (1979), capital controls are an important reason for CIRP violations in foreign exchange markets. For some emerging markets, such as Brazil and Russia, capital controls make it legally impossible for market participants to access domestic and international money markets at the same time. FX forward markets in these emerging economies are relatively liquid in non-deliverable forwards (NDFs).[3] It is, therefore, impossible to conduct arbitrage transactions in the case of pure CIRP. Thus, I exclude all emerging market countries with capital controls. Second, I focus on currencies that have floating exchange rates with the U.S. dollar and that have sufficient depth in the short-term and long-term swap and FX options markets during the given time interval.[4]

I find that for each country, CIRP deviations in both short- and long-term swap markets are time-varying and state-dependent. Thus, in practice, the LOP equilibrium depends on the risk appetite that prevails in the market. While the LOP holds during the pre-crisis period, it is severely violated during the crisis period itself. This

[3]Non-deliverable forwards are derivative products in which two parties settle the transaction not by exchanging the underlying pair of currencies, but by making a net payment in a convertible currency that is the spread of agreed forward and the spot rate which is realized at a pre-agreed future date. One can compute the NDF-implied offshore rate of a currency as

$$(1 + R^{f-ofs}(t,T)) = \frac{S(t)}{F(t,T)}(1 + R^{d}(t,T)),$$

where R^{f-ofs} denotes the foreign offshore interest rate, R^d indicates the U.S. interest rate and F and S are the NDF and spot exchange rates, which are defined concerning the number of foreign currency units per U.S. dollar. For example, when a country faces large capital inflows and imposes capital inflow restrictions, the NDFs are expected to start to show faster-implied appreciation, meaning that NDF-implied offshore rates will decrease.

[4]I leave out Brazil, Russia, and South Korea despite the fact I have data for these countries from non-deliverable forward (NDF) markets because these currencies are not fully convertible and Brazil does not have a basis swap market. Currencies that are occasionally classified as emerging market currencies have also been deliberately excluded, most notably the Singapore Dollar and the Hong Kong Dollar. I also excluded currencies that were sustainably pegged to a major currency over the entire sample period.

is especially true during instances of credit turmoil when CIRP deviations are large, volatile, and highly persistent. This implies that arbitrageurs are subject to certain constraints that prevent them from taking the corresponding positions and providing liquidity to the markets.

Second, I use static and dynamic principal component analysis (PCA) to examine short- and long-term CIRP deviations in emerging and developed economies over different time periods. As opposed to the more conventional measure of excess return, PCA looks at the market concerning correlation and volatility risk. PCA also helps to focus on a small number of important factors that describe the primary sources of volatility for CIRP deviations.

Empirical results suggest that an unexploited arbitrage, although the same in structure, may be driven by different risk factors at different times and in different economies. In other words, the significance of the risk factors depend on the sample period (i.e. pre-crisis, crisis, post-crisis), swap terms (i.e. short- vs. long-term), and the type of economy (i.e. developed vs. emerging). Also, static and dynamic PCA results reveal that, two factors explain up to 93% of the realized variance of CIRP deviations. It also verifies that developed swap markets are more sensitive to the first component - namely, global systemic shocks - while emerging swap markets are sensitive to both the first and the second component - namely, country specific biases. This suggests that arbitrageurs are affected by different market constraints in different economies. During pre- and post-crisis phases, the impacts of the given risk factors are often negligible for both developed and emerging swap markets, implying that LOP holds during these periods.

Third, I try to understand the potential drivers of CIRP deviations and to resolve whether deviations are time-varying and state-dependent. I examine the impact of both local and global risk factors on CIRP deviations, as I believe that investigating a variety of risk components is beneficial when identifying a broad set of arbitrage

constraints. Not only does this enable to evaluate the sensitivities of short- and long-term deviations to time-varying growth and liquidity prospects, but it also provides insights into how developed and emerging markets respond differently to them.

Similar to my PCA analysis, I find that deviations behave differently in developed and emerging countries. During the credit phase, developed swap markets were mainly sensitive to global factors such as funding, liquidity and sentiment. Emerging swap markets, on the other hand, are driven by global factors as well as local ones, for instance, currency crash risks and sovereign credit risks.

As a final step, I conducted a price discovery analysis to examine the ability of investors to process information and to move across different funding markets. The resolution of this issue will provide insight into the extent to which market disequilibrium is contagious in developed and emerging economies and how long it takes this contagion to disappear in each country group. I also investigate lead-lag effects between price discoveries in short- and long-term swap markets. Furthermore, in order to understand the information transmission between the short- and long-term deviations, I conduct a spillover analysis using Garch-BEKK and Garch-DCC methods.

I found that price discovery in short- and long-dated swap markets vary considerably between developed and emerging markets. Before the outbreak of the financial crisis, I find no evidence of price discovery in swap markets in either type of economy. During the crisis phase, however, developed economies consistently display strong price discovery from short- to long-term funding, while their emerging equivalents tend to view two-way discovery. This implies that the general argument in support of the "short- to long-term transmission" is not necessarily the norm across markets. Moreover, while the price discovery effects tend to persist in developed countries even during the post-crisis period, no such transmission is observed in the emerging countries. This suggests that the memory of funding constraints is retained in developed

swap markets but not in their emerging equivalents. Another finding is concerned with the volatility spillover between the short- and long-dated swap markets. My findings suggest that information transmission also varies considerably in developed and emerging swap markets. First of all, there exists no volatility spillover in both economies before the outbreak of the financial distress. During the crisis phase, however, developed economies consistently display a one-way spillover movement (from short- to long-term funding), while their emerging equivalents tend to exhibit two-way movements. Moreover, while the spillover effects tend to persist in developed countries even during the post-crisis period, no such transmission is observed in the emerging countries. This suggests that the memory of funding constraints is again retained in developed swap markets. My results also indicate that there exists a dynamic correlation between short- and long-term deviations, but there exists no correlated-information channel (i.e., price discovery) between these corresponding deviations.

The remainder of this paper is organized as follows. Section 2 provides a review of the literature. Section 3 gives the theoretical motivation of CIRP equilibrium and describes the data. Section 4 and 5 discusses the potential determinants of CIRP deviations, and regression analysis. Section 6 presents price discovery analysis and Section 7 displays spillover test and results. Section 8 executes a robustness check for my findings, and finally, I conclude in Section 9.

1.2 Literature Review

This paper is closely related to three main streams of economic literature. The first deals extensively with the validity of CIRP, starting with Keynes (1923). This stream can be divided into two broad groups divided in terms of the nature of their data: low-frequency and high-frequency. For the former, many studies show that CIRP arbitrage opportunities do not generally arise and that any CIRP dislocations can be explained by transaction costs (Frenkel & Levich, 1975), credit risk (Aliber, 1973), taxes (Levi,

1977), data imperfections (Agmon & Bronfeld, 1975), capital controls (McCormick, 1979), market microstructure (Stoll, 1978), capital market imperfections (Blenman, 1991) and international capital mobility (J. A. Frankel, 1992).

For the high-frequency stream, the main argument is that prices and orders (in FX dealing rooms) in modern financial markets are carried out in a fast and automated fashion that renders the aspect of "infrequent communications" obsolete, thereby making it even harder to explain any CIRP dislocations recorded in the market (Akram, Rime, & Sarno (2008) and Fong, Valente, & Fung (2010)). High-frequency studies show that the duration of CIRP violations is short lived but the size of these violations can be economically significant. Due to the lack of a liquid long-term FX swap market, the analysis in all of these studies is confined to the short-term CIRP condition. With the establishment of liquid cross-currency basis swap markets, some recent studies have been able to evaluate the CIRP condition in the long-dated capital markets (Baba, 2009).

The second related stream of literature explores the limits to arbitrage and focuses on the implications of CIRP violations on market efficiency and equilibrium asset prices. Fama (1970) states that the optimal allocation of resources should ensure an efficient market without any abnormal profits. However, if markets are always efficient and arbitrage opportunities are never observed then arbitrageurs may not have sufficient incentive to provide liquidity to markets. This absence of arbitrage opportunities gives rise to the so-called 'arbitrage paradox,' which was first pointed out by Grossman & Stiglitz (1976).

In order to test market efficiency, however, one must take a stand on the market's model of expected returns. This is later described by Fama (1991) as the "joint hypothesis" problem: "[...] market efficiency per se is not testable. It must be tested jointly with some model of equilibrium, an asset-pricing model." But in the case of CIRP violations (i.e., dislocations in the law of one price), this argument has less

relevance as it is natural to prove that assets with identical cash flows must trade at equal prices. This view is also supported by Shleifer (2000)(p. 31), who stated that "the Fama (1970) critique is irrelevant," given the unique features of the LOP experiment. The stream of literature in this area mainly focuses on the 2007 - 2009 financial crisis and takes two directions when investigating the market conditions and potential risk factors faced by the arbitrageurs. Theoretical studies concentrate on multi-factor models in incomplete markets (Garleanu & Pedersen, 2010); (Gromb & Vayanos, 2010), while empirical studies derive market proxies to understand the time-varying component of LOP violations (Coffey, Hrung, & Sarkar, 2009); (Griffoli & Ranaldo, 2011).

The final related stream of literature deals with price discovery in different economies during the crisis. The economic usage for short-term and long-term FX swap markets might dictate their natural habitats of users; however, in periods of growing uncertainty (i.e., the subprime crisis and Lehman's collapse), changes in market sentiment go beyond the fundamentals and generate the "contagion" phenomena. Recently, Longstaff (2010) discussed contagion under three types of channels. The first is the correlated information channel (Kiyotaki & Moore, 2002), the second is the liquidity channel (Brunnermeier & Pedersen, 2009), and the third is the risk premium channel (Acharya & Pedersen, 2005). He finds that the last two channels were open during the crisis. Duffie (2010) describes the slow-moving nature of capital as another contagion channel. He discusses that when there is a significant level of uncertainty in the system, the search costs that investors face in finding appropriate counterparties can be elevated, and this may cause unusual distortions in asset prices. More recently, Bai & Collin-Dufresne (2011) and Buraschi, Sener, & Menguturk (2011) studied the information content of the same underlying trading across different markets to identify markets that provide more timely information. Their findings suggest that the location of traders, the structure of funding markets, and the ability of investors to

process information and move capital across markets all play a significant role in the process of price discovery.

1.3 Theoretical Motivation and Data Analysis

In this section, I briefly discuss the uses of FX swap markets and cross-currency swap markets. Then, I present the classical equation of CIRP along with its implications as a no-arbitrage condition. I derive the short-term CIRP condition using FX swaps and the long-term CIRP condition using cross-currency basis swap markets. This is important because at each point of term-structure the CIRP condition must be satisfied regardless of the maturity. Therefore, if there are deviations in LOP, I end up having a term-structure of deviations that represents varying levels of funding constraints and market uncertainties at each maturity point. Finally, I discuss dataset and method for determining CIRP violations.

1.3.1 FX Swap and Cross-Currency Basis Swap Markets

FX swaps are transactions in which one party borrows one currency and simultaneously lends another, with an agreement to unwind the transaction on a specific future date at a pre-specified forward rate. FX swaps essentially allow these two parties to exchange funding at predetermined times in the future, in one currency for another currency, without FX risk. Thus, FX swaps can also be regarded as FX risk-free collateralized borrowing/lending.[5] FX swaps retain the highest level of liquidity for short-term transactions (i.e., less than one year) and are mainly used by corporations to hedge their short-term currency exposures and by banks to manage their foreign currency needs and the needs of their customers (i.e., exporters and importers).

When parties wish to commit to an exchange of foreign currency obligations for

[5]It is usually assumed there is no counterparty default risk in forward and basis swap contracts. However, Duffie & Huang (1996) show that counterparty credit risk is inherently embedded in FX swap contracts.

one year or more, they often use cross-currency basis swap markets. The innovation in the long-date basis swap is that periodic interest payments are made to both parties. In contrast, the FX swap market calls for no such regular payments. Basis swaps are commonly quoted in terms of USD Libor against foreign currencies with a positive or negative spread. More specifically, when the credit risk in foreign Libor rates is greater (less) than its equivalent in USD Libor rates, the basis swap should be negative (positive).[6] Hence, the basis stands for the credit risk premium that the riskier counterparty must endure. This also implies that the given swap transactions tend to represent the relative attractiveness of financing in one currency relative to the other.

Basis swaps are commonly employed by banks and multinational corporations either to fund their long-term foreign currency needs or to convert currencies of asset and liabilities. For example, suppose a European company issues 5-year maturity Samurai bonds - JPY-denominated bonds issued in Japan by non-Japanese corporations. A basis swap can be used by this issuer as a hedging tool to minimize currency mismatches and exposures. Mirroring the maturity of this bond transaction with a corresponding basis swap enables the issuer to swap its JPY interest rate risk exposure back into the euro.

Emerging markets often use basis swaps to raise capital. Basis swaps effectively allow countries in emerging markets to switch funding from hard currency to local currency at the current spot FX rate and thereby benefit from the negative basis. For example, in Turkey, due to many currency crises, depositors have a tendency to keep their savings in foreign currency-denominated accounts. This makes Turkish

[6]Remembering that Libor rates bear both credit and liquidity risk, basis swaps reflect both the demand for swapping from one currency into another and the credit quality of the corresponding central bank. For example, Tuckman & Porfirio (2003) argue that basis swaps represent the difference between the credit risks in the Libor rates of two different currencies. This credit risk premium, or basis, is related closely to the credit quality of the benchmark rate. In this context, since the USD Libor rate has a better credit quality than the emerging market interbank rate, the USD borrower should accept the deduction of the basis from the interest he receives.

banks relatively poor in their local currency and rich in foreign currency deposits. To fund their lending in local currency, banks commonly use basis swaps to create local funding by exchanging their foreign currency deposits.

1.3.2 Term-Structure of CIRP Violations

Covered interest rate parity (CIRP) is a no-arbitrage condition that states that interest rate differentials among currencies should be perfectly reflected in FX forward discount rates. In other words, the cost of borrowing one unit of local currency - say one dollar - must be equal to first turning it to foreign currency in the spot market and then lending it at a foreign rate and, finally, converting it back into local currency with an agreed forward rate at maturity. According to CIRP, the following condition must hold for a riskless investment between period t and T:

$$(1 + R^d(t,T)) = \frac{X(t)}{F(t,T)}(1 + R^f(t,T)), \tag{1}$$

where $R^i(t,T)$ is the arithmetic risk-free rate in the two corresponding currencies, $i = (d, f)$; where d is the USD and f is foreign currency; and $X(t)$ and $F(t,T)$ are the spot and forward exchange rates. The notion is, an investor borrows a dollar at time t, thus owing $[1 + R^d(t,T)]$ at time T, can convert one dollar to $X(t)$ units of foreign currency at time t, invest the foreign currency in foreign currency deposits, and receive $X(t)[1+R^f(t,T)]$ at maturity. If the forward exchange rate is $F(t,T)$, the dollar value today of this investment is $X(t)[1 + R^f(t,T)]/F(t,T)$. If today's dollar value of the investment does not equal $[1 + R^d(t,T)]$, an arbitrage opportunity exists.

The CIRP relationship can also be derived from the idea that international interest rates adjust via exchange rates to equalize borrowing costs around the globe. For example, in the absence of barriers to arbitrage across international financial markets, if the dollar cash market rate is lower than the FX swap-implied dollar rate[7], then

[7]The FX swap-implied dollar rate is the value of R^d that solves Eq. (1).

financial institutions increase dollar funding from the cash market rather than the FX swap market until the dollar cash rate rises to the same level.

Note also that T is not restricted to any particular maturity and hence can take on any finite value across the term structure. One of the most important implications of Eq. (1) is that it must hold for any T. Therefore, one can easily deduce that there exists at least one arbitrage opportunity if the equality is violated for at least one T. If the equality is violated for *every* T, I have a continuous term structure of covered interest LOP deviations. If the LOP holds, then the term-structure of LOP violations is naturally flat at the zero axes. If not, however, a dynamic term-structure appears at every t, though not necessarily with a monotonically positive or negative slope. One of the primary objectives of this paper is indeed to investigate the nature of this term-structure at every point t in order to study whether the dynamics of violations vary significantly across different maturity points.

1.3.3 Empirical Implementation and Data

To ensure the maximum possible level of liquidity in trades, I use different empirical proxies of CIRP violations for different T. Transaction-cost adjusted deviations are calculated for both emerging markets (Turkey, Mexico, and South Africa) and developed markets (the European euro market, the United Kingdom, and Japan) for five discrete T (one week, three months, one, two and five years). I capture the short-term violations T (1 week, 3 months) via FX swap markets. The problem with applying the standard CIRP condition presented in Eq. (1) is that, in practice, market participants observe spot rates implied from swap rates, not default-free spot rates. Thus, my implementation of short-term deviations (SD) is calculated from Eq. (2), which is presented below. Following Coffey et al. (2009), I construct short-term CIRP deviations by taking R^i as the 1 week and 3 month Libor rates in the corresponding

currency i.[8] I also incorporate the bid and ask prices into my LOP metric to ensure that CIRP deviations are robust to transactions costs.[9]

$$SD = \underbrace{\frac{F_{bid}(t,T)}{X_{ask}(t)}(1 + R^d_{bid}(t,T)) - (1 + R^f_{ask}(t,T))}_{CIRP\ \ Deviation} \tag{2}$$

The main problem with using the same proxy for CIRP in the long term FX swap market is the lack of liquidity in long-dated financial markets. Thus, for long-dated capital markets, I use transaction cost-adjusted cross-currency basis swap spreads as a proxy to evaluate the covered interest parity condition. I capture long-term deviations (LD) - defined where T equals 1 year, 2 years, or 5 years - from market-priced cross-currency basis swap spreads. I exclude bid-ask spreads in the calculation. Indeed, the average size of a CIRP deviation tends to be much larger than the transaction costs associated with taking advantage of the CIRP violation.

In equilibrium, short- and long-term swap agreements may differ significantly depending on their responses to various exogenous shocks that may pull prices away from fundamentals. Not only may SD and LD differ considerably among one other in terms of deviations, but they may also change across time. For this reason, I aim to find the link between the anomalies of SD and LD by splitting the sample period into three main subsets: pre-crisis, crisis, and post-crisis periods. Each period is presumably affected by different levels of market risk aversion.

The data that I use to study short- and long-term CIRP violations comes from Reuters primarily (made available via Datastream). Similar to Lustig, Roussanov, & Verdelhan (2011), I start from a daily spot and forward exchange rates in U.S. dollars.

[8]Similar to Griffoli & Ranaldo (2011), 1 week CIRP deviations are also constructed by taking R^i as the weekly overnight index swap (OIS) rate in a developed country's currency, i, with similar results achieved. However, I am unable to get weekly OIS rates for emerging markets. To be in line with the rates that I use, I continue to use Libor rates, except with Mexico.

[9]Eq. (2) is calculated using the actual number of business days between the (spot) value date and the maturity date of a contract taking into account bank holidays and other conventions in the home countries of the currencies. In general, the total number of days to maturity in a year is 360. For sterling contracts, however, the total number of days in a year is set at 365.

Following Blanco, Brennan, & Marsh (2005), I measure all changes over a weekly horizon (using Friday to Friday changes) to reduce noise. End-of-week series begins on November 10, 2006, and ends on March 31, 2010, yielding 177 observations. For the implementation of my trading strategy, I use Reuters bid-ask data, which employs a proprietary formula using quotes provided by an exclusive list of contributors.[10] As Lustig et al. (2011) informs Lyons (2001) reports that bid-ask spreads from Reuters are roughly twice the size of inter-dealer spreads, which makes the estimates of transaction costs conservative. Lyons (2001) also notes that these indicative quotes track inter-dealer quotes closely, only lagging the inter-dealer market slightly at a very high intra-day frequency. Because I use weekly horizons, this is not an issue here. The basis rates are based on both Bloomberg and Reuters Eikon. I also often use the latter to cross-check the former.

The main data set contains six currencies: the euro, the British pound, the Japanese yen, the Turkish lira, the South African rand and the Mexican peso. Following the IMF (2008) classification, I split my large sample of into two sub-samples: developed markets (the European euro market, the United Kingdom, and Japan) and emerging ones (South Africa, Mexico, and Turkey).[11] I provide the summary statistics of data and factor analysis to motivate global versus local factors in following subsections.

1.3.3.1 Summary Statistics

Weekly data spans from November 2006 to March 2010. I divide this time series into three main sub-samples and then divide them further into two sub-samples for the crisis period. The "Pre-crisis" period starts on November 10, 2006, and ends on August 8, 2007; the "Crisis" period starts on August 9, 2007, and ends on March

[10]For details, see the Reuters document entitled "Spot and Forward Rates Guide." This report is available on the internet.

[11]The World Economic Outlook classification combines three criteria: (i) per capita GDP, (ii) export diversification and (iii) integration into the global financial system.

31, 2009; and the "Post-crisis" period begins on April 1, 2009, and expires on March 31, 2010. Following J. B. Taylor & Williams (2009), I start the crisis period when BNP Paribas suspended redemptions from their 2 billion USD asset-backed funds. In line with Longstaff (2010), I divide the crisis period further into two additional sub-samples: the "Liquidity Crisis" (August 9, 2007, to August 31, 2008) and the "Credit Crisis" (September 1, 2008, to March 31, 2009).[12]

In Tables 1 and 2, I display the mean, max, and top quartiles of CIRP deviations in developed and emerging markets. CIRP violations across all maturities in emerging markets are, on average, higher than those in developed markets for all sample periods. Also, in both markets, CIRP deviations are highest during the Credit Crisis period, when they are more than ten times their pre-crisis levels. This highlights the impact of the crisis around the globe.

Table 1 presents the average CIRP deviations in the pre-crisis period ranging roughly from 1 to 8 bps for short-term deviations and 0 to 2 bps for long-term deviations. Additionally, during this time, CIRP deviations are not significant, which implies that the CIRP arbitrage condition Eq. (2) holds and that arbitrageur enforce equilibrium relationships.[13] However, during the liquidity and credit crises, CIRP deviations become large, persistent, and highly volatile. During the liquidity crisis, short-term deviations averaged between 6 and 20 bps, and long-term deviations ranged from 3 to 10 bps. This indicates that neither the short-term nor the long-term CIRP condition holds empirically. The magnitudes of CIRP violations continued to grow during the credit crisis, likely due to deteriorating USD funding costs. The deviations attained their highest levels, ranging from 25 to 82 bps for short-term deviations and 25 to 52 bps for long-term deviations. During this period, access to

[12] I take two important dates, September 7^{th} and 15^{th}, into account for the division of the crisis. On these dates, Fannie Mae-Freddie Mac government conservatorship news was released, and Lehman filed for bankruptcy. These breakpoints have been validated by Chow Breakpoint tests.

[13] The small non-zero levels could result from additional trading costs (i.e., brokerage fees or settlement costs) as Fong et al. (2010) investigated.

capital markets may have been limited, and institutional characteristics may have prevented riskless arbitrage trading.

Similar to the findings of McCauley & McGuire (2009), my results validate that high USD demand came from European financial institutions that were able to fund themselves via the relatively cheap USD before the crisis. However, the crisis and the reluctance of U.S. banks to lend, followed by the dollar funding shortages of non-U.S. financial institutions, caused an increasing deterioration of CIRP. On the other hand, as is pointed out by BIS (2010), these respectively moderate deviations of JPY are also partly due to Japanese banks having accumulated a considerable amount of liquid net foreign positions in USD (i.e., U.S. government bonds) over time.

Finally, the first moment of deviations decreases slightly (and monotonically) in the post-crisis phase, but convergence towards pre-crisis levels is far from complete (see Figure 1). The new averages range from 10 to 30 bps for short-term deviations and 15 to 30 bps for long-term deviations. In other words, first moments are slightly higher than those in the liquidity crisis, indicating that memory of the crisis is still retained in the market. During crisis periods, as maturity increases, the mean CIRP deviations tend to decrease. For the euro, the decreasing pattern continues in the post-crisis period while in Japan the averages fall more for lower maturities. In the UK, the average deviations are quite close to each other, irrespective of their maturities.

Table 2 presents the summary statistics for emerging markets. Similar to developed markets, CIRP violations are much larger during the crisis periods. The first moments and top quartiles of the deviations tend to increase monotonically from the pre-crisis to the credit-crisis period. In the pre-crisis period, the average short- and long-term deviations range roughly from 4 to 35 bps for short-term deviations and 7 to 21 bps for long-term deviations. In this period, notice that Mexico's first moments are lower than those of Turkey. While the first moments during the liquidity phase

range from 29 to 46 bps for short-term deviations and 12 to 55 bps for long-term deviations, they increase to ranges of 41 to 156 bps and 28 to 183 bps, respectively, during the credit crisis period. (see Figure 2)

Compared to developed markets, the unprecedented widening of CIRP deviations across all maturities suggests larger unexploited profits in emerging markets. The improvement in swap markets is evidenced by the narrowing of deviations starting in late 2008, although the violations are often greater than they were during the pre-crisis phase. I can also examine the sensitivity of deviations to different maturities in a given period. In the pre-crisis and liquidity crisis periods, as the maturity of the long-term deviations increase, the mean deviations tend to decrease. This pattern is disrupted during the credit-crisis period. In the post-crisis period, as the maturity of the long-term deviations increase, the mean deviations tend to grow in Turkey. However, in South Africa, the mean deviations are similar during each period, irrespective of the maturity of the deviations.

1.3.3.2 Factor Analysis: Global vs. Local Factors

CIRP dislocations are time-variant and state-dependent in both developed and emerging markets. During the pre-crisis period, both short- and long-term dislocations fluctuate around zero. However, they become large, volatile, and highly persistent during the crisis. This suggests that the no-arbitrage theory fails empirically. During the post-crisis period, deviations gradually move towards their pre-crisis levels, although they are still higher and more volatile. While LOP violations are highly correlated in both developed and emerging markets, two critical differences arise. First, compared to LOP violations in advanced markets, violations in emerging markets are consistently five times greater for short-term markets and two-times higher for long-term markets. This presents an interesting anomaly, as arbitrage opportunities appear to be more restricted in emerging markets. The second important difference

is that, while CIRP violations in developed markets show similar patterns across different maturities, patterns for CIRP violations in emerging markets seem to be more country specific.

The CIRP dynamics discussed above give rise to the following question: Are arbitrageurs constrained by the same risk factors across different economies? I address this issue by looking at both local and global risk factors. To do so, I first conduct a principal component analysis (PCA) in this section to identify the factors.[14] PCA is useful in "reducing the dimension" by concentrating on a few important factors that represent the main sources of variation in the market.[15] Similar to Scherer & Avellaneda (2002) I conduct both static and dynamic factor analyses. In static factor analysis, the components are computed for the whole sample, while dynamic factor analysis computes principal components for consecutive windows. In the spirit of Lustig et al. (2011), I refer to the first and second factor as the global and local factor, respectively. In other words, the eigenvector with the largest eigenvalue corresponds to the variance attributable to global risk, and the second component strongly suggests the existence of a country-specific volatility risk factor.[16]By observing the variations of the coupling component (percent of variance explained by the first component) across time, I form a dynamic picture of the behavior of the emerging and

[14]Mathematically speaking, PCA generates two valuable pieces of information: the eigenvalues and the corresponding eigenvectors of the correlation matrix from multiple time series. The eigenvalues denote the explanatory contribution of each eigenvector to the total variance. The eigenvectors form an orthogonal basis which can be used to evaluate the interrelationships between different variables. Consequently, PCA reduces the dimension of the problem by isolating a few critical components that explain the primary sources of volatility. Economically speaking, PCA decomposes market risk into uncorrelated volatility factors.

[15]Factor analysis has a long history as a standard mathematical methodology for analyzing the statistical properties of time series data. Litterman & Scheinkman (1991) were the first to apply PCA to financial data. They uncover a clear factor structure in bond returns in which three factors account for more than 95 percent of the total return variance. Similarly, Longstaff, Pan, Pedersen, & Singleton (2008) find that just three principal components account for more than 50 percent of thevariation in sovereign credit spreads. They also conclude that there is little or no country-specificcredit risk premium after adjusting for global risk factors.

[16]Lustig et al. (2011) conduct PCA to investigate the common risk factors in currency markets and find that these markets are driven by global and local factors.

developed markets. A dynamic factor analysis is useful in analyzing whether the factors change over time. Applying factor analysis to all sub-periods separately allows the importance of market shifts to be measured.[17]

I perform static and dynamic PCA separately for short-term and long-term CIRP deviations in each market. The short-term and long-term static PCA results are presented on the left and right side of Table 3, respectively. The table shows results for the full set of markets, as well as results for developed and emerging markets. Also, Figures 7 and 8 provide visuals for the corresponding dynamic PCA analysis separately for long and short term CIRP deviations. In unreported results, I find that the first two factors are statistically significant over the full-time period.[18]

To form a dynamic picture of how the emerging and developed markets behave, I observe the coupling component, or the global factor, across time.[19] Following Scherer & Avellaneda (2002), I propose three categories to describe the strength of coupling. The first category is extreme coupling, which occurs when the percentage of variance explained by the first principal component is above 80%. The second category, strong coupling, indicates that the percentage of variance explained by the first principal component is between 65-80%. Finally, weak coupling occurs when the percentage of variance explained by the first principal component is below 65%. Without separating developed and emerging markets, Table 3 reveals that there is weak coupling for short-term deviations for all periods. For long-term deviations,

[17]For the dynamic factor analysis, I use a rolling window of 250 days.

[18]In order to decide the number of significant eigenvectors, I also run a sphericity test as proposed by Fluery (1988)(Ch. 2). My sphericity test statistics show that three factors are stable (and hence, interpretable) before the crisis period and two factors that are stable during and after the crisis periods. Accordingly, in the PCA analysis, I focus on the first two components, although I represent the third component in the table as well.

[19]Scherer & Avellaneda (2002) define the coupling coefficient as "the fraction of variance attributed to the first component." More specifically, if $\lambda_1 > \lambda_2 > \ldots > \lambda_n$ are the eigenvalues, then

$$\text{Coupling Coefficient} = \frac{\lambda_1}{\sum_{i=1}^{n} \lambda_i}.$$

The coupling coefficient is a statistical representation of how often the markets co-move as a single block.

there is weak coupling before and after the crisis period, but the coupling is slightly stronger during the crisis period.

An interesting picture emerges when I examine the coupling levels of developed and emerging markets separately. For short-term CIRP deviations of developed countries, the coupling is weak before and after the crisis (42% and 55%, respectively), but the coupling is extreme during the crisis at 87%. The long-term CIRP deviations of developed countries exhibit a similar phenomenon, as the coupling is intense during the crisis at 93%, weak before the crisis at 54%, and strong after the crisis at 79%. This suggests that, for developed countries, almost all CIRP deviations arise due to global systematic risk during volatile periods. Consequently, the explanatory power of the second component, the country-specific risk factor, is low during the crisis period.

Nonetheless, the picture changes for emerging markets. It can be observed that for the short-term deviations, emerging markets have *weak* coupling before and after the crisis period (with 57% and 52%, respectively), and during the crisis period the coupling coefficient is only 65%, which is the threshold between weak and strong couplings. As for the long-term, I observe a similar trait; that is, emerging markets have *weak* coupling before and after the crisis period (with 57% and 55%, respectively), and during the crisis period the coupling coefficient is again 65%. This suggests that when I consider emerging markets, individual country risks have a larger effect compared to the influence of global risks in developed countries. This finding supports my initial conclusion: *emerging swap markets when compared to their developed equivalents, are considerably less sensitive to unexplained global shocks, and more sensitive to their local factor*. This is an important finding as it directs me in identifying more suitable risk proxies (country-specific) for the emerging economies. It can be seen that PCA results are consistent with the panel regressions, which suggest that CIRP deviations of developed countries are mostly driven by global factors, whereas for

emerging markets, they are explained largely by local factors.

1.4 Determinants of CIRP Deviations

Factor analysis suggests that CIRP deviations in developed countries are mostly driven by global factors, whereas for emerging markets, they are explained primarily by local factors. This directs me to identify more appropriate risk proxies for developed and emerging economies. Recent literature has taken two directions when investigating market conditions and risk factors faced by arbitrageurs that can prevent them from eliminating mispricing and providing liquidity to other investors. While theoretical models focus on a multi-factor model in incomplete markets to explain LOP deviations (see Gromb & Vayanos (2010)) empirical studies derive empirical proxies to better understand the time-varying component of these LOP violations (see Coffey et al. (2009), Buraschi et al. (2011) and Griffoli & Ranaldo (2011)). The primary objective of this section is to identify fundamental risk factors that prevented the resulting disequilibrium from converging back to LOP equality.

Garleanu & Pedersen (2010) connect the basis among the bonds and CDSs to interest rate spreads between uncollateralized and collateralized loans (i.e., the Libor-GC spread), credit tightness, and risk premia (i.e., dividend yields). I broaden the scope of previous studies and consider five potential sources of variation in the credit spreads: (i) Liquidity Risk Factors; (ii) Funding Risk Factors; (iii) Macro Risk Factors; (iv) Sentiment Factors; and (v) Local Risk Factors. Goetzmann, Lingfeng, & Rouwenhorst (2005), Longstaff et al. (2008) and Lustig et al. (2011) find evidence that shocks to U.S. financial markets have global effects. In the spirit of these studies and the factor analysis, I consider the following potential sources of constraints: Local Factors and Global Factors. To the best of my knowledge, the potential determinants of CIRP departures with a focus on local and global factors in a similar setting of both developed and emerging markets is a new direction under the flourishing literature of

limits to arbitrage. A discussion and motivation for each variable are discussed below in detail.

1.4.1 Global Factors

1.4.1.1 Liquidity Factors

Liquidity is often viewed as an important feature in the investment environment and the macroeconomy. Many studies investigate whether market-wide liquidity is a state variable important for asset pricing. Starting with Constantinides (1986) and Amihud & Mendelson (1986), theoretical studies have examined the relationship between liquidity and asset prices. Empirical studies also investigate whether market-wide liquidity is a priced state variable. The common element in all recent studies is that fluctuations in various measures of aggregate liquidity are correlated across assets. I explore whether liquidity risk plays a role in CIRP deviations. I investigate two types of liquidity measures.

- *Bond Liquidity*: Fontaine & Garcia (2009) propose a liquidity measure that captures global bond market liquidity from a panel of U.S. Treasury bonds. This liquidity proxy is expected to share a common component with risk premia in other markets (i.e., swap transactions). As discussed in Adrian & Shin (2010) the repo market plays an important role for balance sheet adjustments of financial intermediaries. Therefore, I use the Fontaine & Garcia (2009) measure as a proxy of liquidity, labeling it as FG-LIQ.

- *FX Liquidity*: Pastor & Stambaugh (2003) use cross-sectional averages of individual stock liquidity as an aggregate liquidity measure and find expected stock returns are related cross-sectionally to fluctuations in this total liquidity. Similarly, in Griffoli & Ranaldo (2011), the first principle component of the spot and forward bid-ask spreads against the USD are used to proxy for latent

foreign exchange liquidity. I use the same proxy with weekly forward rates and label it as FX-LIQ. [20]

1.4.1.2 Funding Factors

Arbitrageurs assumed to have access to all capital markets. However, empirical studies find that risk premia tend to rise with tighter funding conditions. As discussed in Brunnermeier & Pedersen (2009), there are two types of traders involved in arbitrage opportunities: prop desks of investment banks and hedge funds. Although these traders chase similar arbitrage opportunities, they usually operate under different funding markets. Since hedge funds make their investments via giving collateral (secured arbitrage), prop desks can use funds from unsecured money markets (unsecured arbitrage). Based on this, I divide global funding factors into two broad categories: unsecured funding and secured funding.

- *Unsecured Funding*: The unsecured overnight interbank market is one of the most significant and immediate sources of liquidity for the banks, and therefore it is a forward-looking indicator of the functioning of a financial system. Disruptions in unsecured interbank markets can lead to a lack of risk sharing between financial players and even trigger bank runs (Afonso, Kovner, & Schoar, 2011). I capture characteristics of the unsecured funding market through the spread between weekly LIBOR and U.S. Overnight Index Swap (OIS) rates.[21]

[20] Figures 3 and 4 reveal that the average and volatility of FX-LIQ tends to increase from the pre-crisis period to the credit crisis period. For emerging markets, it has a 47% and 70% correlation with the first principal component of short- and long-term deviations, respectively, during the latter period. In developed markets, the correlation is 42% and 75%, respectively. The differential narrows during the post-crisis period, although it still has higher volatility and correlation values than it does during the pre-crisis period, suggesting a lasting risk perception in FX liquidity. Notice that the correlation values in short-term maturities is lower than those in long-term maturities.

[21] The average and volatility of Unsecured Funding tend to increase from the pre-crisis period to the credit crisis. During the credit crisis, for emerging markets, it has a 59% and 25% correlation with the first principal component of short- and long-term deviations. The correlation coefficients are 70% and 63%, respectively, in developed markets. The differential narrows during the post-crisis period, although it still has higher volatility and correlation values than it does in the pre-crisis period. This suggests a lasting risk perception in unsecured market transactions. Notice that the

- *Secured Funding*: I capture the characteristics of the secured funding market through the spread between weekly mortgage-backed security ("MBS") repos and general collateral ("GC") repo rates (Coffey et al., 2009).[22] Since both MBS and U.S. GC repo rates are collateralized, this spread captures the difference in value between high-quality and low-quality collateralized securities.[23] I refer to this proxy as SECURED.[24]

1.4.1.3 Macro Factors

Almost all economic theories with rational, utility-maximizing investors imply that investors must be compensated for their exposure to macroeconomic risk. Campbell & Cochrane (1999) and Wachter & Warusawitharana (2009) focus on equity and bond risk premia, respectively, and show that risk premia vary with shocks to aggregate consumption. Bansal & Yaron (2005) show that risk premia fluctuate with countercyclical movements in macroeconomic uncertainty. Despite the growing body of theoretical work rationalizing asset market risk premia, there is little direct evidence of a link between macroeconomic business cycle activity and risk premia. Thus, I focus on macro risk proxies that may play a role in CIRP deviations.

- *Term Premia:* As a proxy for macroeconomic activity, the slope of U.S. term structure should be highly informative (see Diebold & Li (2006)). Estrella &

correlation values in emerging economies are always lower than those in developed economies.

[22] I also use maturity-specific MBS rates (i.e., three months and 1, 2, 5, 7 and ten-year maturities), and my results remain unchanged.

[23] Gabaix, Krishnamurthy, & Vigneron (2007) argue that MBS markets play an important funding role and may affect limits to arbitrage. Moreover, Garleanu & Pedersen (2010) discuss this channel by considering a model with agents that face margin constraints and have heterogeneous risk aversion. They show that adverse shocks to fundamentals make margin constraints bind, lowering risk-free rates and raising the Sharpe ratios of risky securities, especially for high-margin securities. Such a crisis gives rise to "basis" that is, the price gap between securities with identical cash-flows but different margins.

[24] Figures 3 and 4 also reveal that the average and volatility of SECURED increase from the pre-crisis period to the credit crisis. During the latter period, for emerging markets, the correlation coefficients between SECURED and the first principal components of short- and long-term deviations are 79% and 25%, respectively. In developed markets, the correlations are 83% and 67%, respectively. Notice again that the correlation values in emerging economies are always lower.

Hardouvelis (1991) show that improvements in real economic activity are often signaled by the slope of the term structure. Based on these arguments, the slope of the yield curve carries relevant information about the relative cost of funding through arbitrage. I define the slope of the U.S. yield curve as the difference between 10-year Treasury bond rates and 3 month LIBOR yields and call this as TP.

- *Macro Activity:* Ludvigson & Ng (2009) ask the important question of whether there exists a significant link between macroeconomic aggregates and cyclical fluctuations in bond market premiums. Their findings suggest that, with the components of a dynamic factor analysis of 132 measures of economic activity, very strong predictive power for two-year bonds exists, explaining 26% of the one-year-ahead variation in their excess returns for two-year bonds, and even has significant forecasting power for excess returns on three- to five-year government bonds as well. This suggests that the dynamics of expected risk premia cannot be solely explained by yield factors. In this context, it is important to make a similar assumption. To see the impact of U.S. macroeconomic fundamentals on the short- and long-term deviations in developed and emerging markets, I thus use the same macro risk factor used in Ludvigson & Ng (2009), calling it the Macro Activity factor. The main motivation is to understand whether dynamics of macroeconomic fundamentals hinder arbitrage opportunities, which is assumed to be related more to market-driven shocks. It may be argued that deteriorating conditions in macroeconomic variables can create constraints on financial institutions that spoil the arbitrage, which carries a potential cause for CIRP deviations.

1.4.1.4 Sentiment Factors

There is an extensive literature regarding the investors' sentiment and its influence over the asset prices. De Long, Shleifer, Summers, & Waldmann (1990) define investors as "'sentiment-free arbitrageurs and sentiment-driven traders"', discussing that mispricing can occur by the sentiment-based demand shocks and, therefore, influence the possibility to have an arbitrage. As such, Baker & Stein (2004) test their sentiment index on so-called Siamese twins pairs of securities and find that there is a positive relationship between large price deviations and their sentiment indices.[25] Similarly, Yu & Yuan (2011) argue that sentiment's predictive power is concentrated in high-sentiment periods.

- *Closed-End Fund Discounts:* One popular proxy of sentiment risk is closed-end fund discounts (see (Lee, Shleifer, & Thaler, 1991); (Domowitz, Glen, & Madhavan, 1998); (Baker & Wurgler, 2007).)[26] I compute the weighted average of closed-end fund discounts using the four largest U.S. Emerging Market debt funds (EDD, TEI, ESD and MSD).[27] I name this proxy as Closed-End. [28]

- *Perceived Tail Event Risk:* As is pointed out by Wurgler & Zhuravskaya (2002),

[25]Siamese twins are pairs that claim equal cash flows but trade in different markets. Sometimes twins are pairs that trade at substantially different prices. Such deviations are not easy to explain in the context of rational markets with realistic frictions.

[26]Closed-end funds issue a fixed number of shares that later trade on stock markets. A closed-end fund premium (discount) is how much greater (smaller) the fund's market price is compared to its net asset value (NAV). I generate the corresponding premiums (discounts) by dividing market prices by NAVs. The closed-end fund index is created using the weighted average of the premiums (discounts), based on the market capitalization of the related closed-end funds.

[27]The market cap of EDD is 1.189 million USD, managed by Morgan Stanley Emerging Markets, the market cap of TEI is 772 million USD, by Templeton, the market cap of ESD is 580 million USD, by Legg Mason Partners - Western Asset Emerging Markets Debt Portfolio. The market cap of MSD is 235 million USD, by Morgan Stanley Emerging Markets Debt Fund

[28]Figures 3 and 4 reveal that Closed-End reaches its lowest point of 0.61 during November 2008. For emerging markets, it has a correlation of -61% and -60% with the first principal components of short- and long-term deviations, respectively. For developed markets, the correlation is -60% and -86%, respectively. Notice that the emerging market deviations are less correlated with Closed-End than are developed market deviations. Moreover, in emerging economies, the short-term deviations have correlation values that are similar to their long-term equivalents.

many arbitrage opportunities look unattractive to arbitrageurs when volatility is high because volatility yields fundamental and arbitrage risk. Baker & Stein (2004) use the volatility premium as part of their sentiment index.[29]The VIX index is one way to measure the perception of the tail event. The VIX index is a weighted average of implied volatilities of options with different strikes written on the $S\&P500$ index with 30 days maturity. It summarizes the cost of protection against major market tail event risk. Pan & Singleton (2008) use the VIX index as a measure of tail event risk in credit markets and argue that it is an important proxy of investors' appetite for risky assets. They show that emerging market risk premiums are highly sensitive to U.S. stock market volatility (VIX). Further examples include Campbell & Taksler (2003), who find significant co-movement between firm-implied volatility and credit risk premiums. To proxy for perceived tail event risk, I used the first difference of VIX and referred as VIX.[30]

1.4.2 Local Factors

Lustig et al. (2011) show that risk factors in currency markets can be fully understood in terms of a country-specific factor and a global factor. To measure the impact of local factors on CIRP violations, I control for two factors: risk reversal and credit risk.

- *Currency Crash Risk*: In a frictionless economy, CIRP holds when an increase

[29]They define the volatility premium as the year end log of the ratio of the value-weighted average market-to-book ratio of high volatility stocks to that of low volatility stocks.

[30]The level of VIX peaks during the credit crisis. For emerging markets, it has a correlation of 77% and 57% with the first principal components of short- and long-term deviations, respectively. For developed markets, the correlations are 80% and 83% respectively. Notice that long-term deviations in developed markets are more correlated with VIX than the long-term deviations in emerging markets are.

in interest rates is offset by the depreciation of the future exchange rate. Nevertheless, due to liquidity constraints and the market's risk aversion, the dynamics of interest rates and exchange rates rarely maintain such perfect correlation. Brunnermeier, Nagel, & Pedersen (2008) argue that exchange rate movements between high and low interest rate currencies are negatively skewed, calling this currency crash risk in carry trade activities. They argue that the skewness in FX rates stem from temporary changes in the availability of funding liquidity to speculators and arbitrageurs. They measure the price of crash risk by considering the price of a risk reversal (RR), which captures the "combined effects of expected skewness and a skewness risk premium."[31] Similarly, Lustig et al. (2011) show that RR contains useful information about compensation for disaster risk in currency markets. They also find that any increase in RR is associated with a contemporaneous exchange rate depreciation, which reflects the higher riskiness of the currency. To measure the impact of a country-specific currency risk premium, I control for the changes in the 1-month 25-delta risk reversal, denoting it as RR.

- *Credit Risk:* Fletcher & Taylor (1996) state that the persistence in CIRP deviations might be due to "prolonged differences in credit risk perceptions between markets." Hence, I use each country's 5 year sovereign credit default swap spreads to capture perceived credit risk. I label this variable as CDS. [32]

[31]The Price of Risk Reversal is a long position in a call and a short position in a put for equally out of the money options (the slope of the implied volatility smile). Risk Reversal essentially captures the presence of asymmetric downside and upside risk in currency markets. This is because, if foreign currency expected to depreciate (foreign currency is riskier than home currency), out of the money puts should be more expensive than symmetric out of money calls. On the other hand, if exchange rates are normally distributed, then symmetric puts and calls should have the same prices. Option traders use risk-reversal quotes to quantify the asymmetry of the implied volatility smile, which reflects the skewness of the risk-neutral currency return distribution.

[32]I also retrieved CDS rates with 1- and 2-year maturities and my results remain unchanged.

1.5 Regression Analysis

I run panel regressions with country-fixed effects for developed and emerging countries using short-term and long-term maturities. The dependent variable is the change in SD or LD, and the independent variables are changes in the levels of the potential determinants that were discussed in earlier sections. In order to save the space, I assess the three months for short term CIRP deviations (SD) and two years data long term CIRP deviations (LD).[33] By regressing the first differences, I try to avoid spurious results due to the persistence of the time series. To document the persistence of SD and LD shocks, I further control for lagged values of $\Delta SD(LD)_{j,t-1}$, for each country group, j. I run the following fixed-effects regression for two maturity and country groups and each subsample:

$$\begin{aligned}\Delta SD(LD)_{j,t} = \alpha_j &+ \beta_1[\Delta Funding\ Risks_t] + \beta_2[\Delta Liquidity\ Risks_t] + \beta_3[\Delta Global\ Macro_t] \\ &+ \beta_4[\Delta Global\ Sentiment\ Risk_t] + \beta_5[\Delta Local\ Risk_t] \\ &+ \gamma \times \Delta SD(LD)_{j,t-1} + \epsilon_{j,t} \qquad (3)\end{aligned}$$

where $SD(LD)^m_{j,t}$ is the proxy for short- and long-term CIRP deviations for each country group, j, at time t, β's are vectors of coefficients, and γ is a scalar.[34] Liquidity risk includes the FX-Liq and FG-Liq variables; funding risk includes the unsecured and secured variables; local risk includes the RR and CDS variables; global macro risk factors include the LN-Macro and TP variables; and global sentiment factors include the sentiment and VIX variables. In dynamic panel regressions, the finite sample autoregressive bias in time series models persists asymptotically in large panels, as the cross-sectional sample dimension goes to infinity. To correct this problem, I adopt the bias correction methodology proposed in Phillips & Sul (2007).

As shown in Tables 1 and 2; CIRP deviations are highly time-varying and state-dependent. During the pre-crisis period, deviations are around the zero level but

[33]The regression results of short- and long-term deviations are similar for 1 weeks to 3 months and 1,2 to 5 years, respectively.

[34]I report the results using White's standard errors.

became large and extremely volatile during the financial crisis. This suggests limited market participation by arbitrageurs. CIRP deviations were especially acute during the credit sub-period, which includes the collapse of Lehman Brothers. The most striking finding of CIRP deviations is that, when examining them across different maturities, it is highly persistent in both developed and emerging markets. During the post-crisis phase, CIRP deviations gradually begin to converge back to the levels observed during the liquidity crisis period (see Figures 1 and 2).

I draw a number of conclusions when examining the regression results documented in Tables 4 through 9. I find that, during all sub-periods, lagged CIRP violations are negative and highly significant predictors of current CIRP deviations, indicating that the process is mean-reverting. The best predictor of CIRP deviations is simply the lagged values of CIRP violations. If I consider the maturities ranging from 3 months to 2 years for developed markets, the mean reversion coefficient is about -0.21% and -0.32%, respectively, during the crisis period (see Table 4). This also holds for emerging markets, with much lower values of -0.04% and -0.01% for 3 months and 2 years maturities, respectively, during the crisis period (see Table 5). Concerning the economic explanatory variables, I find that, in three different periods (i.e., pre-crisis, crisis, and post-crisis), the dynamics of short- and long-term CIRP violations are explained by various groups of explanatory variables. In general, the short-term deviations have higher R^2 values, indicating that they are more sensitive to observable risk factors. Also, developed countries have higher R^2 values than emerging countries do, which means that deviations in developed countries are more sensitive to the risk factors.

I examine the pre-crisis, crisis, and post-crisis periods of developed and emerging markets in details below subsections.

1.5.1 Pre-Crisis Period

The regression results for developed countries for the pre-crisis period are presented in Table 4. The R^2 values are approximately 21% and 18% for short- and long-term maturities, respectively. Furthermore, nearly all of the explanatory power can be attributed to lagged deviations, because none of the risk factors are significant for both short- and long-term deviations with an exception of term premia factor, which has a t-statistic of 1.66 for short-term deviations. This does not come as a surprise, given that CIRP violations for these countries are approximately zero during this period.

The regression results for emerging countries for the pre-crisis period are presented in Table 5. The R^2 values are approximately 19% and 18% for short- and long-term maturities, respectively. During this period, the deviations are mainly driven by the lagged deviations and the local factors. While both determinants of the local factors (currency crash risk and CDS rates) are significant factors for the short-term maturity, only the currency crash risk factor remains significant for the long-term maturities. However, the levels of deviation are not high so, the economic relevance of these proxies is low throughout this period.

1.5.2 Crisis Period

The regression results for developed countries for the crisis period (i.e. August 9, 2007 - March 31, 2009) are presented in Table 6. The model's explanatory power is considerably higher, with R^2 values of 65% and 60% for short- and long-term deviations, respectively. Global factors; sentiment, funding, and liquidity constraints have the highest significance of all explanatory variables in the short- and long-term panel regressions, with lagged deviations which yield substantial evidence that the dynamics of CIRP deviations are largely driven by global (U.S.) factors for developed countries.

In Table 6, I divide the crisis period for developed countries into liquidity and credit crisis sub-periods. During the liquidity crisis (August 9, 2007, to August 31, 2008), the R^2 values are 39% and 34% for short- and long-term deviations, respectively. Thus, the explanatory power of the model is far stronger during the liquidity crisis than it is during the pre-crisis period. However, the model's explanatory power is even stronger during the "Credit Crisis" period, when the R^2 values jump to 77% and 68% for the short- and long-term deviations, respectively. Recall that the average value of CIRP violations widens and fluctuates severely throughout this period. In the Liquidity Crisis Period, global liquidity factor is the main factor that drives the CIRP deviations. Especially Secured Funding factor and lagged CIRP values are other significant factors for both terms. On the other hand, the Closed-End Fund variable becomes significant only after the collapse of Lehman Brothers, implying that the liquidity crisis period is statistically unaffected by market sentiment, while the credit phase is greatly driven by it. This makes sentiment risk factors the primary source of mispricing during the credit crisis, both at short and long end of the curve. My results also show that even large deviations in CIRP deviations can be persistent when access to capital is limited and that sentiment risk factors embed large risk premia.

I examine marginal contributions of different groups of explanatory variables to the overall R^2 values for all sub-periods and short-long term CIRP deviations, which are shown in Figures 5 and 6. Also, separate regressions for short-term CIRP deviations have been done to indicate the individual significance of determinants as an example and are reported in Table 7.

During the credit crisis period, when I classify and rank the potential factors, I find strong evidence that the Global Sentiment group provides the greatest marginal contribution, explaining 19% of the total variation in CIRP violations. Global liquidity risk factors are the second most important explanatory factor, accounting for

more than 17% of the total variation. In fact, FG-LIQ risk alone plays the significant role in that period. This highlights the importance of the tightening liquidity constraints in the bond markets which is important since it reveals that short-term CIRP violations are indeed very sensitive to risks that are directly related to bond market liquidity. It also highlights the economic importance of cash-flow risk for the relative pricing of asset prices with nearly same cash flows and is consistent with (De Long et al., 1990), who argue that small deviations from fundamentals may not be corrected instantaneously during times of uncertainty.

Funding Risk is the third most significant variable, explaining 15% of the total variation. Within this group, while Secured Funding is quite significant, Unsecured Funding risk is insignificant. The vast LIBOR/OIS spreads that existed in the initial stage of the crisis led the Federal Reserve to intervene in the swap market. Empirical results (see Table 6) indicate that the spread between Mortgage-Backed Securities (MBS) and Treasury repo rates are highly significant (the Secured Funding Risk factor). It has an average t-statistic of 1.92 for short-term deviations and an average t-statistic of 3.3 for long-term deviations. The positive loading implies that CIRP violations tend to increase with tighter funding constraints. The work of (Bernanke & Gertler, 1989), who suggest that collateral values can be severely impaired in the case of adverse shocks to economic activity and can play a role in the efficient allocation of capital is also consistent with m results.

Macro-activity risk is significant only for long-term deviations during the credit crisis. This suggests that shocks to economic fundamentals also play a relevant role in the long-term disequilibrium. However, for local factors, the variables are not significant at all, which highlights the importance of global factors in CIRP deviations of developed countries.

The regression results for emerging countries for the crisis period are documented in Table 8. My model explains around 58% and 49% of the total variation for short-

and long-term deviations, respectively, during the crisis period. The R^2 values for emerging markets are lower than those for developed markets. The explanatory power for short-term deviations can be attributed to local CDS and risk reversal factors, as well as global factors, such as liquidity, funding, and macro risk factors. Global Sentiment and Bond Liquidity are not statistically significant. For long-term deviations, the majority of the impact comes from local factors (CDS, risk reversal), with FX liquidity and secured funding also playing an important role. Furthermore, unlike developed economies, global macro and sentiment are not statistically significant. Along with the short-term findings, this suggests that, unlike developed economies, emerging economies are highly sensitive to local risk factors. Therefore, my results give clear evidence that the CIRP disequilibrium dynamics of emerging markets are driven by *different* risk factors compared to developed economies.

Similar to developed countries' regressions, I divide the crisis period for the emerging countries into liquidity and credit crisis sub-periods and re-run the regression analysis. The results are reported in Table 8. During the liquidity crisis (August 9, 2007, to August 31, 2008), the R^2 values are 33% and 30% for short- and long-term deviations, respectively. For the credit crisis, however, these values are 66% and 54%, respectively. Therefore, similar to the results for developed countries, the explanatory power of the model is stronger in the credit phase than it is in the liquidity phase. During the liquidity crisis, a large part of the model's power comes from currency crash risk, term premia, and unsecured funding factors. [35] While the currency crash risk shows the importance of local factors, term premia validate the importance of the deterioration in U.S. macro-activity as a significant element of CIRP violations together with funding factors in emerging countries. The lagged deviations are also

[35]In Table 9, I investigate separate regressions to understand each factor's marginal contribution to the overall R-squared values.

significant for both liquidity and credit phases.

For emerging markets, unlike for developed countries, during the crisis period, local factors (currency crash risk and credit risk factors) are the most significant, and contribute more than 30% of total variation in CIRP deviations (see Figure 6). This is very different from the pattern in developed countries. (see Figure 5) The importance of currency crash risk in emerging countries CIRP deviations indeed shows the presence of asymmetric downside and upside risks in currency markets and its influence over arbitrageurs. On the other hand, while sovereign credit factors not relevant in developed markets, embedded risk premiums of emerging countries and their effects over CIRP deviations are significant to investigate.

The macro-activity factor is another important factor, which highlights the importance of deterioration in pure U.S. macro-activity. Another significant factor is FX liquidity during the crisis period, which is one of the liquidity control parameters that displays the widening bid-ask spreads of spot and forwards, foreign exchange latent liquidity. In addition, it is also interesting to observe the relationship between funding constraints in emerging and developed economies. Since the impact of unsecured funding is pronounced only for short-term disequilibrium, having the t-statistics of -1.69, these findings show that arbitrageurs are subject to different risk factors in different markets in terms of local versus global factors and also in terms of funding constraints. While developed economies are affected by secured funding costs, emerging economies are affected by unsecured funding costs. In this context, Greenspan (2008) discusses the LIBOR/OIS spread as a proxy for the probability of bank insolvency and extra capital needs. He points to the dramatic rise of this spread during the recent credit crisis. My results show that this dramatic increase was a relevant issue in emerging economies, but that it was not as important in developed economies.

1.5.3 Post-Crisis Period

The regression results for developed countries for the post-crisis period are presented in Table 4. The R^2 values in the post-crisis period drop considerably compared to the crisis period (i.e., 46% for short-term and 38% for long-term). While the impact of Global Sentiment (VIX) and FX Liquidity remain, Bond Liquidity and Closed-End Funds become irrelevant. For short-term deviations, the majority of explanatory power comes from Global Funding factors (primarily Unsecured Funding). The Unsecured Funding, however, is insignificant in the long-term, while local risk factors and Bond Liquidity are significant. Overall, in the post-crisis period, my findings suggest that short-term unsecured funding limits arbitrage opportunities, but that secured funding is not a limiting factor for short-term CIRP arbitrage.

The regression results for emerging countries for the post-crisis period are documented in Table 5. A slightly different pattern is observed in emerging markets. For the short-term CIRP deviations, the R^2 drops considerably, to 28%. For short-term deviations, FX liquidity, local factors, and lagged deviations are significant while all other risk proxies are insignificant. The R^2 for long-term deviations is 20%. The explanatory power is mostly due to unsecured funding and local factors. This also implies that the tightness in interbank lending is still a financial constraint in arbitrage opportunities in emerging economies during the post-crisis period. Overall, the low R^2 values once again draw attention to the necessity of identifying new risk proxies for emerging swap markets.

1.6 Price Discovery Analysis

Financial institutions facilitate short and long term funds, depending on their strategic decisions and the overall macroeconomic environment. The relation between the short- and long-date financing becomes important in the sense that there may exist

a sequential pattern in the volatility spillover in both markets, and financial institutions may have to take positions, accordingly. For instance, Taylor (1989) argue that long term arbitrage opportunities tend to follow short term arbitrage opportunities, especially during turbulent times.

I analyze three channels of contagion between short- and long-term CIRP deviations. First, I investigate the correlated information channel via the price discovery process to examine the ability of investors to process information and to move across different funding markets. In doing so, I observe whether a shock to short-term signals any relevant information to long-term. In case there is price discovery from short- to long-term, immediate effects should arise in the long-term. I test price discovery via Hasbrouck (1995), which requires a cointegration relation between two non-stationary variables. Nonetheless, I observe that short- and long-term deviations are cointegrated during all sample periods, implying that the contagion could be from a correlated-information channel; however I could not find evidence for discovery in any periods.

The conventional view of price discovery relies on the assumption of smoothly-adjusting financial and capital markets. However, the recent subprime and Lehman financial crisis serves as a reminder that financial flows can reverse abruptly, placing intense pressure on the functioning and integrity of markets and market participants. Since both short-term or long-term CIRP reflect the same fundamentals, they should both exhibit a no-arbitrage relationship. Hence, it becomes interesting to investigate micro structural factors, as Duffie (2010) debated, and evaluate whether short- or long-term CIRP deviations provide more timely information and how this result relates to the properties of the CIRP deviations. In other words, I seek to understand what swap maturity makes the greatest contribution to price discovery.

Similar to Blanco et al. (2005), I investigate how short- and long-term deviations contribute to price discovery. Price discovery, with respect to Lehmann (2002),

could be referred as a timely incorporation of trading activity into market prices. Therefore, I try to analyze the differences in the information content of deviations in different maturities. In order to do price discovery analysis, I use the Hasbrouck, 1995) information share (IS) measure and the Gonzalo & Granger (1995) component share (CS) measure.[36] I calculate the IS measures to find the contribution of short-term deviations to long-term deviations. [37] Following Eun & Sabherwal (2003), I generate two spread series by using the midpoint of the last bid and ask quotes in each market.[38] I estimate the relative contribution to price discovery by computing Hasbrouck's IS price discovery measures for all sub-periods and the entire period.

Having observed that cointegration exists, I run the following VECM:

$$\Delta SD_t = A1(SD_{t-1} - c_1 LD_{t-1}) + \sum_{n=1}^{N} \phi_{1n} \Delta SD_{t-n} + \sum_{n=1}^{N} \gamma_{1n} \Delta LD_{,t-n} + u_{1t} \qquad (4)$$

$$\Delta LD_t = A2(SD_{t-1} - c_1 LD_{t-1}) + \sum_{n=1}^{N} \phi_{2n} \Delta SD_{t-n} + \sum_{n=1}^{N} \gamma_{2n} \Delta LD_{t-n} + u_{2t} \qquad (5)$$

SD and LD are the short- and long-term deviations, respectively, and u_{1t} and u_{2t} are the error terms. If short-term swap markets are the significant contributor to price discovery, then $A2$ should be statistically significant. Similarly, if long-term swaps are the most significant contributor, then $A1$ should be statistically significant. If both coefficients are significant, then both significantly contribute to price discovery. Given that Hasbrouck's measures can only provide upper and lower bounds, Baillie, Booth, Tse, & Zabotina (2002) suggest using averages of these bounds. If the average of Hasbrouck's bounds is greater than (less than) 0.5, then SD (LD) leads LD (SD). Results for short-term and long-term CIRP deviations in developed and emerging

[36]Both measures rely on the estimation of vector error-correction models (VECM) of market prices. However, IS assumes that price volatility reflects new information and allows for correlation among multiple markets through the variance and covariance of price innovations.

[37]I first test for the existence of cointegration by Johansen across credit spreads of a single issuer, and estimate a VEC (Vector Error Correction) model. I find the number of lags according to the Akaike information criterion. My results show that short- and long-term deviations are cointegrated for the whole sample period, as well as for each sub-period.

[38]They prefer using quotes over transaction prices, since transaction prices may suffer from auto-correlation due to infrequent trading.

economies are summarized in Table 10.[39] My findings reveal that, for developed market currencies, the $A2$ coefficient in Eq. (5) is statistically significant, implying that the short-term FX swap markets (SD) tend to lead long-term basis swap markets (LD) in terms of price discovery. However, I do not observe any price discovery before the crisis. This shows the strong interlink between funding markets during times of distress. The impact of price discovery in developed markets persists even during the post-crisis period, which implies that the memory of turmoil is still retained.

For emerging market currencies, both $A1$ and $A2$ coefficients in Eq. (4) and (5) are statistically significant, but only for the crisis period. This implies that both FX swap and basis markets tend to contribute price discovery, but only during the crisis period. Taking into account all maturities available, I find that the contributions of short-term FX swap markets are, on average, 80%, 68%, and 76% for euro, pound, and yen, respectively. This suggests that FX swaps were the avenue for spreading turbulence from money markets to long-term cross-currency basis swap markets. These findings are consistent with anecdotal evidence that, during the market turmoil, U.S. financial institutions became highly reluctant to lend dollars to non-U.S. financial institutions. There were two primary reasons for the reluctance of U.S. financial institutions to lend. First, they were cautious against the amplified counterparty risk in uncollateralized interbank markets. Second, they were facing financial difficulties and therefore needed to preserve precautionary liquid funds. The outcome was a severe dollar-funding shortage for non-U.S. financial institutions, who soon attempted to raise dollars by participating in short-term FX swaps and later in longer-term cross-currency swaps.

[39] In my analysis, I fail to reject cointegrations. Thus, I can rely on the VECM representation.

1.7 Spillover Analysis

As the second channel of contagion, I investigate the volatility transmission between short- and long-term deviations. As discussed in Forbes & Rigobon (2002), estimating correlation via rolling windows tends to be biased during crisis periods, as conditional heteroskedasticity is not directly modeled. I, therefore, run a bivariate Garch model with BEKK (1,1) parameterizations based on Engle & Kroner (1995) [40] on short- and long-term CIRP deviations, to test whether there is volatility spillover between the two. More formally, the bivariate GARCH model can be written as

$$\Delta r_t = E[\Delta r_t | \mathcal{F}_{t-1}] + \epsilon_t \tag{6}$$

where Δr_t is the bivariate vector of the returns of SD and LD, and $\mathcal{F}_{t-1}$ represents the information up to time $t-1$. The corresponding shocks are denoted as $\epsilon_t \sim \mathrm{N}(0, \Sigma_t)$, where N is the bivariate normal distribution and Σ_t is the covariance matrix at time t. Using BEKK (1,1), this matrix can be modeled as follows:

$$\Sigma_t = C^{'}C + A^{'}(\epsilon_{t-1}\epsilon_{t-1}^{'})A + G^{'}\Sigma_{t-1}G \tag{7}$$

where C is constant, A is the ARCH coefficient matrix and G is the GARCH coefficient matrix. The quadratic nature of the equation ensures that Σ is positive-definite. Volatility is transmitted through price changes (i.e., an increase in the volatility of the variance of returns) and noise (i.e., an increase in the volatility of the variance of the forecast error). The volatility spillover channel helps to understand whether shocks in the short-term influence the willingness of participants to undertake risk in the long-term. As a third channel, the nature of the correlations between the corresponding deviations is also important to understand the level of contagion in the given markets. Bollerslev (1990) suggested constant conditional correlations

[40] In studies of volatility transmission, there are three main methodologies used extensively in literature: Garch models (Bollerslev, Engle, & Wooldridge, 1988), regime switch models (Lamoureux & Lastrapes, 1990) and (Aggarwal, Inclan, & Leal, 1999), and stochastic volatility models (Harvey, Ruiz, & Shephard, 1994).

model, which restricts the correlation between two asset returns to be constant over time. Nevertheless, in the light of the rejection of constant correlation (Bera & Kim, 2002), Engle (2002) proposed the Garch-DCC Model, which includes the dynamic conditional correlation factor. Based on Engle's idea, I use the Garch-DCC model to recap the gains of assessing the correlations between the short and long term funding behaviors.

During the market turmoil, US financial institutions proved to be highly reluctant in lending dollars to non-US financial institutions, because of two major reasons. First, US institutions were cautious against the amplified counterparty risk in the uncollateralized interbank markets. Second, US institutions were facing financial difficulties, and thus were in need to preserve precautionary liquid funds. The obvious outcome was the severe dollar-funding shortage in the non-US financial institutions that soon attempted to raise dollars by first participating in short-term FX swaps, and later in longer-term cross-currency swaps (see Baba, 2009).

Baba (2009) finds evidence that the money market turmoil has spilled over to FX swap markets amid a heightened counterparty risk. Table 11 gives the summary of the volatility spillovers in developed and emerging countries' swap markets. There are two major findings: First, there were no signs of dynamic spillovers in the pre-crisis, while a severe case of dynamic spillover became evident during the market turmoil, both in developed and emerging markets. This proves the strong interlink between funding markets during times of distress. The direction of the volatility spillover in developed markets was from short- to long-term without exception, validating the observation that European financial institutions were in an urgent demand of usd *firstly* in short-term, and *later* in long-term swap markets (see Baba, 2009). On the other hand, emerging markets consistently displayed a two-way spillover feature during this period. The bi-causality in emerging swap markets is a difficult issue to resolve, and at this point, it can only be linked to the bilateral shifts of funding

needs. More importantly, it reveals that the general pattern (observed in developed markets) is not a general norm around the globe. Second, the impact of volatility spillover (in developed markets) persists even during the post-crisis (implying that the memory of turmoil is still retained), but such impact is not observed in emerging markets. This might be partly related to the extensive accumulation of usd reserves in emerging economies, and to the difference in the motivation behind the use of derivatives. According to Obstfeld, Shambaugh, & Taylor (2009), the dollar-based swap agreements with the emerging markets were mainly symbolic, because adequate amounts of foreign reserves were already being held in these countries, and thus the corresponding swap lines could only be interpreted as signals, that the importance can also be seen from the event analysis.

In Table 11, only the significant conditional correlation values (between short- and long-term deviations) are listed. Results suggest that the correlations become significant in developed markets during the crisis period, and tends to persist still in Japan and Euro Zone even after the market distress, validating the previous BEKK findings. On the other hand, there is little or no evidence of any sign of dynamic correlation in the emerging markets in any of the given subsample periods. One exception is Mexico, where the corresponding co-movements become weakly significant during the crisis period, but still vanishes after that. These findings shed light to an interesting phenomenon. The short- and long-term funding characteristics maintain similar dynamics in developed markets, meaning that if a problem occurs in the short-term, it is likely to happen in the long-term as well. This may be a clue as to why the volatility spillovers continue even after the crisis period. In emerging markets, however, the short- and long-term funding characteristics tend to be relatively more segmented from one another.

Furthermore, based on the correlated-information channel (Longstaff, 2010), I also tested whether there exists any price discovery relation among the short- and

long-term CIRP deviations. One way of testing it is via (Hasbrouck, 1995), which requires a cointegration relation between two non-stationary variables. Nevertheless, my findings show that short- and long-term deviations are cointegrated during all sample periods, implying that the contagion could be from a correlated-information channel; however I could not find evidence for discovery in any periods as seen in Table 12 and 13.

1.8 Robustness

In this section, I examine the robustness of my results. I compare the indicative quotes with the transaction prices, separately rerun panels for each risk category, and include additional economic variables in my regressions.

In the previous section, my results are based on quotes rather than actual transaction prices. One might argue that my findings may be sensitive to traders' updating mechanism, and that quotes respond to market risk factors with a lag. To address this problem, I collect the spot and forward libor prices from actual transactions data from BNP Paribas. When I compare the available data with indicative quotes for the corresponding periods, I find that they are very similar. Similarly, (Collin-Dufresne, Goldstein, & Martin, 2001) conclude that their results (using dealer quotes) are robust to actual transaction prices.

I aim to show that risk proxies that are not included in the panel regressions do not influence my results. While I cannot argue that omitted economic proxies have an insignificant impact on CIRP deviations, I can show that my results do not change significantly when I add new variables. I rerun the panel regressions with all of the original variables as well as a number of new variables. I also add the following variables to the panel regressions: S&P500 Index for developed markets - MSCI Emerging Markets Equity Index for emerging markets to proxy for *equity market risk*; Markit CDX North American Investment Grade Index for developed

markets - Markit CDX Emerging Markets Index for emerging markets as a measure of *default risk*; euro-equivalents of the USD-based risk factors (i.e., the euro version of the dollar funding constraints and Perceived Tail Event risk captured by VIDAX, weighted average of implied volatilities of options with different strikes written on DAX) to examine the relative impact of Euro- vs. USD-originating constraints; and the foreign reserves of investigated countries to control for the importance of foreign currency reserves. My findings are robust, and the tables are available upon request.

1.9 Conclusion

In this paper, I analyze the dynamics of LOP violations in developed and emerging economies during the recent crisis period. I focus on three developed and three emerging market currencies and investigate the potential determinants of both short- and long-term CIRP deviations. In addition, I study the interlink between the two types of funding markets and examine how short-term and long-term deviations contribute to price discovery. In theory, the no-arbitrage condition should force CIRP deviations to be zero. While I find that the no-arbitrage condition holds during the pre-crisis period, it is severely disrupted during the crisis, especially during the credit turmoil. In other words, CIRP equilibrium is not an empirical norm; rather, it is time-varying and state-dependent. This implies that arbitrageurs are subject to certain constraints that prevent them from taking the corresponding positions and providing liquidity to markets.

Furthermore, I investigate whether arbitrageurs are constrained by the same risk factors across different economies. I find that an unexploited arbitrage, though the same in structure, may be driven by different risk factors in different economies. I find this to be the case even during periods of financial distress when the impact of risk factors is expected to be contagious across different markets. The impacts of the risk factors that I explore are often greater for the short-term swap agreements than they

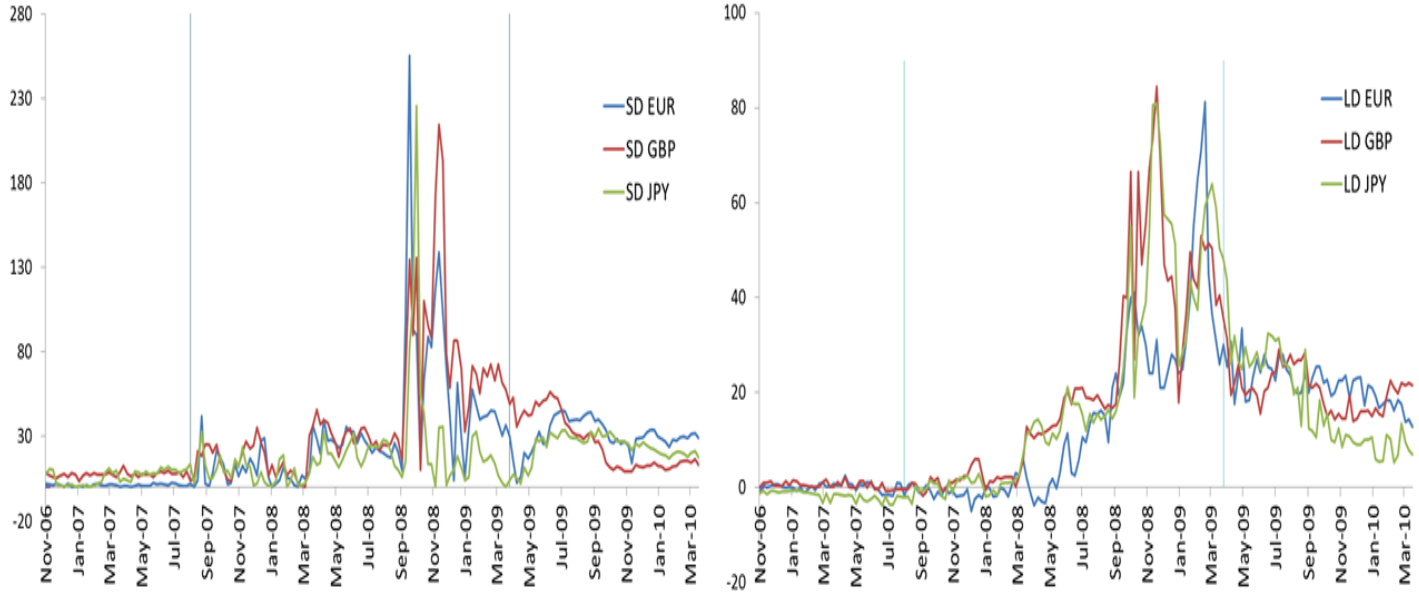
are for long-term swap agreements. Hence, the significance of the risk factors depends on the sample period (i.e. pre-crisis, crisis, post-crisis), swap terms (i.e. short- vs. long-term), and the type of economy (i.e. developed vs. emerging).

To assess what drives CIRP deviations, I examine both local and global risk factors. For both developed and emerging markets, the impacts of the given risk factors are often negligible during the pre- and post-crisis phases. This supports the notion that LOP typically holds during these periods. However, for developed countries, the model explains 65% of the total variation in short-term CIRP deviations and 60% of the total variation in long-term deviations during the crisis period. The model explains 58% and 49% of short-term and long-term deviations, respectively, for emerging markets during the crisis period. Furthermore, during the credit crisis, developed swap markets are mainly sensitive to global factors such as funding, liquidity, and sentiment factors. Deviations in emerging swap markets, on the other hand, are mostly driven by local factors such as currency crash risk and sovereign credit risk. The global sentiment, liquidity, and funding factors are also important for emerging markets during this period. My PCA analysis also indicates that developed swap markets are more sensitive to global systemic shocks, and that emerging swap markets are more sensitive to local factors. Overall, my results suggest that arbitrageurs are affected by different market constraints in different economies. In addition, my results imply that I may need to reconsider whether global risk factors are relevant for worldwide markets, especially during periods of financial distress.

Finally, I examine price discovery between the short- and long-term markets. My findings show that information transmission varies to a certain extent in developed and emerging swap markets. Before the outbreak of the financial crisis, swap markets did not contribute to price discovery in either type of market. During the crisis phase, however, developed economies consistently displayed strong price discovery from short- to long-term funding, while their emerging equivalents tended to exhibit

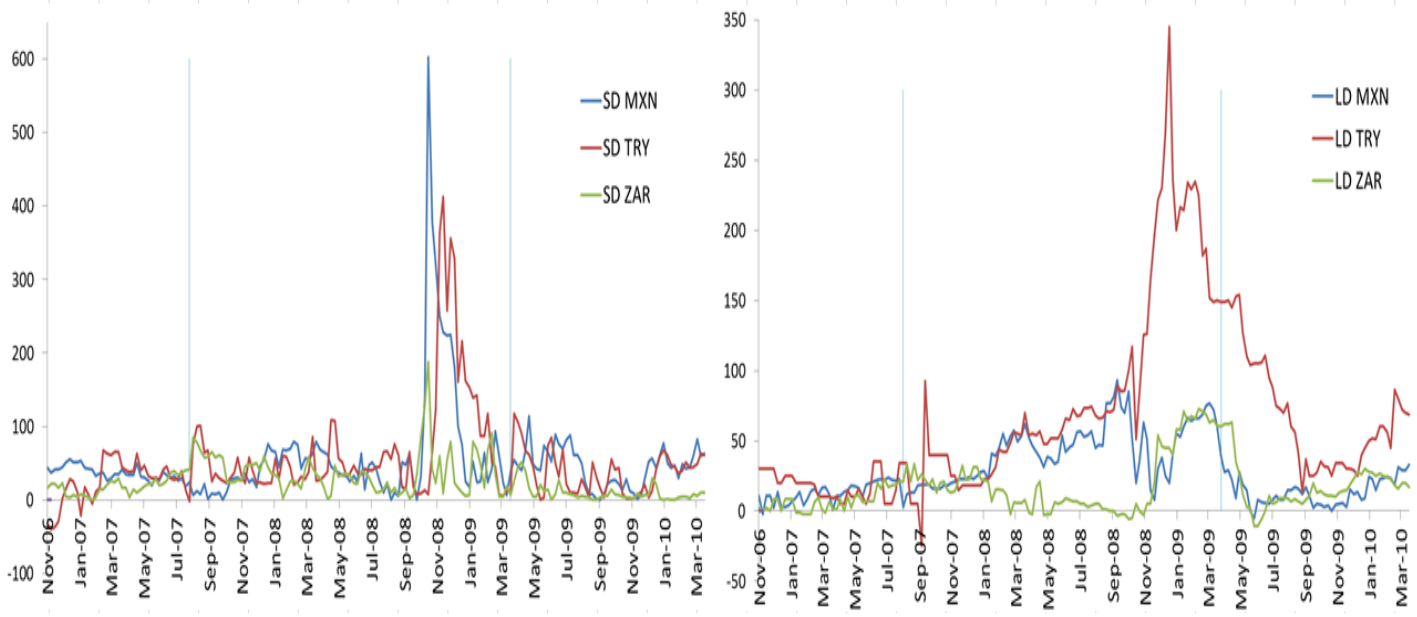
two-way price discovery. Also, I looked at volatility effects and witnessed that there exists no volatility in both economies before the outbreak of the financial distress and during the crisis phase, similarly developed markets consistently display a one-way movement (from short- to long-term funding), but emerging markets tend to exhibit two-way movements. This implies that the general argument in support of "short- to long-term transmission" is not necessarily the norm across markets. Moreover, while the price discovery and effects tend to persist in developed countries even during the post-crisis period, no such transmission is observed in emerging countries. This suggests that the *memory* of funding constraints is retained in developed swap markets, but not in their emerging equivalents. This also indicates to a certain segmentation among developed and emerging economies. My findings also suggest that there exists a dynamic correlation between short- and long-term deviations in developed countries during the credit crisis, and continued after the crisis, but cannot say there is a similar movement in the emerging countries.

Figure 1: CIRP Deviation Levels For Developed Countries



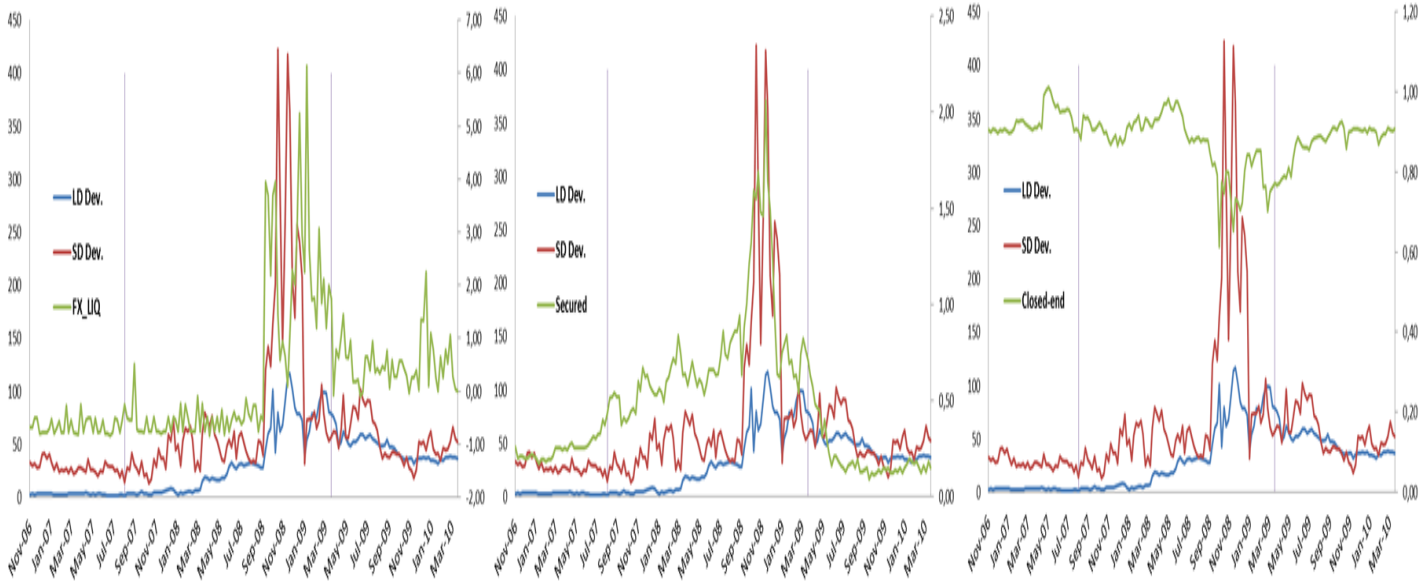
In this figure, estimates for short-term and long-term covered interest rate parity (CIRP) deviations are presented for each period (pre-crisis, liquidity crisis, credit crisis, and post-crisis) that is analyzed in this paper. CIRP deviations are estimated using three month maturities for short-term data and 2-year maturities for long-term data. All estimates are with respect to U.S. rates.

Figure 2: CIRP Deviation Levels For Emerging Countries



In this figure, estimates for short-term and long-term covered interest rate parity (CIRP) deviations are presented for each time period (pre-crisis, liquidity crisis, credit crisis, and post-crisis) that is analyzed in this paper. CIRP deviations are estimated using three month maturities for short-term data and 2-year maturities for long-term data. All estimates are with respect to U.S. rates.

Figure 3: Comparison of Risk Factors with CIRP Deviations in Developed Countries



This figure displays the dynamics of a number of risk factors with the first principal components of short-term and long-term absolute CIRP deviations in developed and emerging countries. The risk factors include secured funding (Secured), Liquidity (FX Liquidity), and closed-end fund discounts (Closed-end). The left axes denote the first principal component of absolute short-term deviations, and the right axes denote the values of the risk factors. The graphs separate the time series into three periods: the pre-crisis period, the crisis period, and the post-crisis period.

Figure 4: Comparison of Risk Factors with CIRP Deviations in Emerging Countries

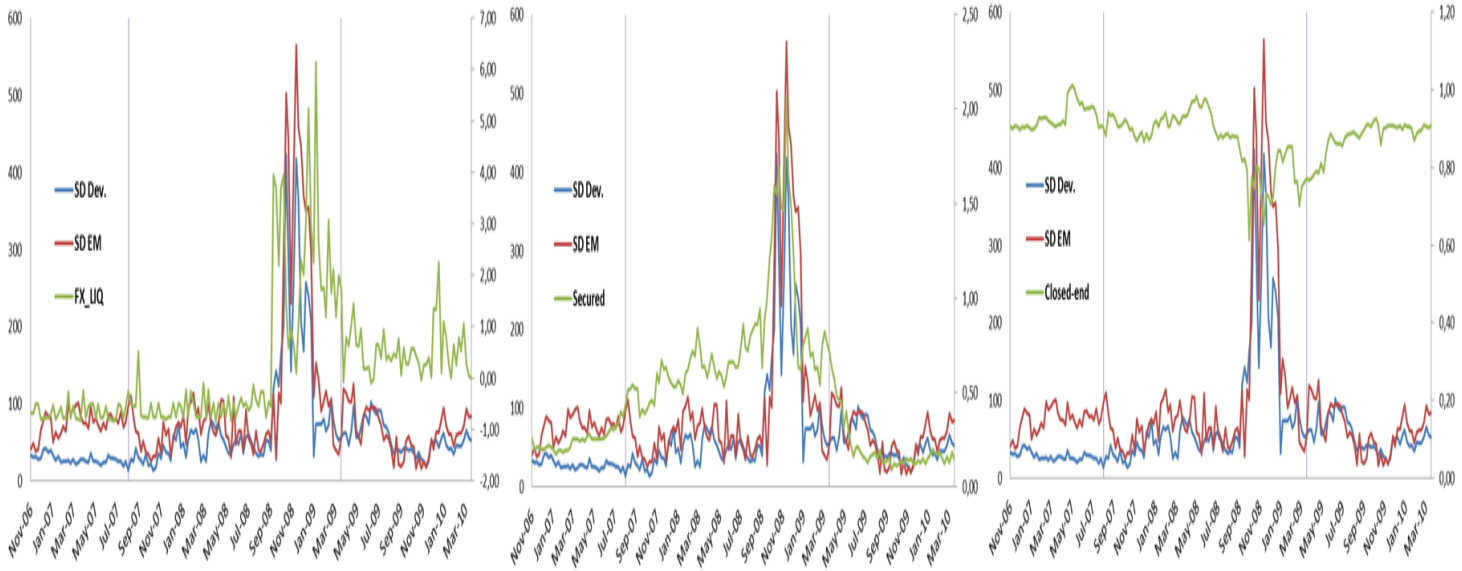


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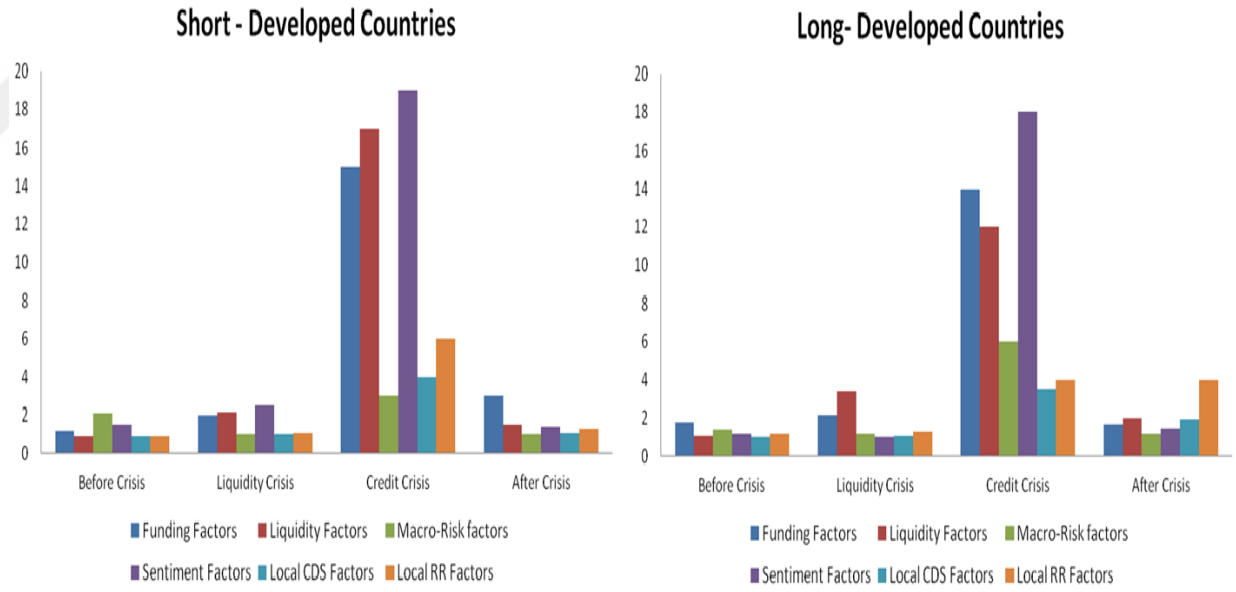
Figure 5: Impacts of Individual Risk Factor Categories on CIRP Deviations



The figures display the total R^2 attained from regressing short-term and long-term CIRP deviation levels on each category of risk factors. Regressions are run separately for each risk factor in developed countries. The sample is broken into four time periods (pre-crisis, liquidity crisis, credit crisis, and post-crisis). Six risk factor categories are examined. The Funding Risk category includes Unsecured and Secured; the Liquidity Risk category includes FX-Liq and FG-Liq; the Macro Risk category includes LN-Macro and TP; the Sentiment category includes Closed-end and VIX; and the Local Risk category includes RR and CDS. Definitions for each variable can be found within the text of the paper. Values are in percentages.

Figure 6: Impacts of Individual Risk Factor Categories on CIRP Deviations

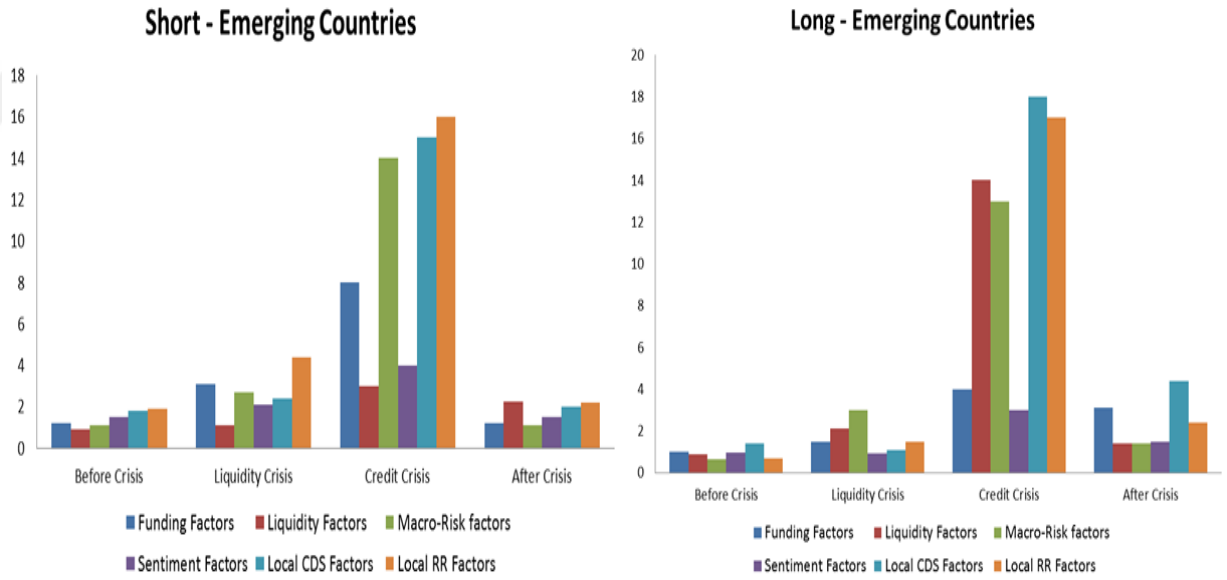


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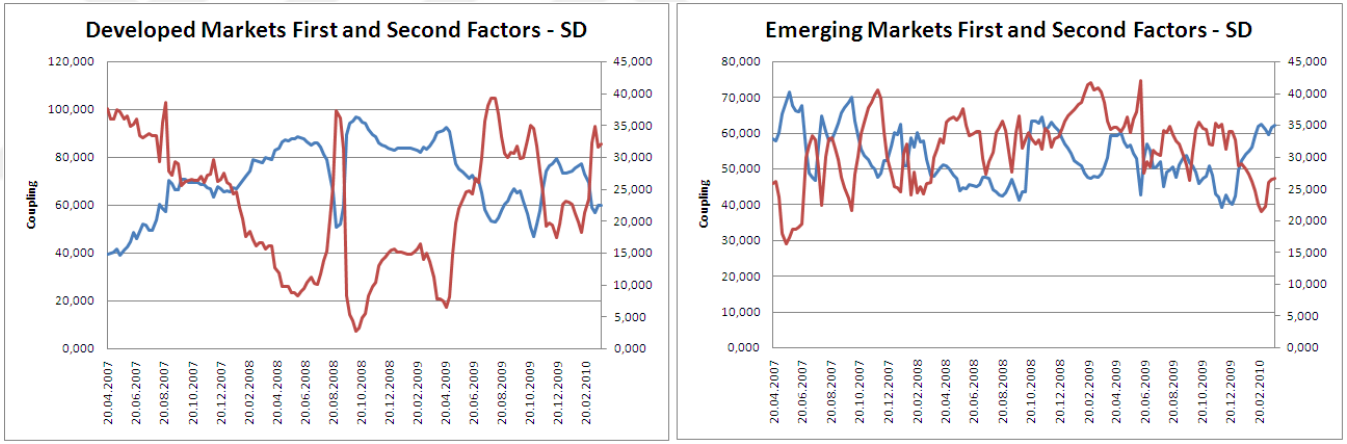
Figure 7: Short-Term CIRP Deviations - First and Second Principal Components



For the short term dynamic PCA version, principal components were performed on consecutive windows (250 days). By observing the variations of the coupling component (percent of variance explained by the first component) across time, I form a dynamic picture of the behavior of the emerging and developed markets. A dynamic factor analysis reveals that the importance of the CIRP deviations variance explained by the factor changes over time and also show dramatic differences for emerging markets and developed market. This variation also helps me to interpret extreme market events CIRP deviations differ. The factor analysis applied on all sub-periods separately, allowing to measure the evolution of important market shifts.

Figure 8: Long-Term CIRP Deviations - First and Second Principal Components

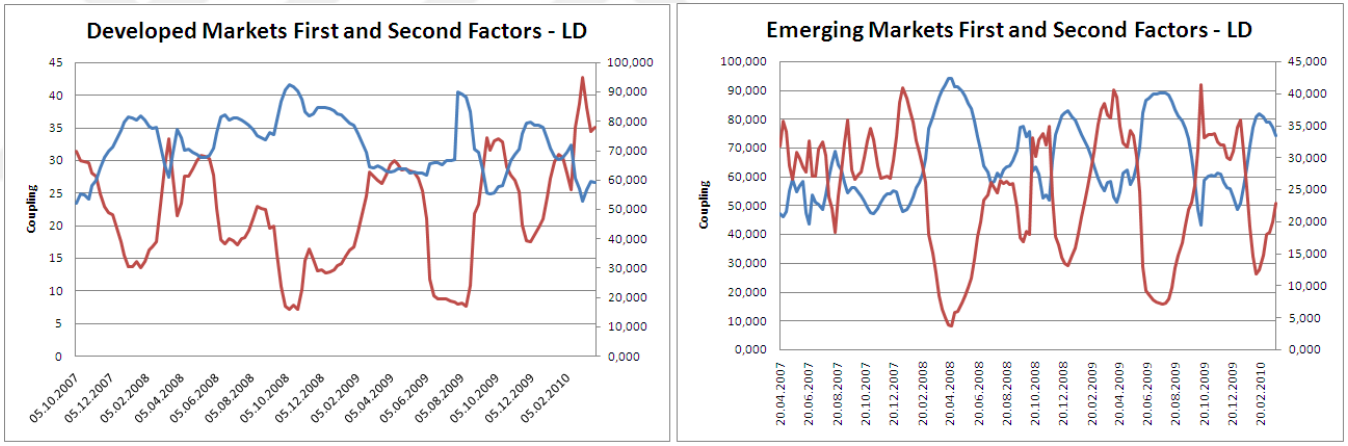


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Table 1: CIRP Summary Statistics for Developed Markets

This table presents summary statistics for absolute short- and long-term CIRP deviations in developed markets. It includes the average, 75th percentile (top quartile), and maximum values of deviations with various maturities. The dataset is divided into pre-crisis, liquidity - credit crisis, and post-crisis periods. Short-term deviations (SD) and long-term deviations (LD) are measured in basis points (bps).

Year	**Maturity**	**Developed Markets**								
		Euro			*United Kingdom*			*Japan*		
		Deviations	*Top Quartile*	*Max*	*Deviation*	*Top Quartile*	*Max*	*Deviation*	*Top Quartile*	*Max*
Pre-Crisis Period	**SD - 1W**	0.73	0.99	3.13	0.72	0.94	3.03	4.68	5.57	18.66
(10 November 2006 - 8 August 2007)	**SD - 3M**	1.01	1.53	2.48	7.34	8.21	12.45	6.07	9.72	13.34
	LD - 1Y	0.79	1.15	2.50	0.64	1.04	1.96	1.75	1.91	3.95
	LD - 2Y	0.73	0.99	2.62	0.68	1.20	2.26	1.76	2.16	3.88
	LD - 5Y	1.60	2.07	3.74	0.60	0.71	2.26	0.79	1.14	2.50
Liquidity Crisis Period	**SD - 1W**	6.64	8.10	43.19	6.57	8.10	43.19	10.69	15.51	50.19
(9 August 2007 - 31 August 2008)	**SD - 3M**	16.35	26.05	41.83	21.22	29.20	45.73	13.70	19.56	32.87
	LD - 1Y	5.12	7.38	21.57	8.78	18.58	28.40	9.17	14.73	30.70
	LD - 2Y	3.70	3.40	16.20	7.73	13.49	21.00	6.76	13.16	21.13
	LD - 5Y	3.50	3.99	15.00	4.54	9.28	13.81	5.33	10.46	18.50
Credit Crisis Period	**SD - 1W**	42.30	39.23	240.04	41.53	39.23	240.04	38.96	38.33	218.06
(1 September 2008 - 31 March 2009)	**SD - 3M**	62.93	87.29	255.25	82.37	89.40	214.19	25.93	32.00	225.45
	LD - 1Y	39.15	54.94	131.90	51.08	69.98	123.55	45.00	54.45	102.65
	LD - 2Y	33.50	45.09	81.22	45.44	52.59	84.50	43.95	57.28	81.88
	LD - 5Y	28.63	41.56	60.63	31.87	42.38	65.10	31.83	41.53	62.00
After-Crisis Period	**SD - 1W**	10.35	15.67	34.24	10.35	15.67	34.24	15.48	19.62	58.21
(1 April 2009 - 31 March 2010)	**SD - 3M**	30.26	37.62	45.22	26.40	41.62	56.06	23.20	29.03	34.48
	LD - 1Y	27.43	29.02	46.00	20.14	24.39	28.00	15.76	22.99	42.00
	LD - 2Y	21.91	24.48	33.50	20.73	22.88	35.50	18.06	26.00	48.00
	LD - 5Y	19.24	22.97	27.25	17.21	21.08	31.75	20.86	30.44	49.00

Table 2: CIRP Summary Statistics for Emerging Markets

This table presents summary statistics for absolute short- and long-term CIRP deviations in emerging markets. It includes the average, 75th percentile (top quartile), and maximum values of deviations with various maturities. The dataset is divided into pre-crisis, liquidity crisis, credit crisis, and post-crisis periods. Short-term deviations (SD) and long-term deviations (LD) are measured in basis points (bps).

Year	**Maturity**	**Emerging Markets**								
		Mexico			*Turkey*			*South Africa*		
		Deviations	*Top Quartile*	*Max*	*Deviation*	*Top Quartile*	*Max*	*Deviation*	*Top Quartile*	*Max*
Pre-Crisis Period	**SD - 1W**	8.75	9.24	11.28	5.78	7.11	12.24	4.07	6.25	17.37
(10 November 2006 - 8 August 2007)	**SD - 3M**	35.61	39.39	55.26	25.04	42.06	67.72	22.57	26.44	41.11
	LD - 1Y	19.83	27.00	32.00	20.45	30.00	40.00	13.75	17.00	23.00
	LD - 2Y	13.47	19.25	23.82	18.36	26.25	35.00	8.65	10.25	23.00
	LD - 5Y	11.89	18.99	26.00	18.25	15.12	20.00	7.87	12.20	21.50
Liquidity Crisis Period	**SD - 1W**	31.66	43.99	72.72	29.07	38.38	95.74	37.55	55.77	82.99
(9 August 2007 - 31 August 2008)	**SD - 3M**	37.09	57.69	79.01	46.28	57.20	109.03	34.58	47.12	84.36
	LD - 1Y	37.83	51.95	71.50	52.27	71.25	81.00	15.91	23.50	37.00
	LD - 2Y	35.18	47.00	62.23	43.59	59.75	92.50	13.37	21.63	34.00
	LD - 5Y	32.90	44.41	56.18	28.61	49.50	70.00	12.65	20.13	34.00
Credit Crisis Period	**SD - 1W**	132.97	222.21	648.01	52.04	45.64	327.10	67.94	96.86	254.56
(1 September 2008 - 31 March 2009)	**SD - 3M**	156.86	164.37	602.73	115.21	158.77	412.02	41.44	68.88	188.13
	LD - 1Y	44.73	68.75	89.50	183.90	235.88	375.00	29.88	51.75	68.00
	LD - 2Y	55.42	71.50	93.00	168.17	224.13	345.00	34.38	63.75	73.00
	LD - 5Y	63,80	76.00	95.57	130.47	174.38	210.00	28.52	50.00	60.00
After-Crisis Period	**SD - 1W**	47.40	67.73	112.90	35.28	47.24	153.94	18.52	24.51	54.72
(1 April 2009 - 31 March 2010)	**SD - 3M**	44.79	61.68	113.68	37.79	56.48	117.34	9.76	10.32	51.68
	LD - 1Y	15.59	20.17	45.00	55.29	80.75	144.00	17.62	24.13	49.00
	LD - 2Y	14.22	22.63	39.00	69.34	97.25	154.00	17.73	25.00	63.00
	LD - 5Y	37.89	45.00	67.00	116.68	143.25	183.00	15.23	24.00	54.00

Table 3: Principal Components Analysis on Short-Term and Long-Term Deviations

The table below presents the results for static Principal Components Analysis (PCA) on short-term and long-term CIRP deviations. The sample is divided into pre-crisis, liquidity crisis, credit crisis, and post-crisis periods. I show the percent of variation explained and the cumulative percent of variation explained by each component.

Year	**Principal Components**	**Short-Term CIRP Deviations**						**Long-Term CIRP Deviations**					
		All Markets		Developed Markets		Emerging Markets		All Markets		Developed Markets		Emerging Markets	
		Exp.	*Cum.*	*Exp.*	*Cum.*	*Exp.*	*Cum.*	*Exp.*	*Cum.*	*Exp.*	*Cum.*	*Exp.*	*Cum.*
Entire Period (10 November 2006 - 31 March 2010)	**First**	55.52	55.52	84.77	84.77	57.48	57.48	60.77	60.77	90.75	90.75	58.88	58.88
	Second	18.66	74.18	13.41	98.18	29.84	87.32	17.95	78.72	7.22	97.97	26.54	85.42
	Third	15.11	89.29	1.82	100.0	12.68	100.0	13.98	92.70	2.03	100.0	14.58	100.0
Pre-Crisis Period (10 November 2006 - 8 August 2007)	**First**	38.99	38.99	41.64	41.64	57.36	57.36	48.07	48.07	53.98	53.98	57.26	57.26
	Second	22.15	61.14	35.18	76.82	29.40	86.76	28.40	76.47	29.11	83.09	27.95	85.21
	Third	15.37	76.51	23.18	100.0	13.24	100.0	6.01	82.48	16.91	100.0	14.79	100.0
Crisis Period (9 August 2007 - 31 March 2009)	**First**	63.64	63.64	86.80	86.80	65.16	65.16	73.99	73.99	93.21	93.21	65.01	65.01
	Second	11.15	74.79	11.98	98.78	23.60	88.76	15.48	89.47	5.24	98.45	21.42	86.43
	Third	16.07	90.86	1.22	100.0	11.24	100.0	5.23	94.70	1.55	100.0	13.57	100.0
Post-Crisis Period (1 April 2009 - 31 March 2010)	**First**	41.99	41.99	55.04	55.04	52.29	52.29	54.43	54.43	79.37	79.37	55.20	55.20
	Second	24.22	66.21	35.24	90.28	32.74	85.03	26.64	81.07	17.53	96.90	33.41	88.61
	Third	13.41	79.62	9.72	100.0	14.97	100.0	9.95	91.02	3.10	100.0	11.39	100.0

Table 4: CIRP Deviation Panel Regressions for Developed Countries Using the Full Time Series

The panel includes both short- and long-term net deviations (with bid-ask spreads subtracted) of the European euro market, the United Kingdom, and Japan. First-differences are taken to make the variables stationary. Global factors and local factors are used as regressors. Local factors include country-specific variables (RR and CDS). Global Factors include the following variables: FG-LIQ, FX-LIQ, UNSECURED, SECURED, TP, LN-Macro, Closed-End, and VIX. Descriptions for all variables can be found within the text. I also include the lag of the dependent variable to capture any potential mean-reversion. CDS and RR are country-specific, and SECURED is swap term-specific. Other variables are neither market nor term-specific. The sample is divided into pre-crisis, crisis, and post-crisis periods. (Phillips & Sul, 2007) bias-corrected parameter estimates are reported, and t-statistics using White's standard errors are displayed below the coefficients. ** and * indicate significance at the 5% and 10% levels, respectively. For each period, I estimate a panel regression with country fixed effects

Risk Categories	**Variables**	**Pre-Crisis** *(10 November 2006 - 8 August 2007)*				**Crisis** *(9 August 2007 - 31 March 2009)*				**Post-Crisis** *(1 April 2009 - 31 March 2010)*			
		SD - 3M		**LD - 2Y**		**SD - 3M**		**LD - 2Y**		**SD - 3M**		**LD - 2Y**	
		Coeff.	*t-stat*	*Coeff.*	*t-stat*	*Coeff.*	*t-stat*	*Coeff.*	*t-stat*	*Coeff.*	*t-stat*	*Coeff.*	*t-stat*
Global Funding	*UNSECURED*	-0.0312	-0.1878	0.0326	1.1925	0.1468	1.4493	0.1097	0.8074	0.4883	4.0432**	0.0634	0.7520
	SECURED	0.0561	1.1861	0.0143	0.5407	0.1812	3.0514**	0.0006	3.0177**	-0.0448	-0.3691	0.0109	0.1585
Global Liquidity	*FG-LIQ*	-0.0261	-0.3075	0.0106	0.7298	-1.4387	-2.4871**	-0.2462	-1.4731	-0.3276	-1.3963	-0.3125	-1.9457*
	FX-LIQ	0.0067	0.5954	-0.0002	-0.1255	-0.0083	-2.5579**	-0.0067	-1.6492*	-0.0079	-1.7041*	0.0014	0.3243
Global Macro	*TP*	0.0637	1.6596*	-0.0044	-0.7678	0.0467	0.5863	0.0206	0.9063	0.0107	0.3809	0.0178	0.9544
	LN-Macro	-0.0072	-1.2814	-0.0001	-0.1410	-0.0540	-1.3362	-0.0221	-1.9055*	0.0049	0.4612	-0.0010	-0.1344
Global Sentiment	*Closed-End*	0.1376	0.9521	-0.0596	-1.3373	-3.0670	-6.4977**	-0.8701	-6.5536**	-0.0658	-0.2176	-0.0111	-0.0515
	VIX	0.0015	1.0084	0.0000	0.0117	0.0063	1.8053*	0.0021	2.0609**	0.0015	1.9114*	0.0008	0.7165
Local	*RR-EUR*	0.0121	0.9733	0.0014	0.6488	-0.0016	-0.2192	0.0032	1.5103	0.0055	0.8455	-0.0004	-0.0791
	RR-JPY	-0.0052	-0.3422	-0.0013	-0.4847	0.0099	0.3056	0.0009	0.0978	0.0088	0.6729	-0.0032	-0.3541
	RR-GBP	-0.0118	-0.4713	-0.0007	-0.1615	-0.0548	-1.6258	0.0021	0.2145	-0.0111	-0.8373	-0.0165	-1.8412*
	CDS-EUR	-0.0021	-0.3274	0.0016	1.3941	-0.0013	-0.3073	0.0038	3.1681**	0.0015	0.9907	0.0028	2.5848**
	CDS-JPY	-0.0103	-0.6211	0.0013	0.4273	-0.0026	-0.6831	0.0013	1.1687	0.0011	1.1263	-0.0005	-0.7603
	CDS-GBP	0.0063	0.3783	0.0015	0.5367	-0.0048	-1.4375	0.0020	2.0989**	0.0010	1.3273	0.0013	2.5018**
Mean-Reversion	$SD(LD)_{j,t-1}$	-0.4592	-4.9026**	-0.1585	-3.6402**	-0.2126	-3.2374**	-0.3219	-5.2318**	-0.0121	-2.1563**	-0.0177	-2.2466**
R-squared			21%		18%		65%		60%		46%		38%

Table 5: CIRP Deviation Panel Regressions for Emerging Countries Using the Full Time Series

The panel includes both short- and long-term net deviations (with bid-ask spreads subtracted) of Turkey, South Africa, and Mexico. First-differences are taken to make the variables stationary. Global factors and local factors are used as regressors. Local factors include country-specific variables (RR and CDS). Global Factors include the following variables: FG-LIQ, FX-LIQ, UNSECURED, SECURED, TP, LN-Macro, Closed-End, and VIX. Descriptions for all variables can be found within the text. I also include the lag of the dependent variable to capture any potential mean-reversion. CDS and RR are country-specific, and SECURED is swap term-specific. Other variables are neither market nor term-specific. The sample is divided into pre-crisis, liquidity crisis, credit crisis, and post-crisis periods. (Phillips & Sul, 2007) bias-corrected parameter estimates are reported, and t-statistics using White's standard errors are displayed below the coefficients. ** and * indicate significance at the 5% and 10% levels, respectively. For each period, I estimate a panel regression with country fixed effects

Risk Categories	**Variables**	**Pre-Crisis** *(10 November 2006 - 8 August 2007)*				**Crisis** *(9 August 2007 - 31 March 2009)*				**Post-Crisis** *(1 April 2009 - 31 March 2010)*			
		SD - 3M		**LD - 2Y**		**SD - 3M**		**LD - 2Y**		**SD - 3M**		**LD - 2Y**	
		Coeff.	*t-stat*	*Coeff.*	*t-stat*	*Coeff.*	*t-stat*	*Coeff.*	*t-stat*	*Coeff.*	*t-stat*	*Coeff.*	*t-stat*
Global Funding	*UNSECURED*	0.3344	0.4126	0.0986	0.2850	-0.3040	-1.2764	0.0197	0.3231	0.5620	1.0654	0.7776	3.9257**
	SECURED	0.0556	0.3787	-0.1118	-1.5547	0.2998	2.2508**	0.9006	2.3569**	-0.6434	-1.2576	0.0458	0.3074
Global Liquidity	*FG-LIQ*	0.1824	0.4307	-0.1244	-0.6907	0.3184	0.2241	-0.1834	-0.4956	0.6620	0.6586	-0.0646	-0.1747
	FX-LIQ	-0.0306	-0.5343	0.0196	0.8154	0.0028	2.0781**	0.0307	3.5402**	-0.0511	-1.9149*	-0.0046	-0.4540
Global Macro	*TP*	-0.1239	-0.7371	-0.0047	-0.0647	-0.1532	-0.7758	0.0233	0.4578	0.0927	0.7114	-0.0406	-0.8886
	LN-Macro	0.0293	1.0094	-0.0207	-1.6021	-0.2103	-2.1244**	0.0132	0.5112	-0.0105	-0.2217	-0.0128	-0.7496
Global Sentiment	*Closed-End*	1.4369	0.9260	0.0602	0.1882	0.6883	0.5928	-0.2614	-0.8666	-0.5708	-0.4361	0.1293	0.2620
	VIX	-0.0016	-0.1778	0.0018	0.4979	0.0020	0.1761	0.0047	1.5358	-0.0038	-0.5381	-0.0017	-0.6477
Local	*RR-TRY*	-0.0239	-0.4519	-0.0099	-0.4402	-2.0041	-2.1227**	-0.0329	-3.8325**	-0.0488	-1.7683*	-0.0277	-1.9875**
	RR-ZAR	-0.1142	-1.7929*	-0.0023	-0.0868	-0.0024	-0.1734	-0.0089	-2.4474**	0.0000	0.0013	-0.0075	-1.7733*
	RR-MXN	-0.0288	-0.9174	-0.0147	-1.8101*	-0.0773	-4.9533**	-0.0071	-1.7040*	-0.0098	-0.3508	0.0007	0.0700
	CDS-TRY	-0.0021	-1.0845	-0.0009	-1.1110	-0.0006	-0.4999	0.0009	2.7813**	-0.0003	-0.1877	-0.0017	-2.5771**
	CDS-ZAR	0.0115	1.6509*	0.0003	0.0952	0.0030	1.9846**	0.0002	0.5574	0.0017	1.1647	0.0002	0.4375
	CDS-MXN	-0.0017	-0.3784	0.0002	0.1179	0.0025	1.8751*	0.0203	2.7586**	0.0021	1.6618*	0.0000	0.0068
Mean-Reversion	$SD(LD)_{j,t-1}$	-0.2032	-1.9812**	-0.0381	-2.3519**	-0.0403	-0.6901	-0.0109	-2.1767**	-0.0942	-1.9506*	-0.0163	-1.8880*
R-squared			19%		18%		58%		49%		28%		20%

Table 6: CIRP Deviation Panel Regressions for Developed Countries during Crisis Sub-Periods

The panel includes both short- and long-term net deviations (with bid-ask spreads subtracted) of the European euro market, the United Kingdom, and Japan. First-differences are taken to make the variables stationary. Global factors and local factors are used as regressors. Local factors include country-specific variables (RR and CDS). Global Factors include the following variables: FG-LIQ, FX-LIQ, UNSECURED, SECURED, TP, LN-Macro, Closed-End, and VIX. Descriptions for all variables can be found within the text. I also include the lag of the dependent variable to capture any potential mean-reversion. CDS and RR are country-specific, and SECURED is swap term-specific. Other variables are neither market nor term-specific. The crisis period is divided into liquidity crisis and credit crisis sub-periods. (Phillips & Sul, 2007) bias-corrected parameter estimates are reported, and t-statistics using White's standard errors are displayed below the coefficients. ** and * indicate significance at the 5% and 10% levels, respectively. For each period, I estimate a panel regression with country fixed effects.

Risk Categories	**Variables**	**Liquidity Crisis** *(9 August 2007 - 31 August 2008)*				**Credit Crisis** *(1 September 2008 - 31 March 2009)*			
		SD - 3M		**LD - 2Y**		**SD - 3M**		**LD - 2Y**	
		Coeff.	*t-stat*	*Coeff.*	*t-stat*	*Coeff.*	*t-stat*	*Coeff.*	*t-stat*
Global Funding	*UNSECURED*	0.0816	0.7092	-0.0086	-0.4316	0.1901	1.3897	0.1501	0.6629
	SECURED	0.1171	2.2199**	0.0484	1.6982*	0.1638	1.9226*	0.0151	3.3393**
Global Liquidity	*FG-LIQ*	-0.8434	-0.1014	-0.1418	-2.2241**	-6.0062	-4.6859**	-0.6980	-1.7602*
	FX-LIQ	-0.0140	-2.4953**	-0.0091	-2.1241**	-0.0109	-0.5891	-0.0089	-1.4733
Global Macro	*TP*	0.0403	0.5357	-0.0149	-1.2458	-0.0516	-0.4451	0.0256	0.7328
	LN-Macro	-0.0094	-0.3609	0.0010	0.2358	-0.0141	-0.1748	-0.0347	-1.7404*
Global Sentiment	*Closed-End*	0.5205	0.8666	-0.0891	-0.9011	-3.2143	-4.8490**	-0.9323	-4.7822**
	VIX	0.0034	2.0656**	-0.0005	-1.0812	0.0076	1.7220*	0.0031	1.9725*
Local	*RR-EUR*	-0.0272	-1.3602	-0.0020	-0.6394	-0.0010	-0.1069	0.0032	1.1573
	RR-JPY	-0.0197	-0.4472	0.0115	1.6097	-0.0087	-0.2104	-0.0044	-0.3412
	RR-GBP	-0.0503	-0.9909	0.0039	0.4847	-0.0802	-1.8695*	-0.0002	-0.0150
	CDS-EUR	0.0090	-0.6630	-0.0017	-0.8153	-0.0010	-0.1991	0.0041	1.6700*
	CDS-JPY	-0.0006	-0.0945	0.0001	0.0484	0.0038	0.8287	0.0014	0.9811
	CDS-GBP	-0.0024	-0.3689	0.0000	-0.0235	0.0046	1.7378*	0.0023	1.8591*
Mean-Reversion	$SD(LD)_{j,t-1}$	-0.1742	-1.6512*	-0.0725	-1.6930*	-0.2130	-2.5450**	-0.3615	-4.4338**
Adjusted R-squared			39%		34%		77%		68%

Table 7: Separate Regressions for Short-Term CIRP Deviations in Developed Countries

Regressions are run using weekly changes in absolute short-term CIRP deviations (SD) in the European euro market, the United Kingdom, and Japan as the dependent variable. The regression covers the credit crisis period. First-differences are taken to make the variables stationary. I regress CIRP deviations on a number of explanatory variables that fall into different risk categories. The Liquidity Risk category includes the variables FX-Liq and FG-Liq; the Global Funding Risk category includes Unsecured and Secured; the Global Macro category includes LN-Macro and TP; and the Sentiment category includes Closed-End and VIX. Definitions for each variable can be found within the text of the paper. I regress CIRP deviations on each risk category separately.(Phillips & Sul, 2007) bias-corrected parameter estimates are reported, and t-statistics using White's standard errors are displayed below the coefficients. ** and * indicate significance at the 5% and 10% levels, respectively.

Risk Categories	**Variables**	**Specifications on Credit Crisis (1 September 2008 - 31 March 2009)**											
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Global Funding	UNSECURED	0.1433	0.3526	0.2617	-0.0974	0.1397	0.1385						
		1.1362	2.8965**	1.2750	-0.8136	1.0744	1.0734						
	SECURED	0.2358	0.1950	0.2026	0.3515	0.2397	0.2452						
		2.6797**	2.3952**	2.4137**	2.8972**	1.9656**	1.8894*						
Global Liquidity	FG-Liq		-10.2423										-7.8810
			-4.7846**										-3.7161**
	FX-Liq		-0.0152										00168
			-0.6132										0.7222
Global Macro	TP			0.0146								-0.1891	
				0.0782								-1.4531	
	LN-Macro			0.2616								0.2071	
				1.6708*								1.3628	
Global Sentiment	Closed-End				-4.4611						-4.0369		
					-5.3374**						-4.7766**		
	VIX				-0.0091						-0.0070		
					-1.8291*						-1.9361*		
Local	RR-EUR					-0.0005				0.0028			
						-0.0342				0.2074			
	RR-JPY					0.0204				0.0408			
						0.3232				0.6407			
	RR-GBP					-0.0580				-0.0460			
						-0.9274				-1.7262*			
Local Risk	CDS-EUR						0.0007		0.0008				
							0.0781		0.0942				
	CDS-JPY						0.0052		0.0050				
							0.7352		0.7017				
	CDS-GBP						-0.0020		-0.0021				
							-1.7642*		-1.3291				
Mean Reversion	Z_(t-1)							-0.3023					
								-2.9908**					
R-squared		15%	35%	20%	37%	16%	11%	14%	4%	6%	19%	3%	17%

Table 8: CIRP Deviation Panel Regressions for Emerging Countries during Crisis Sub-Periods

The panel includes both short- and long-term net deviations (with bid-ask spreads subtracted) of Turkey, South Africa, and Mexico. First-differences are taken to make the variables stationary. Global factors and local factors are used as regressors. Local factors include country-specific variables (RR and CDS). Global Factors include the following variables: FG-LIQ, FX-LIQ, UNSECURED, SECURED, TP, LN-Macro, Closed-End, and VIX. Descriptions for all variables can be found within the text. I also include the lag of the dependent variable to capture any potential mean-reversion. SECURED is swap term-specific. Other variables are neither market nor term-specific. The crisis period is divided into liquidity crisis and credit crisis sub-periods. (Phillips & Sul, 2007) bias-corrected parameter estimates are reported, and t-statistics using White's standard errors are displayed below the coefficients. ** and * indicate significance at the 5% and 10% levels, respectively. I estimate a panel regression with country fixed effects.

Risk Categories	**Variables**	**Liquidity Crisis** *(9 August 2007 - 31 August 2008)*				**Credit Crisis** *(1 September 2008 - 31 March 2009)*			
		SD - 3M		**LD - 2Y**		**SD - 3M**		**LD - 2Y**	
		Coeff.	*t-stat*	*Coeff.*	*t-stat*	*Coeff.*	*t-stat*	*Coeff.*	*t-stat*
Global Funding	*UNSECURED*	0.1615	0.6805	0.1730	1.8958*	-0.5753	-1.6979*	0.0015	0.0174
	SECURED	0.1190	2.0996**	-0.2726	-1.9411*	0.1076	0.4773	-0.1174	-1.2272
Global Liquidity	*FG-LIQ*	-0.5233	-0.6222	-0.4539	-1.5322	-0.7013	-0.2095	-0.2674	-0.3123
	FX-LIQ	-0.0049	-0.0831	0.0045	0.2290	0.0113	0.2391	-0.0283	-2.5528**
Global Macro	*TP*	0.2340	2.4348**	0.1402	2.4096**	-0.2610	-0.8628	-0.0270	-0.3567
	LN-Macro	0.0809	1.5127	-0.0044	-0.2314	-0.6335	-3.0309**	-0.3514	-2.9572**
Global Sentiment	*Closed-End*	0.4977	0.4078	-0.4192	-0.9523	0.3728	0.2159	0.0574	0.1315
	VIX	-0.0051	-0.6617	-0.0001	-0.0318	0.0065	0.3349	0.0081	1.5354
Local	*RR-TRY*	-0.0760	-2.2981**	-0.0145	-0.7171	-0.0028	-2.0659**	-0.0319	-2.9364**
	RR-ZAR	-0.0373	-1.9655**	-0.0067	-0.5707	-0.0031	-0.1735	-0.0094	-2.0696**
	RR-MXN	0.0281	0.7393	0.0150	1.0793	0.0762	3.6918**	-0.0095	-1.7480*
	C̃DS-TRY	0.0022	0.8156	0.0002	0.1867	-0.0011	-0.6578	-0.0011	-2.4364**
	CDS-ZAR	0.0021	0.6185	-0.0006	-0.4711	0.0026	2.2967**	0.0001	0.1894
	CDS-MXN	-0.0030	-0.7355	0.0001	0.0592	0.0022	3.2911**	-0.0003	-1.7228*
Mean-Reversion	$SD(LD)_{j,t-1}$	-0.3692	-3.4878**	-0.1673	-1.6579*	-0.0143	-1.7911*	-0.0119	-1.7468*
Adjusted R-squared			33%		30%		66%		54%

Table 9: Separate Regressions for Short-Term CIRP Deviations in Emerging Countries

Regressions are run using weekly changes in absolute short-term CIRP deviations (SD) in Turkey, South Africa, and Mexico as the dependent variable. The regression covers the 7 months in the credit crisis period (from September 1, 2008 to March 31, 2009). First-differences are taken to make the variables stationary. I regress CIRP deviations on a number of explanatory variables that fall into different risk categories. Definitions for each variable can be found within the text of the paper. I regress CIRP deviations on each risk category separately. (Phillips & Sul, 2007) bias-corrected parameter estimates are reported, and t-statistics using White's standard errors are displayed below the coefficients. ** and * indicate significance at the 5% and 10% levels, respectively.

Risk Categories	**Variables**	**Specifications on Credit Crisis (1 September 2008 - 31 March 2009)**											
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Global Funding	UNSECURED	-0.0343	-0.1273	-0.7287	-0.2859	-0.1779	-0.0794						
		-1.8164*	-2.1158**	-1.9549**	-1.7405*	-1.9188*	-2.2851**						
	SECURED	0.0398	0.0821	0.2023	-0.0466	0.1708	-0.0517						
		0.1213	0.2245	0.6181	-0.1455	0.5388	-0.1726						
Global Liquidity	FG-Liq		4.6861										3.9030
			0.8364										0.7546
	FX-Liq		-0.0029										-0.0017
			-0.0439										-0.0297
Global Macro	TP			-0.4248								0.0558	
				-0.9941								0.1913	
	LN-Macro			-0.8699								-0.6985	
				-2.4339**								-2.0495**	
Global Sentiment	Closed-End				3.4255						3.6403		
					1.5516						1.4986		
	VIX				0.0483						0.0441		
					1.1750						1.3726		
Local	RR-TRY					-0.0022				-0.0043			
						-2.0413**				-3.2840**			
	RR-ZAR					0.0133				0.0118			
						0.7385				0.6834			
	RR-MXN					0.0972				0.0968			
						4.5124**				4.5538**			
Local	CDS-TRY						-0.0004		-0.0005				
							-0.2518		-0.3007				
	CDS-ZAR						0.0028		0.0027				
							2.5097**		2.4498**				
	CDS-MXN						0.0050		0.0049				
							2.9112**		2.8621**				
Mean Reversion	Z_(t-1)							-0.0361					
								-2.3407**					
R-squared		8%	18%	28%	20%	27%	30%	12%	15%	16%	4%	14%	3 %

Table 10: Price Discovery Analysis

This table summarizes the results of price discovery regressions between the short- and long-term CIRP deviations for the entire period. Separate regressions are run for each country. The tests are based on a VECM specification, where SD (3 months) and LD (2 years) CIRP deviations, respectively, and u_{1t} and u_{2t} are error terms. I impose the restrictions that $c_1 = 1$. The regressions are run using the optimal number of lags, which is determined by the AIC. Only the coefficients for A1 and A2 are displayed in the table, and t-statistics are shown immediately below the coefficients. H_x and H_y are the Hasbrouck bounds. HM, which captures the contribution of short term CIRP deviations to long term CIRP deviations, is the arithmetic mean of the two Hasbrouck measures. The VECM is specified as follows:

$$\Delta SD_t = A1(SD_{t-1} - c_1 LD_{t-1}) + \sum_{n=1}^{N} \phi_{1n} \Delta SD_{t-n} + \sum_{n=1}^{N} \gamma_{1n} \Delta LD_{,t-n} + u_{1t}$$

$$\Delta LD_t = A2(SD_{t-1} - c_1 LD_{t-1}) + \sum_{n=1}^{N} \phi_{2n} \Delta SD_{t-n} + \sum_{n=1}^{N} \gamma_{2n} \Delta LD_{t-n} + u_{2t}$$

	EUR						**GBP**					
	Pre- Crisis		Crisis		After Crisis		Pre- Crisis		Crisis		After Crisis	
	A1	A2	A1	A2	A1	A2	A1	A2	A1	A2	A1	A2
	-1.38	-0.13	-0.73	0.03	0.06	0.08	-0.91	0.01	-0.78	0.04	-0.64	0.11
	[-1.06]	[-0.63]	[-1.15]	[-2.89]	[0.96]	[3.95]	[-0.83]	[1.76]	[-1.06]	[3.54]	[-1.31]	[2.75]
H_x	0.02		0.74		0.99		0.57		0.81		0.58	
H_y	0.04		0.85		0.94		0.74		0.57		0.62	
HM	0.03		0.80		0.97		0.66		0.68		0.60	
	JPY						**TRY**					
	Pre- Crisis		Crisis		After Crisis		Pre- Crisis		Crisis		After Crisis	
	A1	A2	A1	A2	A1	A2	A1	A2	A1	A2	A1	A2
	-0.10	-0.13	-0.75	0.04	-0.68	0.07	-0.03	-0.10	-0.36	-0.16	-0.72	0.15
	[-0.61]	[-0.79]	[-0.89]	[1.79]	[-0.52]	[1.49]	[-0.17]	[-0.57]	[-2.11]	[2.81]	[-1.59]	[1.34]
H_x	0.15		0.97		0.59		0.99		0.42		0.25	
H_y	0.65		0.55		0.89		1.00		0.35		0.41	
HM	0.40		0.76		0.76		1.00		0.38		0.33	
	MXN						**ZAR**					
	Pre- Crisis		Crisis		After Crisis		Pre- Crisis		Crisis		After Crisis	
	A1	A2	A1	A2	A1	A2	A1	A2	A1	A2	A1	A2
	-0.75	-0.24	-0.63	-0.45	-0.11	0.07	-0.02	0.24	-0.24	-0.41	0.01	-0.01
	[-1.48]	[-0.47]	[-4.26]	[-2.16]	[-0.73]	[1.45]	[-0.11]	[1.37]	[-1.99]	[2.39]	[0.46]	[-0.21]
H_x	0.31		0.70		0.57		0.87		0.22		0.09	
H_y	0.39		0.84		0.42		1.00		0.07		0.08	
HM	0.35		0.77		0.50		0.93		0.15		0.9	

Table 11: Volatility Spillover Table

This table presents the directions of volatility spillovers in both developed and emerging markets during each subsample period. Both Garch-BEKK and Garch-DCC methods are used. SD is for short-term deviations, and LD is for long-term deviations in the covered interest rate parity condition; and for Garch-DCC it is the correlation values between short-term and long-term deviations significant at 1% only during each subsample period.

Developed Countries

	EUR		**GBP**		**JPY**	
	BEKK	**DCC**	**BEKK**	**DCC**	**BEKK**	**DCC**
Before Crisis						
Crisis	*SD to LD*	*0.45*	*SD to LD*		*SD to LD*	*0.42*
After Crisis	*SD to LD*	*0.45*	*Two-Way*	*0.27*	*SD to LD*	*0.37*

Emerging Markets

	MXN		**TRY**		**ZAR**	
	BEKK	**DCC**	**BEKK**	**DCC**	**BEKK**	**DCC**
Before Crisis						
Crisis	*Two-way*	*0.18*	*Two-way*		*Two-way*	
After Crisis						

Table 12: Garch-BEKK Results for Developed Markets

	Before Crisis		**Crisis**		**After Crisis**	
Japan	**t-value**	**Prob.**	**t-value**	**Prob.**	**t-value**	**Prob.**
Arch(1,1,1)	2.95	0.00	10.38	0.00	7.96	0.00
Arch(1,2,1)	-0.11	0.92	0.70	0.48	2.40	0.02
Arch(1,1,2)	-0.33	0.74	2.32	0.02	-0.03	0.98
Arch(1,2,2)	2.55	0.01	3.57	0.00	7.96	0.00
Garch(1,1,1)	10.14	0.00	30.85	0.00	42.21	0.00
Garch(1,2,1)	-1.22	0.22	2.33	0.02	-4.02	0.00
Garch(1,1,2)	0.43	0.67	0.86	0.39	0.73	0.47
Garch(1,2,2)	13.74	0.00	89.45	0.00	22.73	0.00
EUR	**t-value**	**Prob.**	**t-value**	**Prob.**	**t-value**	**Prob.**
Arch(1,1,1)	6.66	0.00	6.35	0.00	9.93	0.00
Arch(1,2,1)	-0.41	0.68	1.30	0.20	2.64	0.01
Arch(1,1,2)	0.10	0.92	5.61	0.00	0.32	0.75
Arch(1,2,2)	3.39	0.00	7.28	0.00	6.08	0.00
Garch(1,1,1)	15.83	0.00	24.77	0.00	19.98	0.00
Garch(1,2,1)	0.02	0.98	-5.87	0.00	-3.28	0.00
Garch(1,1,2)	0.06	0.96	0.20	0.84	0.39	0.69
Garch(1,2,2)	-0.01	0.99	33.41	0.00	25.85	0.00
United Kingdom	**t-value**	**Prob.**	**t-value**	**Prob.**	**t-value**	**Prob.**
Arch(1,1,1)	3.53	0.00	6.99	0.00	-2.01	0.05
Arch(1,2,1)	-1.21	0.23	2.94	0.00	-8.84	0.00
Arch(1,1,2)	-0.98	0.33	7.24	0.00	6.21	0.00
Arch(1,2,2)	3.88	0.00	8.41	0.00	7.04	0.00
Garch(1,1,1)	8.19	0.00	32.51	0.00	13.19	0.00
Garch(1,2,1)	2.14	0.03	-6.45	0.00	8.22	0.00
Garch(1,1,2)	0.99	0.32	0.08	0.94	-7.82	0.00
Garch(1,2,2)	6.68	0.00	56.24	0.00	7.81	0.00

* Significance is at 1% level

Table 13: Garch-BEKK Results for Emerging Markets

	Before Crisis		**Crisis**		**After Crisis**	
Mexico	**t-value**	**Prob.**	**t-value**	**Prob.**	**t-value**	**Prob.**
Arch(1,1,1)	3.46	0.00	17.56	0.00	2.47	0.01
Arch(1,2,1)	3.01	0.00	-2.26	0.02	2.65	0.01
Arch(1,1,2)	0.34	0.74	4.50	0.00	-1.14	0.26
Arch(1,2,2)	7.66	0.00	14.37	0.00	6.68	0.00
Garch(1,1,1)	-0.91	0.37	50.96	0.00	35.05	0.00
Garch(1,2,1)	0.39	0.70	3.92	0.00	1.63	0.11
Garch(1,1,2)	-1.29	0.20	-9.40	0.00	-0.56	0.57
Garch(1,2,2)	5.63	0.00	54.01	0.00	27.39	0.00
Turkey	**t-value**	**Prob.**	**t-value**	**Prob.**	**t-value**	**Prob.**
Arch(1,1,1)	0.63	0.53	10.06	0.00	6.08	0.00
Arch(1,2,1)	-0.12	0.91	-3.20	0.00	1.05	0.30
Arch(1,1,2)	3.14	0.00	5.15	0.00	0.64	0.53
Arch(1,2,2)	0.02	0.98	16.07	0.00	6.56	0.00
Garch(1,1,1)	7.97	0.00	33.35	0.00	16.85	0.00
Garch(1,2,1)	-0.07	0.94	3.93	0.00	-2.20	0.03
Garch(1,1,2)	0.20	0.84	-3.33	0.00	-1.31	0.19
Garch(1,2,2)	3.62	0.00	70.36	0.00	12.63	0.00
South Africa	**t-value**	**Prob.**	**t-value**	**Prob.**	**t-value**	**Prob.**
Arch(1,1,1)	0.75	0.45	8.73	0.00	5.96	0.00
Arch(1,2,1)	-0.76	0.45	-4.32	0.00	2.03	0.04
Arch(1,1,2)	2.88	0.00	1.01	0.31	2.97	0.00
Arch(1,2,2)	6.56	0.00	15.24	0.00	11.40	0.00
Garch(1,1,1)	1.88	0.06	55.69	0.00	10.96	0.00
Garch(1,2,1)	-0.55	0.58	4.24	0.00	-2.03	0.04
Garch(1,1,2)	-0.49	0.62	0.59	0.56	-0.70	0.48
Garch(1,2,2)	39.41	0.00	73.59	0.00	58.71	0.00

* Significance is at 1% level

Chapter II

THE IMPACT OF POLICY DECISIONS ON CIRP DEVIATIONS

The clearest causes of the recent financial crisis are the housing bubble and the subprime lending boom (Beachy, 2012). Overvaluation in the U.S. housing market and the subsequent crash set off a series of events that caused liquidity to dry up across the globe. In this paper, I evaluate the impact that policies adopted by the Federal Reserve, and the U.S. Treasury had on international funding liquidity during the recent financial crisis. Also, I examine the impact of important financial and economic news events, such as write-down announcements on U.S. financial institutions and the Lehman Brothers bankruptcy announcement, on international liquidity. To perform the study, I examine the impact of Fed and Treasury liquidity interventions, lending facilities, stress tests, and asset purchase programs on the dynamics of covered interest rate parity ($CIRP$) violations.

I find that a number of programs instituted by the Fed and the U.S. Treasury resulted in the compression of $CIRP$ deviations. Results support the anecdotal evidence that the Fed's provision of liquidity to global markets and its freeing funding markets from uncertainty were successful in relieving market frictions in foreign exchange (FX) markets. I also find that these unconventional policies reduced $CIRP$ deviations for both developed and emerging markets, but that the response of $CIRP$ to these policies differed significantly across different markets and maturities. Taken as a whole, I find evidence that funding markets are responsive to governmental programs that target credit risk in financial markets, but that the impact of these policies differs across economies.

From 2007 to 2009, the Federal Reserve implemented a variety of programs that were aimed at different market risk exposures. The first Fed policies were intended to addressing illiquidity in financial markets. The first significant step in addressing liquidity issues was the Federal Reserve's Term Auction Facility (TAF) program, which was initiated on December 12, 2007. The TAF program encouraged depository institutions to access short-term funds through competitive auctions. A variety of financial assets were able to be used as collateral for these loans. As is discussed in Bernanke (2009), the TAF program's primary goal was to provide an accessible source of liquidity via the central bank.

With the growing concern over liquidity, the Federal Reserve later attacked funding market tightness (unsecured and secured) by announcing the creation of the Term Securities Lending Facility (TSLF) on March 11, 2008. Its primary objective was to meet the high global demand for USD. Aizenman & Pasricha (2009) argue that emerging markets with high US bank and trade exposures were the main targets of swap lines. The Fed was not alone in initiating policy programs. According to BIS, 2010, both European and emerging countries took action. As such, ECB and the Swiss National Bank opened swap lines, and central banks of Turkey and Brazil injected foreign currency into the market by shorting the USD through repo auctions and currency swaps. In addition, while South Korea primarily channeled the USD supply through FX swap auctions, Mexico undertook direct USD sales.

With the collapse of Lehman Brothers in September 2008, the crisis transformed the U.S.-based European funding problem into a large-scale global phenomenon. Hence, as heightened uncertainty over capital allocation and collateral values continued to threaten bank loan operations, the Federal Reserve began to take actions addressing rising credit concerns in global financial markets. As such, Krishnamurthy, 2010 argues that the Federal Reserve replaced arbitrageurs when it came to providing liquidity to the market. The interventions during the post-Lehman period, however,

were not the only attempts at reducing dislocations in swap markets. The Federal Reserve also addressed the heightened "uncertainty" risk in the market by making positive public announcements and releasing stress tests from February to May of 2009. The primary objective of these actions was to boost the confidence of market agents.

Recent literature is divided on the impact of the effectiveness of Fed interventions during the crisis. For instance, Coffey et al. (2009) argue that swap lines were effective in reducing $CIRP$ deviations before the Lehman collapse, but that they were mostly unsuccessful with the outbreak of heightened counterparty risk. Griffoli & Ranaldo (2011) also argue that the central bank swap line announcements were ineffective at reducing $CIRP$ deviations following the Lehman collapse. Furthermore, Aizenman & Pasricha (2009) find that the Fed swap lines had a significant impact on the exchange rates of emerging markets but had little effect on their CDS spreads. On the other hand, McAndrews, Sarkar, & Wang (2008), Christensen, Lopez, & Rudebusch (2009), and Goldberg, Kennedy, & Miu (2010) support the notion that the measures have been effective.

The analysis adds to the significant discussion on the effectiveness of Fed policies during the recent financial turmoil. Results indicate that Fed policies were effective at facilitating international funding liquidity for both developed and emerging markets. Furthermore, the unconventional policies have taken on by the U.S. Treasury also led to the compression of $CIRP$ deviations. I also find that funding liquidity is impacted by both positive and negative macro news, but that the immediate effect is primarily isolated to developed markets.

2.1 Theoretical Framework

2.1.1 Covered Interest Rate Parity

Covered Interest Rate Parity is an economic argument that is used to calculate forward foreign exchange rates. It states that the return of lending one unit of local currency must be equal to converting that one unit of local currency to foreign currency in the spot market, lending it in foreign rate, and converting it back to local currency with an agreed forward rate in the maturity. It must be noted that this condition requires the following assumptions: (i) there is a sufficient amount of investment in the market, (ii) there is perfect financial mobility without capital controls, and (iii) transaction costs and default risks are negligible. Based on Tuckman & Porfirio (2003), I shall define the following variables:

S_0: Spot exchange rate of local currency per unit of foreign currency r: T-year default free local spot interest rate $\tilde{r}$: T-year default free foreign spot interest rate F: Forward exchange rate of local currency per unit of foreign currency for delivery in T years.

Let me denote local currency as LC, and foreign currency as FC. Assuming that throughout the period there is no counterparty default risk in forwards or swap contracts, I may consider the following transactions at t=0:

Transactions	**Today (LC)**	**Time T (LC)**	**Today (FC)**	**Time T (FC)**
Borrow S_0 LC	$+S_0$	$-S_0(1+r)^T$		
Sell S_0 LC, buy 1 FC	$-S_0$		+1	
Invest FC			-1	$(1+\tilde{r})^T$
Sell foreign forward		$F(1+\tilde{r})^T$		$-(1+\tilde{r})^T$
TOTAL	0		0	0

According to the no-arbitrage argument, since these transactions do not produce cash today, they should not produce any cash at time T as well. Hence, I may write

the following expression:

$$S_0(1+r)^T = F(1+\tilde{r})^T$$

or, similarly,

$$SD = F(1+\tilde{r})^T - S_0(1+r)^T \tag{8}$$

However, the default-free interest rates are often not observable in the market, so that I can observe short term deviation as SD. As Feldhütter & Lando (2008) suggests the market participants use spot rates implied from swap rates as the benchmark risk-free rate.

In this context, a positive deviation indicates that it is cheaper to borrow at the foreign risk-free rate than the US risk-free rate. In normal circumstances, a deviation from the $CIRP$ condition could be arbitraged by borrowing a unit of foreign currency, converting it to USD at the spot rate, lending the dollar, and buying back the original foreign currency in the forward swap market. Thus, arbitragers should eventually drive $CIRP$ deviations back to zero. Nevertheless, as Goldberg et al. (2010) point out, arbitragers were unable to take advantage of $CIRP$ deviations during the recent subprime crisis due to a shortage of USD lending.[1] In addition, Shleifer & Vishny 1997) suggest that arbitragers may avoid volatile arbitrage positions even if these positions present attractive returns, as volatility exposes arbitragers to the potential for huge losses and may create the need to liquidate a position.[2]

[1]Grossman & Stiglitz (1976) note the arbitrage paradox: If arbitrage is never observed, market participants may not have sufficient incentives to watch the market, in which case arbitrage opportunities could arise.

[2]M. P. Taylor (1989) argues that during turbulent periods, long-term arbitrage possibilities tend to occur following short term arbitrage opportunities.

2.1.2 Swap Markets

Short Date CIRP and FX Swap Markets

Foreign exchange swaps (FX swaps) are transactions in which a party simultaneously borrows one currency and lends another at the current spot exchange rate with an agreement to reverse the transaction at a specified future date and forward exchange rate. Thus, FX swaps have two main components: a spot FX trade and a forward trade. At terms shorter than one year, FX swaps are highly liquid. Thus, I use FX swaps to examine short-date $CIRP$ violations.

Long Term CIRP and Cross-Currency Basis Swap Spreads

In a cross currency basis swap, a party borrows one currency from a counterparty and simultaneously lends another currency to the counterparty. The parties agree to exchange the original principal of each currency at maturity, which is typically a period of 1 to 30 years. While this is similar to a foreign exchange swap, there is also a period exchange of two floating-rate payments denominated in the separate currencies.[3] A premium, or *basis*, is often subtracted from the riskier currency's interest rate. Because the cross-currency swap market is considerably more liquid than the long term FX swap market, I follow the existing $CIRP$ literature and use cross-currency basis swap spreads to test the long-term covered interest rate parity condition.(LD, as long term deviation) [4]

What determines the LD for a given maturity of basis swap? Below I discuss the theoretical link across the different maturities of CIRP condition.

[3]Duffie & Huang (1996) argue that currency swaps carry a greater level of default risk than interest rate swaps.

[4]Amatatsu & N. (2008) note that the basis may reflect a default risk premium between lenders and borrowers or a default risk premium between currencies. However, they also note that the majority of the long-term interest rate parity literature uses the basis to measure deviations from CIRP.

Assume that S_t is the spot rate (dollar per unit of foreign currency), $r^d_{t,T}$ is the T-year usd zero-coupon swap rate, $r^f_{t,T}$ is T-year foreign zero-coupon swap rate, $F_{t,T}$ is the T-year forward exchange rate, and X is a finite value such that any swap rate of 3-month local LIBOR plus X trades fair against 3-month foreign LIBOR. Therefore, the time T local payoff in a no-arbitrage environment can be expressed as follows:

$$S_t \left[\left(1 + \frac{X}{S_t} \right) (1 + r^d_{t,T})^T - \frac{X}{S_t} \right] = F_{t,T}(1 + r^f_{t,T})^T$$

As opposed to the unobservable default rates, the new equality depends on swap rates and cross-currency market basis swap spreads. With algebraic arrangements, I may express the new equality as follows:

$$F_{t,T} = S_t \frac{(1 + r^d_{t,T})^T}{(1 + r^f_{t,T})^T} \left[1 + PV(X) \right]$$

where $PV(X)$ is the present value of X, or in other words, the price of the cross currency basis swap. As shown previously, the deviation in covered interest rate parity is represented as follows:

$$\text{Deviation} = F_{t,T}(1 + r^f_{t,T})^T - S_t(1 + r^d_{t,T})^T$$

I may then claim:

$$\text{Deviation} = F_{t,T}(1 + r^f_{t,T})^T - S_t(1 + r^d_{t,T})^T = S_t(1 + r^d_{t,T})PV(X)$$

$$LD = \underbrace{\frac{F_{bid}(t,T)}{X_{ask}(t)} \frac{(1 + r^d_{bid}(t,T))^T}{(1 + r^e_{ask}(t,T))^T} - 1}_{CIRP\ Deviation}$$

I know that in arbitrage-free economy covered interest rate parity holds. This will force the price of basis swaps across different maturities to be zero. If there

is any deviation, an arbitrageur will bridge this disconnection across the different maturity markets by incorporating information about current and future short and forward rates into the basis prices. Thus, the term structure of CIRP may exhibit extreme segmentation and would evolve independently of other maturities in the case of restrictions for arbitrageurs. Also, when arbitrageurs are risk averse, shocks to investor demands for specific-maturity basis swaps affect the price of basis. This leads to the additional determinants of basis prices to current and expected future spot and forward rates. Understanding how demand shocks manifest themselves in the cross-section of maturities of short term FX swap and long term basis swaps are central to my analysis.

2.2 Data

Data on spot rates, forward rates and interest rates are provided by BNP Paribas. The dataset includes information on three emerging market currencies (Turkey, Mexico, and South Africa) and three developed market currencies (Euro, United Kingdom, and Japan). Dataset spans from August 9, 2007 through March 31, 2010. Thus, the data begins at the onset of the financial crisis and continues into the post-crisis period.

I examine the short-date covered interest rate parity condition using 1 week and 3-month interbank offer rates of corresponding currencies, spot exchange rates, and forward swap levels.[5] Short-term deviations from the covered interest rate parity condition are computed according to Eq. (8). Deviations in long-term covered interest rate parity are represented by 1, 2, and 5 year cross currency basis swap spreads, or in other words, the basis.

[5]FX swaps are denominated in points, called swap points, which are the difference between forward price and spot rate. By convention, all of the spot exchange rates are quoted with four decimals, except for the Japanese yen, where two decimals are used. Cross currency swaps are expressed in terms of 'spreads' relative to a benchmark rate.

In Tables 14 and 15, I report summary statistics for magnitudes of $CIRP$ deviations in developed and emerging markets, and in Figures 9 and 10 show the time-varying graphs respectively. I break the summary statistics for my sample into three subperiods: the liquidity crisis, the credit crisis, and the post-credit crisis. Following J. B. Taylor & Williams (2009), I define August 9, 2007, as the starting date of the crisis period. The first subperiod that I define is the liquidity crisis, which spans from the start of the crisis to August 31, 2008. The second subperiod, the crisis period, is defined to include the September 2008 collapse of Lehman Brothers and its aftermath. The last subperiod, the post-credit crisis period, begins on April 1, 2009, and ends on March 31, 2010. The subperiods are summarized as follows:

1. Liquidity Crisis: August 9, 2007 - August 31, 2008
2. Credit Crisis: September 1, 2008 - March 31, 2009
3. Post-Credit Crisis: April 1, 2009 - March 31, 2010

I can see from the tables that $CIRP$ deviations in emerging tend to be larger than those in developed markets. In addition, I can see that the deviations for each country in developed and emerging markets are higher during the credit crisis period than they are in the liquidity crisis and post-crisis periods.

To understand the effects of economic news and policy programs, I create an extensive database that tracks the most important financial and political news that occurred around the financial crisis. I build my database by classifying and aggregating economic news and policy announcements into 8 types of events:

1. Write-down announcements of U.S. financial institutions (WRD)
2. News on Lehman Brothers (L)
3. Fed Swap Lines to developed and emerging markets (SWAP)

4. Fed direct interventions via its balance sheet (FED)

5. Treasury direct interventions via its balance sheet (TRE)

6. Stress Tests on US financial institutions (STRESS)

7. Positive Macro announcements from the US (MACRO+)

8. Negative Macro announcements from the US (MACRO-).

In total, I identify 216 financial and political news events originating from the US from 2007 to early 2010.[6] Table 16 provides a brief summary of these policy events and also gives an example of a news event or announcement. It also displays the number of events that occur during each of the crisis subperiods that were defined previously. Also through tables 18 to 25, I provided the related classified events with their dates. It can be seen that all of the write down announcements (WRD) occur during the liquidity crisis sub-period. News on Lehman Brothers, Fed swap lines, Fed interventions through its balance sheet, and positive macro news all occur in each of the sub-periods. Finally, Treasury interventions through its balance sheet, bank stress tests, and negative macro news are isolated to the second and third sub-periods of my sample.

In figure 9 and 10, I display the time series of short and long-term $CIRP$ deviations for developed and emerging markets. It can be seen from the figures that $CIRP$ deviations began to increase during the liquidity crisis. Short- and long-term deviations reached their maximum levels in the fourth quarter of 2008, around the Lehman collapse and its aftermath. The figures also show that emerging economies tend to reach their maximum deviations *after* their developed counterparts. This pattern is consistent with the findings of Dooley & Hutchison (2009), who find that

[6]Similar to Dooley & Hutchison (2009), I used the crisis timeline of an official source (the Federal Reserve Bank of Saint Louis) and a market source (Bloomberg), and beyond I also collected the news from various channels, such as fdic.com/bank; creditwritedowns.com; BBC.co.uk report on crisis, FT special report on Financial crisis via web, at 12/08 and BIS paper of (Borio, 2008)

emerging markets were partly decoupled from the U.S.-centric turmoil from 2007 to mid-2008.

2.3 Empirical Analysis

In this section, I investigate the impact that financial policy and economic news events had on international funding liquidity by examining the dynamics of $CIRP$ violations. To examine the impact of economic news and policy programs on $CIRP$ deviations, I employ a regression-based event study using the following regression model:

$$\begin{aligned}\Delta CIRP^m_{t,j} = \alpha^m_j &+ \beta^m_{1,j} WRD + \beta^m_{2,j} L + \beta^m_{3,j} SWAP + \beta^m_{4,j} FED \\ &+ \beta^m_{5,j} TRE + \beta^m_{6,j} STRESS_t + \beta^m_{7,j} (MACRO+) \\ &+ \beta^m_{8,j} (MACRO-) + \beta^m_{9,j} \Delta CIRP_{t-1,j} \end{aligned} \tag{9}$$

where $\Delta CIRP^m_{t,j}$ is the weekly change in the $CIRP$ deviation for country j and maturity m. Each event, which is defined in the data section, is treated as a dummy variable that equals 1 on the day of the announcement and 0 otherwise. I include lagged $CIRP$ deviations as a dependent variable to absorb any residual autocorrelation. Table 17 summarizes the results. I find strong evidence that the impact of Lehman news (L) is highly significant for both developed and emerging markets across all $CIRP$ deviation maturities. News of Lehman's collapse raised short (long) deviations levels by an average of 29,5 (10) bps and 37,5 (48,3) bps for developed and emerging markets, respectively. This indicates that, after the failure of Lehman Brothers, funding markets around the globe came under extreme stress and that escalating credit and liquidity concerns evolved into a much broader systemic issue.

When I examine macro news, I find that both positive and negative news have a

significant impact on short-term and long-term $CIRP$ deviations in developed markets. The slope coefficients for positive macro news indicate that positive news significantly reduces $CIRP$ deviations by between 142 to 202 basis points. Negative macro news, on the other hand, increases $CIRP$ deviations by 138 to 212 basis points. For developed countries, all positive macro news variables are statistically significant at the 5% level or better and all negative macro news variables are significant at the 10% level or better. Neither positive nor negative macro news tends to have an impact on short or long-term $CIRP$ deviations for emerging markets.

For both developed and emerging markets, I find that bad news regarding large write-downs and downgrades of U.S. banks (WRD) has a negligible impact on long-term $CIRP$ deviations. Significance for this type of news is isolated to the shorter end of the maturity structure, but even then the impact of this type of news is typically only marginally significant. The only exception is for 1 week maturities in emerging markets, where $CIRP$ deviations are reduced by 2 bps.

One of the issues debated by monetary economists when examining the effectiveness of the first round of policy interventions by the Federal Reserve is the extension of USD swap lines to international Central Banks through bilateral currency arrangements. These reciprocal currency arrangements were designed to ease dollar funding stresses overseas. For emerging markets, I find that the extension of swap lines (SWAP) significantly reduces $CIRP$ deviations for shorter-term maturities only. This validates the findings of Aizenman & Pasricha (2009), whose findings suggest that swap lines have a relatively large short-run impact on the exchange rates of emerging market countries but a much smaller effect on swap arrangements.[7] In contrast, for developed markets, I find that currency swap lines significantly reduce

[7]Aizenman & Pasricha (2009) also develop a theoretical model in which they show that, under a large systemic shock, swap arrangements are a win-win for both the source and the recipient countries.

$CIRP$ deviations for both short- and long-term maturities. The negative sign suggests that these policy measures are successful at alleviating constraints on funding liquidity. Therefore, swap line extensions make a significant contribution to restoring the $CIRP$ condition. Thus, similar to the findings of Griffoli & Ranaldo (2011), my results suggest that swap facilities are an important tool for minimizing systemic liquidity disruptions and are also effective in restoring the link between price and fundamentals in both developed and emerging markets.

I now examine the second step of policy interventions. These programs were pursued by the Fed and the Treasury, who began to use their balance sheets to launch various lending facilities and asset purchasing programs. I include these programs in my regression analysis through the FED and TRE variables. These programs tried to compensate for capital losses sustained by U.S. banks. They were intended to restart lending activities through a substantial mortgage-backed security (MBS) purchase program. The key difference between the programs introduced by the Fed and the Treasury comes from the nature of the assets that each one purchase, while the interventions of Treasury primarily targets secured markets, FED interventions, however, address unsecured markets.

My results reveal that these programs are indeed improved funding conditions, as they significantly impacted short-term $CIRP$ deviations in developed and emerging markets. For developed markets, the coefficients for TRE are -2.10 and -4.83 for 1 week and 3 month maturities, respectively, and are statistically significant at the 5% level. The U.S. Treasury interventions also had a significant impact on short-term $CIRP$ deviations in emerging markets. For the emerging markets, the coefficients for TRE coefficient estimates for TRE are -2.31 and -1.83 for 1 week and 3 month maturities, respectively, and are significant at the 5% level. TRE is insignificant for long-term maturities in both emerging and developed markets.

The magnitude and significance of the impact of the Fed's announcements (FED)

on short-term $CIRP$ deviations are much smaller. FED is negative and significant for short-term maturities in both markets. However, it is insignificant for long-term maturities in both markets. The results for long-term $CIRP$ deviations are similar to those of J. B. Taylor & Williams (2009), who find no evidence of an effect of the Term Auction Facility on LIBOR-OIS spreads. They argue that the Term Auction Facilities program did not effectively increase market liquidity.

In February 2009, $CIRP$ levels were still high for short- and long-term maturities. I find that stress tests (STRESS) significantly reduce $CIRP$ deviations. STRESS has a negative coefficient that ranges from -1.12 to -4.20 for developed markets and -1.05 to -5.63 for emerging markets. The STRESS coefficient is significant at the 5% level for each market at every maturity. The results for the announcement of the stress tests, combined with the results presented previously, highlight the importance of government policy and communication on the dynamics of $CIRP$ deviations. [8]

2.4 Conclusion

Findings support the argument that the compression of CIRP deviations during the financial crisis can largely be attributed to policy actions undertaken by the Federal Reserve and the U.S. Treasury. I find that Lehman-associated news, macro news originating from the U.S., Fed and Treasury interventions, and stress tests all had a significant impact on CIRP deviations in developed and emerging markets. This implies that the actions were taken by the Fed and the U.S. Treasury helped ease international liquidity problems and unlock credit markets. Thus, my results indicate that funding markets are responsive to governmental announcements and programs that target credit risk in financial markets. In addition, my results show that Fed and

[8] This also supports the argument in Acharya & Merrouche (2010) that points out the importance of stress tests:"[...] regulatory attempts to thaw the money market stress and reduce variability of inter-bank rates [...] should involve addressing insolvency concerns (for example, early supervision and stress tests, and recapitalization of troubled banks) and not just provisions of emergency liquidity."

Treasury policies significantly influenced liquidity for both emerging and developed markets, but that the magnitude and significance of the impact differed across these markets.

Table 14: CIRP summary statistics for Developed Markets

This table presents the average, 75th percentile, and maximum values of short-term and long-term CIRP deviations (SD and LD, respectively) for currencies of three developed markets during the recent financial crisis. The summary statistics are divided into three subperiods: the liquidity crisis, the credit crisis, and the post-credit crisis period. All values are shown in basis points (bps).

Year	**Maturity**	**Developed Markets**								
		Euro			*United Kingdom*			*Japan*		
		Deviations	*Top Quartile*	*Max*	*Deviation*	*Top Quartile*	*Max*	*Deviation*	*Top Quartile*	*Max*
Liquidity Crisis Period	**SD - 1W**	6.64	8.10	43.19	6.57	8.10	43.19	10.69	15.51	50.19
(9 August 2007 - 31 August 2008)	**SD - 3M**	16.35	26.05	41.83	21.22	29.20	45.73	13.70	19.56	32.87
	LD - 1Y	5.12	7.38	21.57	8.78	18.58	28.40	9.17	14.73	30.70
	LD - 2Y	3.70	3.40	16.20	7.73	13.49	21.00	6.76	13.16	21.13
	LD - 5Y	3.50	3.99	15.00	4.54	9.28	13.81	5.33	10.46	18.50
Credit Crisis Period	**SD - 1W**	42.30	39.23	240.04	41.53	39.23	240.04	38.96	38.33	218.06
(1 September 2008 - 31 March 2009)	**SD - 3M**	62.93	87.29	255.25	82.37	89.40	214.19	25.93	32.00	225.45
	LD - 1Y	39.15	54.94	131.90	51.08	69.98	123.55	45.00	54.45	102.65
	LD - 2Y	33.50	45.09	81.22	45.44	52.59	84.50	43.95	57.28	81.88
	LD - 5Y	28.63	41.56	60.63	31.87	42.38	65.10	31.83	41.53	62.00
Post Crisis Period	**SD - 1W**	10.35	15.67	34.24	10.35	15.67	34.24	15.48	19.62	58.21
(1 April 2009 - 31 March 2010)	**SD - 3M**	30.26	37.62	45.22	26.40	41.62	56.06	23.20	29.03	34.48
	LD - 1Y	27.43	29.02	46.00	20.14	24.39	28.00	15.76	22.99	42.00
	LD - 2Y	21.91	24.48	33.50	20.73	22.88	35.50	18.06	26.00	48.00
	LD - 5Y	19.24	22.97	27.25	17.21	21.08	31.75	20.86	30.44	49.00

Table 15: CIRP summary statistics for Emerging Markets

This table presents the average, 75th percentile, and maximum values of short-term and long-term CIRP deviations (SD and LD, respectively) for currencies of three emerging markets during the recent financial crisis. The summary statistics are divided into three subperiods: the liquidity crisis, the credit crisis, and the post-credit crisis period. All values are shown in basis points (bps).

Year	**Maturity**	**Emerging Markets**								
		Mexico			*Turkey*			*South Africa*		
		Deviations	*Top Quartile*	*Max*	*Deviation*	*Top Quartile*	*Max*	*Deviation*	*Top Quartile*	*Max*
Liquidity Crisis Period	**SD - 1W**	31.66	43.99	72.72	29.07	38.38	95.74	37.55	55.77	82.99
(9 August 2007 - 31 August 2008)	**SD - 3M**	37.09	57.69	79.01	46.28	57.20	109.03	34.58	47.12	84.36
	LD - 1Y	37.83	51.95	71.50	52.27	71.25	81.00	15.91	23.50	37.00
	LD - 2Y	35.18	47.00	62.23	43.59	59.75	92.50	13.37	21.63	34.00
	LD - 5Y	32.90	44.41	56.18	28.61	49.50	70.00	12.65	20.13	34.00
Credit Crisis Period	**SD - 1W**	132.97	222.21	648.01	52.04	45.64	327.10	67.94	96.86	254.56
(1 September 2008 - 31 March 2009)	**SD - 3M**	156.86	164.37	602.73	115.21	158.77	412.02	41.44	68.88	188.13
	LD - 1Y	44.73	68.75	89.50	183.90	235.88	375.00	29.88	51.75	68.00
	LD - 2Y	55.42	71.50	93.00	168.17	224.13	345.00	34.38	63.75	73.00
	LD - 5Y	63.80	76.00	95.57	130.47	174.38	210.00	28.52	50.00	60.00
Post Crisis Period	**SD - 1W**	47.40	67.73	112.90	35.28	47.24	153.94	18.52	24.51	54.72
(1 April 2009 - 31 March 2010)	**SD - 3M**	44.79	61.68	113.68	37.79	56.48	117.34	9.76	10.32	51.68
	LD - 1Y	15.59	20.17	45.00	55.29	80.75	144.00	17.62	24.13	49.00
	LD - 2Y	14.22	22.63	39.00	69.34	97.25	154.00	17.73	25.00	63.00
	LD - 5Y	37.89	45.00	67.00	116.68	143.25	183.00	15.23	24.00	54.00

Table 16: Policy Events and Analysis Summary

This table summarizes the 8 types of events that are analyzed in this paper. The table includes a definition for each event type, an example of the event, and the date on which the example occurred. The table displays the number of events that occurred in each of the crisis subperiods that are defined in this paper.

Event	Definition	Example	Date	Number of Events		
				Liquidity	Credit	Post
WRD	Write-down announcements on US financial institutions	HSBC in $17bn credit crisis loss	03.03.2008	47	-	-
L	News on Lehman Brothers	Lehman Bros seeks capital	06.06.2008	1	2	1
SWAP	FED Swap Lines to both developed and emerging markets	The FOMC and Reserve Bank of New Zealand establish a $15 billion swap line.	28.10.2008	4	9	3
FED	FED Intervention via her balance sheet	Term Securities Lending Facility (TSLF) by Federal Reserve Board	24.02.2009	5	25	10
TRE	Treasury Intervention via her balance sheet	Treasury sells its remaining shares of Citigroup common stock.	07.12.2010	-	21	13
STRESS	Stress Tests on US financial institutions	FED releases the results of the stress tests for 19 largest US banks.	07.05.2009	-	1	2
MACRO +	Positive Macro Announcement originating from US	Economy in U.S. Expands for First Time in More Than a Year	29.10.2009	2	11	2
MACRO -	Negative Macro Announcement originating from US	U.S. Manufacturing Contracts Most Since 2001	01.10.2008	-	54	3

Table 17: Economic Policy and News Event Regressions

This table displays estimates from regressing weekly changes in CIRP deviations on a series of financial and economic news and policy announcement dummy variables. The CIRP deviation regressions are run for currencies of three developed economies (EUR, GBP, and JPY) and three emerging economies (TRY, MXN, and ZAR) over five different maturities (1 week, 3 months, 1 year, 2 years, and 5 years). ** and * indicate significance at the 5% and 10% levels, respectively. I use the following regression specification:

$$\Delta CIRP^m_{t,j} = \alpha^m_j + \beta^m_{1,j} WRD + \beta^m_{2,j} L + \beta^m_{3,j} SWAP + \beta^m_{4,j} FED + \beta^m_{5,j} TRE + \beta^m_{6,j} STRESS_t + \beta^m_{7,j}(MACRO+) + \beta^m_{8,j}(MACRO-) + \beta^m_{9,j}\Delta CIRP_{t-1,j}$$

Developed Markets	**1 WEEK**		**3 MONTH**		**1 YEAR**		**2 YEAR**		**5 YEAR**	
Variable	Coefficient	t-Statistic	Coefficient	t-Statistic	Coefficient	t-Statistic	Coefficient	t-Statistic	Coefficient	t-Statistic
WRD	0.02	2.02**	0.01	1.67*	0.01	1.00	0.01	1.10	0.01	1.05
L	0.35	3.66**	0.24	3.88**	0.17	2.44**	0.10	2.09**	0.03	2.02**
SWAP	-1.04	-2.04**	-0.07	-2.36**	-0.04	-2.19**	-0.01	-1.95*	-0.03	-1.93*
FED	-0.02	-1.94*	-0.03	-1.94*	0.02	1.53	0.02	1.23	-0.01	-1.44
TRE	-2.10	-1.99**	-1.83	-2.01**	-0.70	-1.25	-0.90	-0.29	-1.00	-0.01
STRESS	-2.21	-2.01**	-2.20	-1.99**	-2.54	-3.10**	-2.02	-1.99**	-1.12	2.01**
MACRO +	-1.42	-1.98**	-1.46	-1.83*	-1.62	-1.99**	-2.02	-1.98**	-1.14	-2.20**
MACRO -	1.64	1.86*	1.38	1.90*	2.12	1.90*	1.65	2.50**	1.76	3.87**
$\Delta CIRP_{t-1,j}$	-0.37	-3.46**	-0.26	-4.26**	-0.35	-7.38**	-0.29	-5.82**	-0.13	-2.49**
R-squared	45%		38%		22%		19%		16%	

Emerging Markets	**1 WEEK**		**3 MONTH**		**1 YEAR**		**2 YEAR**		**5 YEAR**	
Variable	Coefficient	t-Statistic	Coefficient	t-Statistic	Coefficient	t-Statistic	Coefficient	t-Statistic	Coefficient	t-Statistic
WRD	0.02	1.76*	0.01	0.25	0.00	0.04	0.00	0.05	0.01	0.54
L	0.42	2.68**	0.33	2.45**	0.35	1.88*	0.48	1.97**	0.62	2.72**
SWAP	-0.19	-1.99**	-0.12	-1.87*	-0.05	-1.65	-0.01	-0.59	-0.01	-0.34
FED	-0.09	-1.74*	-0.21	-3.72**	0.01	0.30	-0.03	-1.11	-0.02	-1.46
TRE	-2.31	-2.22**	-1.83	-2.91**	-0.75	-0.55	-1.10	-0.29	-0.89	-1.06
STRESS	-1.15	-2.41**	-2.18	-3.14**	-2.08	-2.38**	-4.05	-2.17**	-5.63	-2.55**
MACRO +	-0.10	-0.94	-0.01	-0.03	0.06	1.06	-0.01	-0.60	-0.01	-0.06
MACRO -	0.06	0.66	0.14	1.97**	0.02	0.94	0.06	1.31	0.03	1.65
$\Delta CIRP_{t-1,j}$	-0.35	-7.45**	-0.09	-1.89*	-0.14	-3.06**	-0.05	-1.05	-0.24	-4.39**
R-squared	32%		24%		15%		11%		13%	

Figure 9: CIRP Deviations For Developed Markets

The figure below displays short-term (3 months) and long-term (2 years) CIRP deviations that occurred for currencies in three developed economies (EUR, GBP, and JPY) during the recent crisis period.

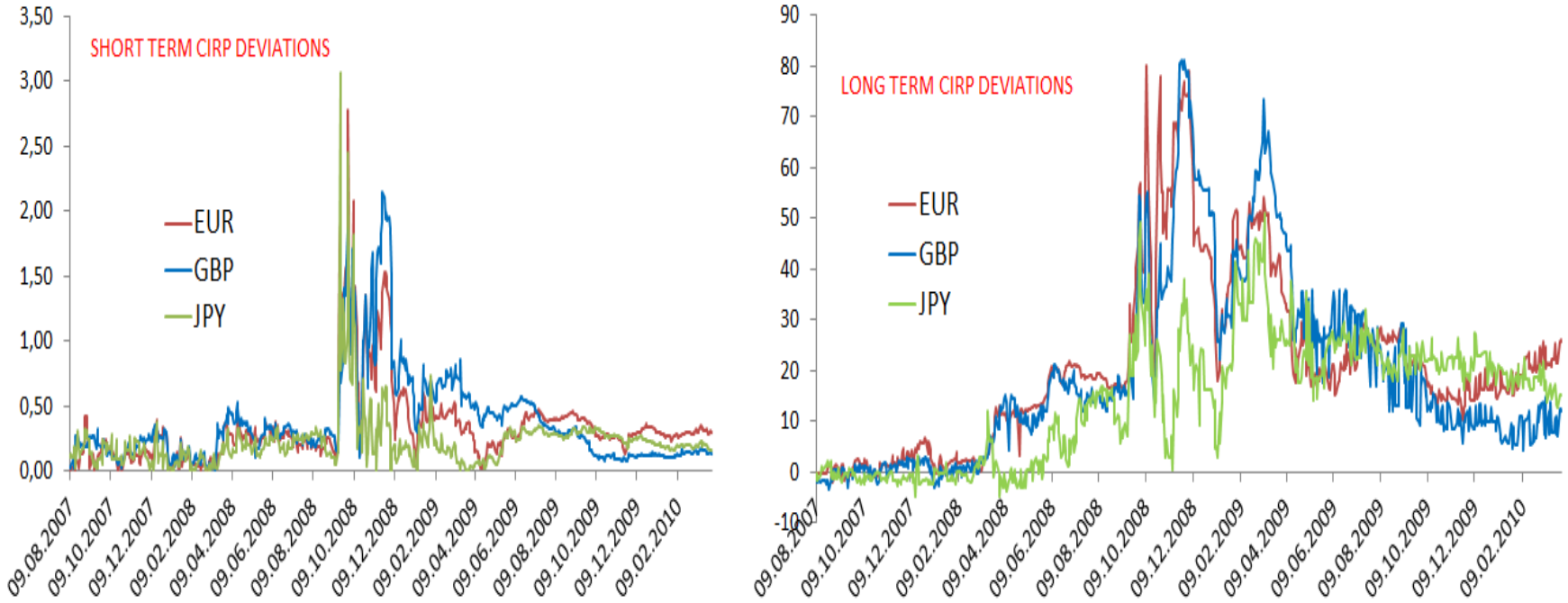
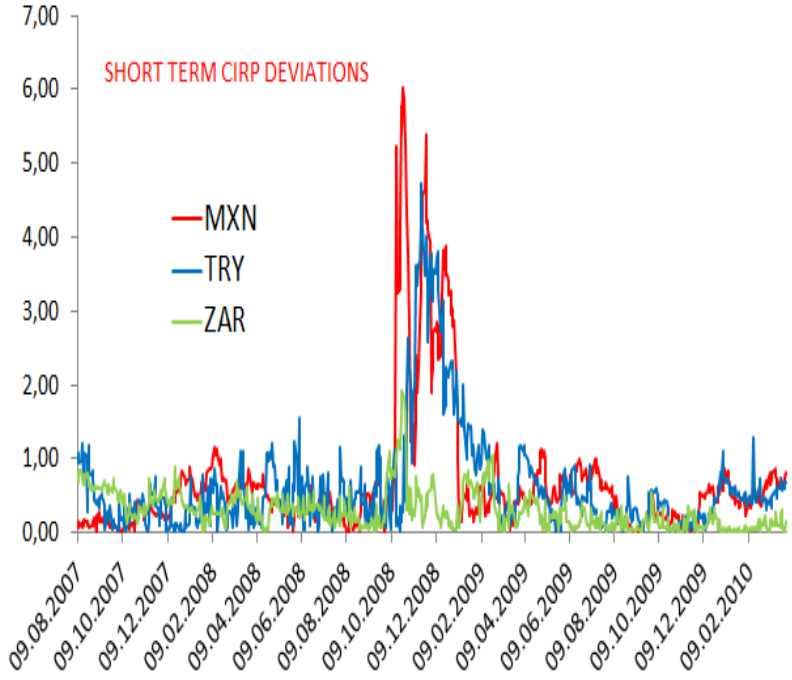


Figure 10: CIRP Deviations For Emerging Markets

The figure below displays short-term (3 months) and long-term (2 years) CIRP deviations that occurred for currencies in three emerging economies (MXN, TRY, and ZAR) during the recent crisis period.



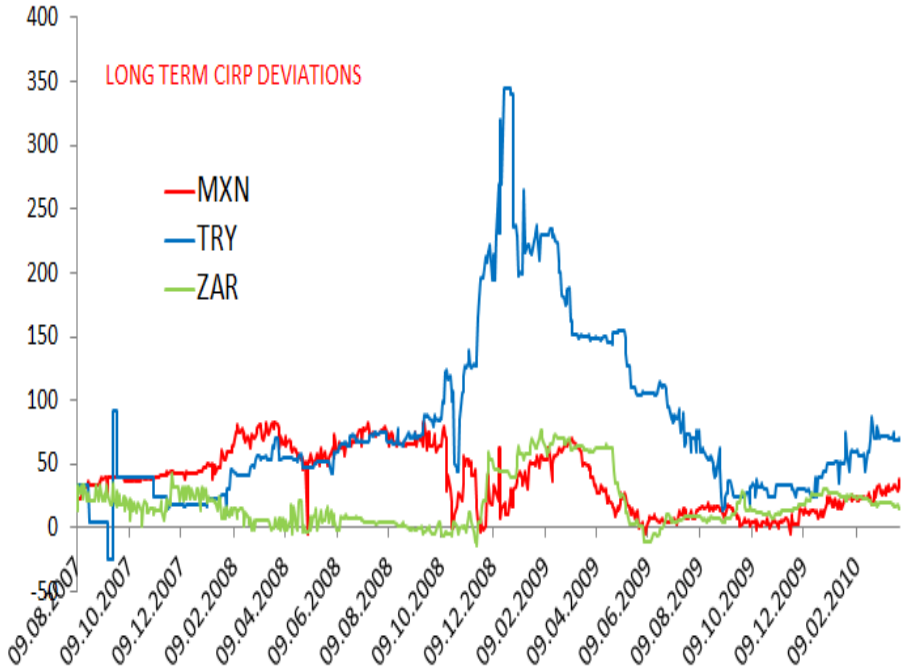


Table 18: News for Write Downs

Date	Write Down News
05.10.2007	Merrill in $5.5bn sub-prime loss
24.10.2007	Merrill Lynch Reports Loss on $8.4 Billion Writedown
31.10.2007	Fed Lowers Rate by a Quarter Point to 4.5 Percent
08.11.2007	Morgan Stanley takes $3.7bn hit
27.11.2007	Citigroup to Sell $7.5 Billion Stake to Abu Dhabi
06.12.2007	Black Humor Pervades Norway as Subprime Losses Extend to Arctic
10.12.2007	UBS posts fresh $10bn writedown
11.12.2007	U.S. rates reduced for third time
12.12.2007	Florida Fund Reduced By $1.9 Billion After SIV Losses
13.12.2007	World central banks agree to inject at least $100bn into inter-bank markets
14.12.2007	Citigroup Rescues SIVs With $58 Billion Debt Bailout
17.12.2007	$20bn from Fed to ease credit woe
18.12.2007	The ECB lends over $500 billion for Christmas
19.12.2007	Ambac, MBIA Outlook Lowered by S&P, ACA Cut to CCC
24.12.2007	Merrill Lynch to Get $6.2 Billion From Temasek, Davis
15.01.2008	Citi Writes Down $18 Billion; Merrill Gets Infusion
22.01.2008	As markets implode, Fed panics and cuts 75bps
28.01.2008	Scandal stings not just bank, but French pride, too
30.01.2008	The Federal Reserve cuts again, 50 basis points
14.02.2008	UBS confirms sub-prime $18.4 billion loss
03.03.2008	HSBC in $17bn credit crisis loss
06.03.2008	Peloton Capital hedge fund collapses
07.03.2008	Ambac Gets $1.5 Billion in Capital to Keep AAA Grade
11.03.2008	Carlyle Fund Tries to Halt Liquidation

Date	Write Down News
01.04.2008	UBS writes down another $19 billion, Deutsche Bank to write down $4B
04.04.2008	MBIA Loses AAA Insurer Rating From Fitch Over Capital
08.04.2008	Washington Mutual Raising $7 Billion
14.04.2008	Wachovia's Loss a Grim Sign for Banks
18.04.2008	Citigroup Reports Loss on $15 Billion of Credit Costs
21.04.2008	Funds to invest up to $8bn in National City bank
22.04.2008	Merrill Raises $9.55 Billion in Sales of Debt,Pref. Shares,RBS aims to raise $24B in new capital
29.04.2008	Citigroup Sells $3 Billion of Stock, HBOS Plans to Raise 4 Billion Pounds in Share Sale
30.04.2008	Citigroup Increases Stock Offering to $4.5 Billion
06.05.2008	Fannie Mae to raise $6bn new capital
07.05.2008	Town of Vallejo, California goes bankrupt
09.05.2008	Citigroup to wind down $400bn of assets
19.05.2008	Banks Keep $35 Billion Markdown Off Income Statements
26.05.2008	UBS Falls After Saying More Mortgage Losses Possible
02.06.2008	Morgan Stanley, Merrill, Lehman Ratings Cut by S&P,Bradford & Bingley shares plunge as lender warns on profits
05.06.2008	MBIA, Ambac, $1 Trillion of Debt, Lose S&P AAA Rating
09.06.2008	Lehman Brothers to post $3 bln loss; sets $6 bln stock sale, Lehman to post $2.8 billion quarterly loss, Lehman Cuts $130 Billion of Assets to End Bear Stigma
12.06.2008	KeyCorp to raise $1.5 billion, cut dividend 50%
18.06.2008	Fifth Third Falls on Plan to Raise $2 Billion, Cut Dividend
25.06.2008	Countrywide Sued by California Over Mortgage Loans,faces Illinois Suit Over Mortgage Loans
30.06.2008	Florida Sues Countrywide
07.07.2008	Freddie Mac, Fannie Mae Plunge on Capital Concerns
10.07.2008	U.S. Mulls Future of Fannie, Freddie

Table 19: News For Lehman

Date	Lehman Related News
06.06.2008	Lehman Bros seeks capital
15.09.2008	Lehman Brothers Holdings Incorporated files for Chapter 11 bankruptcy protection.
16.09.2008	The net asset value of shares in the Reserve Primary Money Fund falls below $1, primarily due to losses on Lehman Brothers commercial paper and medium-term notes.
18.09.2009	The U.S. Department of the Treasury announces the expiration of the Guarantee Program for Money Market Funds, which was implemented in the wake of the failure of Lehman Brothers in September 2008.

Table 20: News Related with Swaps

Date	Swap News
12.12.2007	The Federal Reserve Board announces the creation of a Term Auction Facility (TAF) in which fixed amounts of term funds will be auctioned to depository institutions against a wide variety of collateral.
11.03.2008	The Federal Reserve Board announces the Term Securities Lending Facility (TSLF)
02.05.2008	The FOMC expands the list of eligible collateral for Schedule 2 TSLF auctions to include AAA/Aaa-rated asset-backed securities
30.07.2008	The Federal Reserve Board extends the TSLF and PDCF through January 30, 2009, introduces auctions of options on $50 billion of draws on the TSLF, and introduces 84-day TAF loans. The FOMC increases its swap line with the ECB to $55 billion.
18.09.2008	The FOMC expands existing swap lines by $180 billion and authorizes new swap lines with the Bank of Japan, Bank of England, and Bank of Canada.
24.09.2008	The FOMC establishes new swap lines with the Reserve Bank of Australia and the Sveriges Riksbank for up to $10 billion each and with the Danmarks Nationalbank and the Norges Bank for up to $5 billion each. (Through January 30, 2009)
26.09.2008	The FOMC increases existing swap lines with the ECB by $10 billion and the Swiss National Bank by $3 billion.
29.09.2008	The FOMC authorizes a $330 billion expansion of swap lines with Bank of Canada, Bank of England, Bank of Japan, Danmarks Nationalbank, ECB, Norges Bank, Reserve Bank of Australia, Sveriges Riksbank, and Swiss National Bank Swap lines outstanding now total $620 billion.
13.10.2008	The FOMC increases existing swap lines with foreign central banks. The Bank of England, European Central Bank, and Swiss National Bank announce that they will conduct tenders of U.S. dollar funding at 7-, 28-, and 84-day maturities at fixed interest rates.
14.10.2008	The FOMC increases its swap line with the Bank of Japan.

Date	Swap News
28.10.2008	The FOMC and Reserve Bank of New Zealand establish a $15 billion swap line.
29.10.2008	The FOMC establishes swap lines with the Banco Central do Brasil, Banco de Mexico, Bank of Korea, and the Monetary Authority of Singapore for up to $30 billion each.
03.02.2009	The Federal Reserve announces the extension, through October 30, 2009, of the existing liquidity programs scheduled to expire on April 30, 2009. The Board of Governors and the FOMC note "continuing substantial strains in many financial markets." In addition, the swap lines between the Federal Reserve and other central banks are also extended to October 30, 2009. The expiration date for the TALF remains December 31, 2009, and the TAF does not have an expiration date.
06.04.2009	The Federal Reserve announces new reciprocal currency agreements (swap lines) with the Bank of England, the European Central Bank, the Bank of Japan and the Swiss National Bank that would enable the provision of foreign currency liquidity by the Federal Reserve to U.S. financial institutions.
10.06.2009	The Federal Reserve issues the first of an ongoing series of monthly reports on its credit and lending facilities.
24.06.2009	The Federal Reserve announces extensions of and modifications to a number of its liquidity programs. The expiration date of the Asset-Backed Commercial Paper Money Market Mutual Fund Liquidity Facility (AMLF), the Commercial Paper Funding Facility (CPFF), the Primary Dealer Credit Facility (PDCF) and the Term Securities Lending Facility (TSLF) is extended through 01.02.2010. The expiration date of the Term Asset-Backed Securities Loan Facility (TALF) remains set at December 31, 2009. In addition, the temporary reciprocal currency arrangements (swap lines) between the Federal Reserve and other central banks have been extended to February 1, 2010. The Federal Reserve also announces that the amounts auctioned at the biweekly auctions of Term Auction Facility (TAF) funds will be reduced from $150 billion to $125 billion, effective with the auction to be held on July 13, 2009.

Date	Swap News
09.05.2010	The Federal Reserve re-establishes temporary reciprocal currency arrangements (swap lines) with the Bank of Canada, the Bank of England, the European Central Bank and the Swiss National Bank in response to the re-emergence of strains in U.S. dollar short-term funding markets in Europe.
11.05.2010	The Federal Reserve publicly releases the text of three agreements with foreign central banks to reestablish temporary dollar swap facilities and announces that it would disclose information weekly on use of the swap lines by each of the counterparty central banks.

Table 21: News Related with FED

Date	FED Related News
15.10.2007	Citigroup, BOA, and JPMorgan Chase announce plans for an $80 billion Master Liquidity Enhancement Conduit to purchase highly rated assets from existing special purpose vehicles.
11.01.2008	Bank of America announces that it will purchase Countrywide Financial in an all-stock transaction worth approximately $4 billion.
07.03.2008	FED announces $50 billion TAF auctions on March 10 and March 24 and extends the TAF for at least 6 months, also initiates a series of term repurchase transactions, expected to cumulate to $100 billion, conducted as 28-day term repurchase agreements with primary dealers.
13.07.2008	Treasury Department announces a temporary increase in the credit lines of Fannie Mae and Freddie Mac and a temporary authorization for the Treasury to purchase equity in either GSE if needed.
30.07.2008	President Bush signs into law the Housing and Economic Recovery Act of 2008 (Public Law 110-289), which, among other provisions, authorizes the Treasury to purchase GSE obligations and reforms the regulatory supervision of the GSEs under a new Federal Housing Finance Agency.
07.09.2008	The Federal Housing Finance Agency (FHFA) places Fannie Mae and Freddie Mac in government conservatorship. Treasury announces three additional measures to complement the FHFA's decision: 1) Preferred stock purchase agreements between the Treasury/FHFA and Fannie Mae and Freddie Mac to ensure the GSEs positive net worth; 2) a new secured lending facility which will be available to Fannie Mae, Freddie Mac, and the Federal Home Loan Banks; and 3) a temporary program to purchase GSE MBS.
15.09.2008	Bank of America announces its intent to purchase Merrill Lynch & Co. for $50 billion.

Date	FED Related News
19.09.2008	The Federal Reserve Board announces the creation of the Asset-Backed Commercial Paper Money Market Mutual Fund Liquidity Facility (AMLF) to extend non-recourse loans at the primary credit rate to U.S. depository institutions and bank holding companies to finance their purchase of high-quality asset-backed commercial paper from money market mutual funds. The Federal Reserve Board also announces plans to purchase federal agency discount notes (short-term debt obligations issued by Fannie Mae, Freddie Mac, and Federal Home Loan Banks) from primary dealers.
20.09.2008	The U.S. Treasury Department submits draft legislation to Congress for authority to purchase troubled assets.
29.09.2008	The FDIC announces that Citigroup will purchase the banking operations of Wachovia Corporation. The FDIC agrees to enter into a loss-sharing arrangement with Citigroup on a $312 billion pool of loans, with Citigroup ,absorbing the first $42 billion of losses and the FDIC absorbing losses beyond that. In return, Citigroup would grant the FDIC $12 billion in preferred stock and warrants. The U.S. House of Representatives rejects legislation submitted by the Treasury Department requesting authority to purchase troubled assets from financial institutions.
03.10.2008	Wells Fargo announces a competing proposal to purchase Wachovia Corporation that does not require assistance from the FDIC.
07.10.2008	The Federal Reserve Board announces the the Commercial Paper Funding Facility (CPFF), which will provide a liquidity backstop to U.S. issuers of commercial paper through a special purpose vehicle that will purchase three-month unsecured and asset-backed commercial paper directly from eligible issuers.
14.10.2008	U.S. Treasury Department announces the Troubled Asset Relief Program (TARP) that will purchase capital in financial institutions under the authority of the Emergency Economic Stabilization Act of 2008. The U.S. Treasury will make available $250 billion of capital to U.S. financial institutions. This facility will allow banking organizations to apply for a preferred stock investment by the U.S. Treasury. Nine large financial organizations announce their intention to subscribe to the facility in an aggregate amount of $125 billion.

Date	FED Related News
21.10.2008	The Federal Reserve Board announces the Money Market Investor Funding Facility (MMIFF) Under the facility, the Federal Reserve Bank of New York provides senior secured funding to a series of special purpose vehicles to facilitate the purchase of assets from eligible investors, such as U.S. money market mutual funds. Among the assets the facility will purchase are U.S. dollar-denominated certificates of deposit and commercial paper issued by highly rated financial institutions with a maturity of 90 days or less.
24.10.2008	PNC Financial Services Group Inc. purchases National City Corporation, creating the fifth largest U.S. bank.
10.11.2008	The Federal Reserve Board and the U.S. Treasury Department announce a restructuring of the government's financial support of AIG. The Treasury will purchase $40 billion of AIG preferred shares under the TARP program, a portion of which will be used to reduce the Federal Reserve's loan to AIG from $85 billion to $60 billion. The terms of the loan are modified to reduce the interest rate to the three-month LIBOR plus 300 basis points and lengthen the term of the loan from two to five years. The Federal Reserve Board also authorizes the Federal Reserve Bank of New York to establish two new lending facilities for AIG: The Residential Mortgage- Backed Securities Facility will lend up to $22.5 billion to a newly formed limited liability company (LLC) to purchase residential MBS from AIG; the Collateralized Debt Obligations Facility will lend up to $30 billion to a newly formed LLC to purchase CDOs from AIG (Maiden Lane III LLC).
12.11.2008	U.S. Treasury Secretary Paulson formally announces that the Treasury has decided not to use TARP funds to purchase illiquid mortgage-related assets from financial institutions.
17.11.2008	Three large U.S. life insurance companies seek TARP funding: Lincoln National, Hartford Financial Services Group, and Genworth Financial announce their intentions to purchase lenders/depositories and thus qualify as savings and loan companies to access TARP funding.
25.11.2008	The Federal Reserve Board announces a new program to purchase direct obligations of housing related government-sponsored enterprises (GSEs)—Fannie Mae, Freddie Mac and Federal Home Loan Banks MBS backed by the GSEs. Purchases of up to $100 billion in GSE direct obligations will be conducted as auctions among Federal Reserve primary dealers. Purchases of up to $500 billion in MBS will be conducted by asset managers.

Date	FED Related News
29.12.2008	The U.S. Treasury Department announces that it will purchase $5 billion in equity from GMAC as part of its program to assist the domestic automotive industry. The Treasury also agrees to lend up to $1 billion to General Motors "so that GM can participate in a rights offering at GMAC in support of GMAC's reorganization as a bank holding company." This commitment is in addition to the support announced on December 19, 2008.
30.12.2008	The Federal Reserve Board announces that it expects to begin to purchase mortgage-backed securities backed by Fannie Mae, Freddie Mac and Ginnie Mae under a previously announced program in early January 2009 (see November 25, 2008).
28.01.2009	The National Credit Union Administration (NCUA) Board announces that the NCUA will guarantee uninsured shares at all corporate credit unions through February 2009 and establish a voluntary program for uninsured shares of credit unions through December 2010. The Board approves a $1 billion capital purchase in U.S. Central Corporate Federal Credit Union. Corporate credit unions provide financing, check clearing, and other services to retail credit unions.
10.02.2009	U.S. Treasury Secretary Timothy Geithner announces a Financial Stability Plan involving Treasury purchases of convertible preferred stock in eligible banks, the creation of a Public-Private Investment Fund to acquire troubled loans and other assets from financial institutions, expansion of the Federal Reserve's Term Asset-Backed Securities Loan Facility (TALF), and new initiatives to stem residential mortgage foreclosures and to support small business lending.
18.02.2009	President Obama announces The Homeowner Affordability and Stability Plan. The plan includes a program to permit the refinancing of conforming home mortgages owned or guaranteed by Fannie Mae or Freddie Mac that currently exceed 80 percent of the value of the underlying home. The plan also creates a $75 billion Homeowner Stability Initiative to modify the terms of eligible home loans to reduce monthly loan payments. The U.S. Treasury Department will increase its preferred stock purchase agreements with Fannie Mae and Freddie Mac to $200 billion, and increase the limits on the size of Fannie Mae and Freddie Mac's portfolios to $900 billion.

Date	FED Related News
26.02.2009	Fannie Mae reports a loss of $25.2 billion in the fourth quarter of 2008, and a full year 2008 loss of $58.7 billion. Fannie Mae also reports that on February 25, 2009, the Federal Housing Finance Agency submitted a request for $15.2 billion from the U.S. Treasury Department under the terms of the Senior Preferred Stock Purchase Agreement in order to eliminate Fannie Mae's net worth deficit as of December 31, 2008.
27.02.2009	The U.S. Treasury Department announces its willingness to convert up to $25 billion of Citigroup preferred stock issued under the Capital Purchase Program into common equity. The conversion is contingent on the willingness of private investors to convert a similar amount of preferred shares into common equity. Remaining U.S. Treasury and FDIC preferred shares issued under the Targeted Investment Program and Asset Guarantee Program would be converted into a trust preferred security of greater structural seniority that would carry the same 8% cash dividend rate as the existing issue.
11.03.2009	Freddie Mac announces that it had a net loss of $23.9 billion in the fourth quarter of 2008, and a net loss of $50.1 billion for 2008 as a whole. Further, Freddie Mac announces that its conservator has submitted a request to the U.S. Treasury Department for an additional $30.8 billion in funding for the company under the Senior Preferred Stock Purchase Agreement with the Treasury.
18.03.2009	The FOMC votes to maintain the target range for the effective federal funds at 0 to 0.25 percent. In addition, the FOMC decides to increase the size of the Federal Reserve's balance sheet by purchasing up to an additional $750 billion of agency mortgage-backed securities, bringing its total purchases of these securities to up to $1.25 trillion this year, and to increase its purchases of agency debt this year by up to $100 billion to a total of up to $200 billion. The FOMC also decides to purchase up to $300 billion of longer-term Treasury securities over the next six months to help improve conditions in private credit markets.
23.03.2009	The U.S. Treasury Department announces the Public-Private Investment Program for Legacy Assets. The program will have two parts: a Legacy Loans Program and Securities Program.

Date	FED Related News
31.03.2009	Four bank holding companies announced that they had redeemed all of the preferred shares that they had issued to the U.S. Treasury under the Capital Purchase Program of the Troubled Asset Relief Program (TARP).
01.05.2009	The Federal Reserve Board announces that, starting in June, commercial mortgage-backed securities (CMBS) and securities backed by insurance premium finance loans will be eligible collateral under the Term Asset-Backed Securities Loan Facility (TALF).
08.05.2009	Fannie Mae reports a loss of $23.2 billion for the first quarter of 2009.
12.05.2009	Freddie Mac reports a first quarter 2009 loss of $9.9 billion, and a net worth deficit of $6.0 billion as of March 31, 2009.
09.06.2009	The U.S. Treasury Department announces that 10 of the largest U.S. financial institutions participating in the Capital Purchase Program have met the requirements for repayment established by the primary federal banking supervisors.
08.07.2009	The U.S. Treasury Department, Federal Reserve and the FDIC announce the details of the Legacy Securities Public-Private Investment Program (PPIP).
06.08.2009	Fannie Mae reports a loss of $14.8 billion in the second quarter of 2009.
01.11.2009	CIT Group, Inc., files for bankruptcy protection under Chapter 11 of the bankruptcy code. The U.S. Government purchased $2.3 billion of CIT preferred stock in December 2008 under the Troubled Asset Relief Program (TARP).
02.12.2009	Bank of America announces that it will repurchase the entire $45 billion of cumulative preferred stock issued to the U.S. Treasury under the Troubled Asset Relief Program (TARP) after the completion of a securities offering.
24.12.2009	The U.S. Treasury Department announces the removal of caps on the amount of preferred stock that the Treasury may purchase in Fannie Mae and Freddie Mac to ensure that each firm maintains a positive net worth.
19.01.2010	In response to a request from the House Committee on Oversight and Government Reform, the Federal Reserve Bank of New York provides documents that relate to Maiden Lane III LLC.

Table 22: News Related With Treasury

Date	The U.S. Treasury Related News
28.10.2008	The U.S. Treasury purchases a total of $125 billion in preferred stock in nine U.S. banks under the Capital Purchase Program. (CPP) (also all below)
14.11.2008	Treasury purchases a total of $33.5 billion in preferred stock in 21 U.S. banks.
21.11.2008	Treasury purchases a total of $3 billion in preferred stock in 23 U.S. banks.
05.12.2008	Treasury purchases a total of $4 billion in preferred stock in 35 U.S. banks.
12.12.2008	Treasury purchases a total of $6.25 billion in preferred stock in 28 U.S. banks.
19.12.2008	Treasury purchases a total of $27.9 billion in preferred stock in 49 U.S. banks.
23.12.2008	Treasury purchases a total of $15.1 billion in preferred stock from 43 U.S. banks.
31.12.2008	Treasury purchases a total of $1.91 billion in preferred stock from seven U.S. banks.
09.01.2009	Treasury purchases a total of $4.8 billion in preferred stock from 43 U.S. banks.
16.01.2009	Treasury purchases a total of $1.4 billion in preferred stock from 39 U.S. banks.
23.01.2009	Treasury purchases a total of $326 million in preferred stock from 23 U.S. banks.
30.01.2009	Treasury purchases a total of $1.15 billion in preferred stock from 42 U.S. banks.
06.02.2009	Treasury purchases a total of $238.5 million in preferred stock from 28 U.S. banks.
13.02.2009	Treasury purchases a total of $429 million in preferred stock from 29 U.S. banks.
17.02.2009	Treasury releases its first monthly survey of bank lending by the top 20 recipients of government investment through the CPP.
24.02.2009	Treasury purchases a total of $365.4 million in preferred stock from 23 U.S. banks.
27.02.2009	Treasury purchases a total of $394.9 million in preferred stock from 28 U.S. banks.
06.03.2009	Treasury purchases a total of $284.7 million in preferred stock from 22 U.S. banks.
13.03.2009	Treasury purchases a total of $1.45 billion in preferred stock from 19 U.S. banks.
20.03.2009	Treasury purchases a total of $80.8 million in preferred stock from 10 U.S. banks.
27.03.2009	Treasury purchases a total of $193 million in preferred stock from 14 U.S. banks.
03.04.2009	Treasury purchases a total of $54.8 million in preferred stock from 10 U.S. banks.
10.04.2009	Treasury purchases a total of $22.8 million in preferred stock from 5 U.S. banks.

Date	The U.S. Treasury Related News
17.04.2009	Treasury purchases a total of $40.9 million in preferred stock from 6 U.S. banks.
24.04.2009	Treasury purchases a total of $121.8 million in preferred stock from 12 U.S. banks.
01.05.2009	Treasury purchases a total of $45.5 million in preferred stock from 7 U.S. banks.
08.05.2009	Treasury purchases a total of $42 million in preferred stock from 7 U.S. banks.
15.05.2009	Treasury purchases a total of $107.6 million in preferred stock from 14 U.S. banks.
22.05.2009	Treasury purchases a total of $108 million in preferred stock from 12 U.S. banks.
29.05.2009	Treasury purchases a total of $89 million in preferred stock from 8 U.S. banks.
05.06.2009	Treasury purchases a total of $40 million in preferred stock from 3 U.S. banks.
12.06.2009	Treasury purchases a total of $39 million in preferred stock from 7 U.S. Banks under the CPP.
19.06.2009	Treasury purchases a total of $84.7 million in preferred stock from 10 U.S. banks under the CPP.
26.06.2009	Treasury announces its policy regarding the disposition of warrants acquired under the CPP.

Table 23: News Related with Stress Tests

Date	Stress Tests News
25.02.2009	The Federal Reserve Board, Federal Deposit Insurance Corporation, Office of the Comptroller of the Currency and Office of Thrift Supervision announce that they will conduct forward-looking economic assessments or "stress tests" of eligible U.S. bank holding companies with assets exceeding $100 billion. Supervisors will work with the firms to estimate the range of possible future losses and the resources to absorb such losses over a two-year period.
24.04.2009	The Federal Reserve Board publishes a white paper describing the process and methodologies employed by federal banking supervisory authorities in their forward looking assessment ("stress test") of large U.S. bank holding companies.
07.05.2009	The Federal Reserve releases the results of the Supervisory Capital Assessment Program ("stress test") of the 19 largest U.S. bank holding companies.

Table 24: Positive Macro News

Date	Positive Macro News
02.05.2008	US Unemployment Rate Drops to 5.00%
30.07.2008	Visa's Profit Rises 41% as More Consumers Use Cards
01.10.2008	GE Says It Can Fund Operations Without Tapping Credit Lines
22.10.2008	Homebuilders' Forecast for Sales Gain Clashes With Mortgage Bankers Group
23.10.2008	Microsoft Profit, Sales Top Estimates as Demand Holds
12.11.2008	Frank's Plan Gives GM, Ford, Chrysler $25 Billion
22.11.2008	Obama Targets 2.5 Million New Jobs in 2-Year Economic Stimulus
04.12.2008	GM, Chrysler Said to Consider Pre-Arranged Bankruptcy to Get U.S. Bailout
11.12.2008	House Approves $14 Billion Automaker Bailout, Sending It to U.S. Senate
19.12.2008	GM and Chrysler Will Get $13.4 Billion in U.S. Loans
26.12.2008	GM Gets Boost as GMAC Bank Approval Helps Loan Access
06.01.2009	Jobless Benefit Rolls in U.S. Jump to 26-Year High
03.03.2009	Fed Says Loan Plan to Start March 25, May Add Rentals
26.05.2009	U.S. Consumer Confidence Jumps by Most in Six Years
29.10.2009	Economy in U.S. Expands for First Time in More Than a Year

Table 25: Negative Macro News

Date	Negative Macro News
25.09.2008	Shipping Market Sinks Most in Nine Years as Growth, Steel Production Fall
01.10.2008	U.S. Manufacturing Contracts Most Since 2001
01.10.2008	Ford Motor's, Honda's September U.S. Auto Sales Tumble as Credit Tightens
15.10.2008	Oil Falls to 13-Month Low on Recession Concern, Equities Drop
15.10.2008	U.S. Retail Sales Decline Most in Three Years on Job Losses
16.10.2008	Industrial Output in U.S. Falls Most Since 1974
17.10.2008	Consumer Confidence in U.S. Falls Most on Record
05.11.2008	Oil Falls More Than $5 After Unexpected Gasoline Supply Gain K9
07.11.2008	Jobless Rate In U.S. Jumps To 6.5%, Highest Since 1994, As Payrolls Tumble
13.11.2008	U.S. Jobless Claims Reach Seven-Year High of 516,000
13.11.2008	Traders Bet on $30 Crude Oil as OPEC Plans Talks on Output Cut
14.11.2008	Fidelity Investments Will Eliminate 1,700 Jobs in First Quarter
17.11.2008	Toyota, BMW, Hyundai Workers' Senators Oppose U.S. Auto Loans
20.11.2008	Crude Oil Tumbles to Lowest Since May 2005 as Consumption Drops
20.11.2008	U.S. Economy: Jobless Claims Approach Highest Level Since 1982
20.11.2008	General Motors, Ford, Chrysler Leave Congress Empty-Handed After Hearings
20.11.2008	Bernanke May Find Deflation 'Back on the Table' as Fed Concern
21.11.2008	Financial Job Losses May Reach 350,000 in Banking Industry 'Seismic Shift'
24.11.2008	Recessions Grip Forces U.S. to Flood World With More Dollars
24.11.2008	Bernanke Tells New Yorker He Underestimated Housing Meltdown
25.11.2008	Home Prices for 20 U.S. Cities Decline Most on Record
25.11.2008	Citigroup Bailout Charts New U.S. Course for Rescues, Adding Taxpayer Risk
25.11.2008	Recession Kills Travel Plans, Spoils Reunions for U.S. Thanksgiving Day
26.11.2008	Sales of New Houses in U.S. Fall to Lowest Level in 17 Year
26.11.2008	U.S. Durable Orders Fall Twice as Much as Forecast
01.12.2008	America Exports Unemployment as Slump Shrinks Consumer Demand, Investment
02.12.2008	U.S. Automakers, UAW to 'Genuflect' to Divided Congress for Aid
02.12.2008	Manufacturing in U.S. Shrinks at Fastest Pace Since 1982 as Orders Slump
02.12.2008	U.S. Recession Began Last December, Making Contraction Longest Since 1982
03.12.2008	State Street to Cut 1,700 Jobs, 6% of Workforce, By Early 2009
03.12.2008	Jefferies Group Said to Eliminate 10 Percent of Its Employees

Date	Negative Macro News
03.12.2008	U.S. Economy: Service Companies Shrink at Record Pace
03.12.2008	GM, Chrysler Need $15 Billion to Survive Until Next Month as Cash Runs Out
04.12.2008	AT&T Plans to Cut 12,000 Jobs, Citing Economic Slump
05.12.2008	Employers in U.S. Cut 533,000 Jobs; Jobless Rate Rises to 6.7%
16.12.2008	U.S. Consumer Prices Fall 1.7% in November; Core Rate Unchanged
16.12.2008	Housing Starts in U.S. Fell 18.9% to 625,000 Pace in November
23.12.2008	U.S. Housing Prices Collapse at Near-Depression Pace After Purchases Slide
23.12.2008	U.S. Economy Contracted 0.5% Last Quarter, the Most Since 2001 Recession
24.12.2008	U.S. Initial Jobless Claims Rose 30,000 to 586,000 Last Week
29.12.2008	Holiday Sales Slump to Force U.S. Store Closings, Bankruptcies
02.01.2009	U.S. Manufacturing Shrinks at Fastest Pace Since 1980 as Recession Spreads
06.01.2009	U.S. Economy: Service Industries, Pending Home Resales Decline
09.01.2009	Employers in U.S. Cut 524,000 Jobs; 2008 Losses Most Since 1945
14.01.2009	U.S. Retail Sales Decline for a Record Sixth Month
22.01.2009	Microsoft Cuts 5,000 Jobs as Recession Curbs Growth
29.01.2009	U.S. New-Home Sales Fell in December to Lowest Level on Record
30.01.2009	U.S. Economy Shrank 3.8% in Fourth Quarter, Most Since 1982
06.02.2009	U.S. Jobless Rate Rises to 16-Year High of 7.6%; Payrolls Fall by 598,000
18.02.2009	GM Seeks Up to $16.6 Billion in New U.S. Aid, Plans 47,000 More Job Cuts
18.02.2009	U.S. Housing Starts Fell to Record Low in January
24.02.2009	U.S. Consumer Confidence Collapsed to Record Low in February
27.02.2009	U.S. Economy Shrank 6.2% in Fourth Quarter, Most Since 1982
06.03.2009	U.S. Unemployment Rises to 8.1%, Highest in 25 Years, as 651,000 Jobs Lost
06.11.2009	U.S. Unemployment Rate Jumps to 10.2% as Payrolls Fall More Than Forecast
30.12.2009	Home Prices in 20 U.S. Cities Tumbled 18% From Year Ago
30.12.2009	October Home Prices in 20 U.S. Metro Areas Fall 18%

Chapter III

A PARSIMONIOUS EARLY WARNING INDEX FOR TURKEY

Most economists would argue that the seeds of the financial crisis were planted some time prior to the onset of the crisis. Hence, I investigate whether the determinants of covered interest rate parity (CIRP) deviations can be used as an early warning indicator for financial crisis in a local economy, namely Turkey. Applied to covered interest rate parity data, I determine within a threshold regression model a crisis-level of the early warning index (EWI) at which financial stress tends to depress CIRP deviations as a proxy to the law of one price. This will allow regulators or investors to be increasingly forward looking in their decisions either in interventions or asset allocation and so preemptive rather than reactive in the century of high speed information flow.

This study is an addition to current literature in terms of a new EWI for Turkey, with a high level of signaling power that indicates the crisis in Turkey one to three months prior to its occurrence. Indeed, the aim of this recent EWI is to identify the key empirical irregularities in Turkish markets which would empower can enable me to recognize crises at an earlier stage. This would lead policymakers, for instance those work at Central Bank or Capital Markets Board of Turkey to be increasingly forward-looking, and therefore to act as pre-emptive rather than reactive. Furthermore an approach that differentiates this paper from previous ones on EWIs that are used by institutions is that I employ daily data as opposed to monthly or quarterly data. Daily data permits me to work with a larger sample. I also assess the results of first chapter for the emerging countries in which I investigate the determinants of

the CIRP deviations for the recent financial crisis. Besides using the deviations from the CIRP as an EWI, I also use the principal component analysis in the aim of extracting the communality indication of the data which is expected to signal the trends beforehand. Hence, this study aims to monitor and control the financial risks with a holistic approach by using an early warning index and by taking the necessary measures. Contrary to the methodology available in the literature, EWIs aspire to generate anticipatory information about the analysis of financial products in the best and fastest way possible by combining information hidden in them.

In order to further analyze the index, I propose a new way to determine critical levels (i.e., crisis thresholds and regimes) for created EWI as the endogenous outcome of a parsimonious econometric regime switching model. This approach is the threshold regression model that helps to find the threshold levels of the EWIs at or above which EWI indicates a stressed environment on the related country and shows no significant relationship when the EWI is below that threshold.

In the literature of early warning systems, there is a wide range of estimation techniques and a part of literature has converged on a number of independent variables that are most frequently examined as leading indicators of crisis. As J. Frankel & Saravelos (2012) collected, three extensive reviews done by Kaminsky, Lizondo, & Reinhart (1998), (KLR, 1998), Hawkins & Klau (2000) and Abiad (2003), J. Frankel & Saravelos (2012) evaluated the results of seven new papers published from 2002, and all together reviewed 83 papers over a period covering crisis episodes from 1950s up to 2012. [1]

The early warning index literature can be categorized into two groups, market-based and theory-based indexes. While theory-based indexes originate from economic or financial models and typically focus on specific markets, market-based indexes

[1] See Table 27 for a list of particular indicators that was found to be statistically significant across the reviews.

aggregate information from various financial markets using statistical methods. Since market based indexes combine many different types of risk, the subcomponents do not always move together.

3.1 A Parsimonious Early Warning Indicator

In any empirical analysis, one can learn as much from the falsification of the statistical significance of some factors as from finding successful factors. The previous large-scale multivariate regressions (my first section findings) show that several economic factors that are often discussed in the asset pricing literature have limited significance in explaining the variations in CIRP deviations. In what follows, I investigate a parsimonious specification, which focuses only on the risk factors that are significant in all specifications for Turkey: currency crash risk, credit risk, and funding risk:

$$\Delta CIRP^{m}_{j,t} = \alpha_j + \underbrace{\gamma^{m}_{1}\left[\Delta_{\text{Risk Reversal}}\right]'_{t}}_{Currency\ Crash\ Risk} + \underbrace{\gamma^{m}_{2}\left[\Delta_{\text{CDS}}\right]'_{t}}_{Credit\ Risk} + \underbrace{\gamma^{m}_{3}\left[\Delta_{\text{Unsecured}}\right]'_{t}}_{Funding\ Risk}$$

$$= \alpha_j + \gamma^{m}_{1} R'_t + \gamma^{m}_{2} C'_t + \gamma^{m}_{3} F'_t$$

Therefore, in order to create a market based indicator that has a signaling power, I will use the risk appetite index methodology, and I use my earlier findings to create the EWI, that are mainly statistically important for determinants of CIRP violations.

As a proxy for the currency crash risk, I use the price of risk reversal, which is buying a call option and simultaneously selling a put option for the same amount at the same delta options (This is also called the slope of the implied volatility smile). Risk reversal essentially captures the presence of asymmetric downside and upside risk in currency markets. This is because, if foreign currency expected to depreciate (foreign currency is riskier than home currency), out of the money puts should be more expensive than symmetric out of the money calls. However, if exchange rates are

normally distributed, which is not the distribution for TRY currency, then symmetric puts and calls should have the same prices. Option traders use risk-reversal quotes to quantify the asymmetry of the implied volatility smile, which reflects the skewness of the risk-neutral currency return distribution. Hence, I use daily spot values of 25 delta risk reversal USD/TRY currency which comes from Bloomberg and Reuters Eikon (made available via Datastream)[2]

On the other hand, I will use Turkey's 5-year sovereign credit default swap spreads to capture perceived credit risk of Turkey while to creating the early warning index. Credit default swap (CDS) is one of the key credit derivatives product and provides insurance against a default on a particular company or sovereign entity. CDS isolates credit risk and allows financial institutions to trade and manage the credit risk in a similar way to the market risk. Credit risk can be transferred more efficiently than in the cash bond market. The buyer of the CDS makes periodic payments to the seller and in return obtains the right to sell a bond issued by the reference entity for its face value if a credit event occurs. [3]

I use the spread between weekly LIBOR and U.S. Overnight Index Swap (OIS) rates for the global funding factor, as discussed in the first chapter. The unsecured overnight interbank market is one of the most important and immediate sources of liquidity for the banks, and therefore it is a forward-looking indicator of the functioning of a financial system. Disruptions in unsecured interbank markets can lead to a lack of risk sharing between financial players and even trigger bank runs (Afonso et al., 2011).

[2]I also often use the latter to cross-check the former.

[3]The default of a company is known as a credit event and the occurrence of a credit event can be the result of bankruptcy, failure to make an interest payment, debt restructuring or a rating migration.

As Hatzius, Hooper, Mishkin, Schoenholtz, & Watson (2010) described, for market based EWI creation, two methods are primarily discussed, first is the weighted-sum and the second is the principal-components analysis method. In the first method, the weight of each financial variable is weights are assigned with respect to its estimate of the impact of changes on independent variables. And, estimates could come from reduced-form demand equations or the models of simulations with large-scale macroeconomic or vector autoregression (VAR).

Principal components analysis is the other method, in which from a number of variables, a common component created and this component can be used as the EWI. EWI finds a systematic pattern in the origin of financial crises which looks beyond the last prominent crisis to a larger sample. In most cases, EWIs are based on the current value of financial variables, but some take into account lagged or mathematically transformed financial variables as well.

Here, in this study, I assess the principal component analysis instead of the weighted-average approach because of lower misclassification errors. I did not use the outright levels of each variable; instead, I used z-score analysis, meaning that, standardizing the variable by subtracting its mean and dividing it by the standard deviation.

3.1.1 Principal Component Analysis

Principal Component Analysis (PCA) is a powerful statistical variable reduction procedure that finds patterns in high dimensional data and determines the number of principal components which affect the variability of the dependent variables under question. Mathematically speaking, PCA generates two valuable pieces of information: the eigenvalues and the corresponding eigenvectors of the correlation matrix provided from given multiple time series.[4] The eigenvalues denote the explanatory

[4]Refer to Anderson (1963) for a detailed discussion on PCA.

contribution of each eigenvector to the total variance.[5] The eigenvectors form an orthogonal basis which can be used to evaluate the interrelationships between different variables. Consequently, PCA reduces the dimension of the problem and allows the analyst to concentrate on a few critical components which explain the main sources of volatility. Economically speaking, PCA decomposes market risk into uncorrelated volatility factors.

In the literature, it is common to see PCA applied to financial data. Litterman & Scheinkman (1991) analyze yield curves, determine three factors explaining the majority of variability: level, slope, and curvature. Laloux, Cizeau, Bouchaud, & Potters (1999) investigate the fluctuations of stocks in S&P500 Index and argue the importance of random matrix theory in analyzing empirical correlation matrices. Zhu & Avellaneda (1997) analyze the term structure of implied volatility of foreign exchange options and develop a three-factor term structure model while observing that the term structure of volatility is a stochastic process away from equilibrium. Brady Bond Debt of Latin American countries are studied in Scherer & Avellaneda (2002), where the first component is attributed to regional Latin risk. Collin-Dufresne et al (2001) suggest that credit spreads of corporate bonds are mainly driven by a common systematic factor and Ericsson, Jacobs, Oviedo, et al. (2009) observe that theoretical variables such as leverage, volatility and the risk-free rate explain a significant amount of the variation in CDS data. In addition, Alexander & Leigh (1997) and Tsay (2002) discuss volatility modeling through PCA.

In my analysis, I use the sphericity test proposed by Flury (1988). In this approach, the sample is tested for sphericity, where the test-statistic for an asymptotic

[5]Regard λ_i for $i = 1, .., n$ as the eigenvalues of the sample correlation matrix, where n is the number of time series analyzed. Then, denoting λ_1 as the largest eigenvalue, its explanatory power; E is simply calculated as follows:

$$E = \frac{\lambda_1}{\sum_{i=1}^{n} \lambda_i}$$

distribution of χ^2 is defined as follows:

$$t - statistic = 2Nlog\frac{\lambda_i + \lambda_{i+1}}{2\sqrt{\lambda_i\lambda_{i+1}}}$$

In this representation, N is the number of observations, and λ_i is assumed to be the maximum likelihood estimate of the population eigenvalue ϕ_i. Based on sphericity logic, it is tested whether λ_i are all distinct, and whether the expression is indeed unique.

In a given population, any set of sample estimates λ_i and α_i are specific to the given sample, and may thus be subject to significant changes if different samples are used. Therefore, it is important to see how reliable or *stable* these estimates are in the sense of representing the population. It is interesting to note that the precision of sample estimates with respect to the population can be estimated using the given sample. Based on Flury (1988), the standard error of the eigenvector α_{mi} for $k \neq i$ is given as follows:

$$SE(\alpha_{mi}) = \left[\frac{1}{N}\lambda_i \sum_{k=1}^{n} \frac{\lambda_k}{(\lambda_k - \lambda_i)^2}\alpha_{mk}^2\right]^{\frac{1}{2}}$$

Here, N is the sample size of the n x n covariance matrix ψ, and α_m is the corresponding element of the ith eigenvector v_i. Although there is not a single statistical value that determines the limit of the standard error to be significant, it is reasonable to choose this limit as 0.25. This means that if SE(α_{mi}) > 0.25, it is concluded that the given eigenvector elements are not reliably representative of the corresponding eigenvector of the population. As a matter of fact, once it is shown that the eigenvalues are distinct, the stability test helps to conclude which of the eigenvectors show significant sampling variability, and which should be disregarded.

Based on the results of sphericity test, I can assess only one factor for the PCA. The first eigenvector can be used as an early warning index that directs investor to take the position by looking at it, or for regulators to take decisions pro-actively.

However, to establish when an indicator is issuing a crisis signal, the threshold has to be chosen well enough.

3.2 Threshold Regression

Threshold regression models are regime-switching models in which regimes are assumed to be triggered when a variable passes a certain threshold level which has to be calculated. Therefore, policy makers can find a possible opportunity to estimate crisis by assessing the threshold level before.

It is assumed a priori that the EWI-TR is the relevant threshold variable and the number of the regimes and the relevant thresholds have chosen to minimize the Akaike information criteria. Hence, I also opt for the shortest lag-order suggested by standard specification tests and F-Test suggests that a regression with two lags may suffice.

The observed data y_{it},q_{it},x_{it} :1 $\leq$ i $\leq$ n, 1 $\leq$ t $\leq$ T. The subscript i indexes the individual and t indexes time. The dependent variable y_{it} is a scalar, and stands for the CIRP deviations, q_{it} is scalar and represents the threshold variable EWI-TR and the regressor x_{it} EWI-TR is a k vector. The structural equation of interest is;

$$y_{it} = \mu_i + \beta_1' x_{it} I(q_{it} \leq \gamma) + \beta_2' x_{it} I(q_{it} > \gamma) + \epsilon_{it}, \tag{10}$$

where I(.) is the indicator function. An alternative intuitive way of writing (15) is

$$y_{it} = \begin{cases} \mu_i + \beta_1' x_{it} + \epsilon_{it}, & q_{it} \leq \gamma \\ \mu_i + \beta_2' x_{it} + \epsilon_{it}, & q_{it} > \gamma \end{cases}$$

Another compact representation of (15) is to set [6]

$$x_{it}(\gamma) = \begin{cases} x_{it} I(q_{it} \leq \gamma) \\ \\ x_{it} I(q_{it} > \gamma) \end{cases}$$

and $\beta = (\beta_1' \ \beta_2')'$ so that (15) equals

$$y_{it} = \mu_i + \beta' x_{it}(\gamma) + \epsilon_{it}.$$

EWI-TR is assumed to be the relevant threshold variable q_{it}, determining regime shifts in the dynamic relationship between EWI-TR and CIRP deviations, where the latter is expected to be significantly higher when the level of EWI-TR is at or above the estimated threshold (high stressed environment) than when it is below the threshold (low stress environment). Since I want to measure the effect of EWI-TR, I also include this variable as a regressor in my model.

Chan (1993) and Hansen (1999) recommend estimation of γ by least squares which they refer as easy to achieve by minimization of the sum of squared errors. The threshold parameter γ is then estimated by minimizing the sum of squared $S_1(\gamma)$

$$\gamma' = \underbrace{ArgMin S_1(\gamma)}_{\gamma}. \tag{11}$$

It is best to have balanced regimes after all, instead of a very small number of observations in each regime. In order to prevent this situation, I limit the minimum possibility of observations placed in the regimes by setting a certain number (say, 1% or 5%) that lies in each regime to the values of γ in Eq. (11).

[6] In the data, the regimes assumed to be divided into two parts due to the threshold variable (q_{it}) calculated measure. For the identification of β_1 and β_2 of the two regimes, x_{it} do not have to be time-invariant. The error ϵ_{it} is assumed to be identically distributed and independent with zero mean and finite variance δ^2. The analysis is asymptotic with fixed T as n $\to \infty$. For further discussion, refer to Hansen (1999).

3.2.1 Testing for a Threshold

The model formulation of Eq. (10) assumed that there exists some threshold effect in the data. However, since the formulation introduces extra(threshold) parameter in the model, estimation problems may arise due to specification error when there is no threshold effects in the data. Therefore, it is important to assess the presence of a threshold using a formal statistical test. I rely on the likelihood ratio test proposed in Hansen (1999). The null hypothesis of no threshold effect in the model Eq. (10) can be written as;

$$H_0 = \beta_1' = \beta_2'$$

Clearly, under H_0 the model takes the form of a linear model;

$$y_{it} = \mu_i + \beta' x_{it} + \epsilon_{it},\ \epsilon_{it} \geq 0,$$

which does not involve the threshold parameter γ. This hypothesis could be tested using a standard test. If I note S_0 as the sum of squares of the linear model, the approximate likelihood ratio test of H_0 is based on the following:

$$F_1 = \frac{S_0 - S_1(\gamma')}{\delta'^2}$$

where δ'^2 denotes a convergent estimate of δ^2 . The main problem is that under the null, the threshold parameter γ is not identified. Consequently, the asymptotic distribution of F_1 is not standard and, in particular, does not correspond to a chi-squared distribution. One solution is to use bootstrapping simulation to determine the asymptotic distribution of the statistic F_1. Hansen (1996) shows that using a bootstrap procedure to attain the asymptotic distribution works, so that p-values constructed from the bootstrap are asymptotically valid.

3.3 Results

Table 28 shows the estimated threshold $\gamma = 5.92$ in Panel A. It is striking that this threshold has a point estimate of 5.92 with a 5% confidence interval and is almost identical for various alternative specifications of the relationship (including whether or not lagged variables are included).

Moreover, as seen in Figure 11, for the last ten year, the threshold level of 5.92 is crossed over 8 times, and 7 times of these keep higher than the threshold level longer. In order to further investigate EWI-TR signaling power, I can check in the Table 26 levels, where the threshold first passed over. It is seen that for the eight different periods, EWI warned before 27 days in average for a stressed period, that means higher CIRP deviations here.

Regression results in Table 28 Panel B, confirm the presence of a structural shift in the data when EWI-TR crosses a certain threshold which is quite robust and indicates how important the level of the EWI-TR is for CIRP deviations. As the Panel B shows, the relationships below and above 5.92 are rather different from each other. When I investigate the EWI-TR effect on CIRP deviations, I find that levels of EWI-TR have a significantly larger impact on CIRP deviations above the threshold 5.92. As the regression in Panel B shows, the coefficient of the contemporaneous change below the threshold is 0.0094, while that above it is 0.5441 with the difference being statistically significant. This means that an increase in the level of EWI-TR by 10%, below the threshold of 5.92, induces a contemporaneous increase in the levels of CIRP deviations of %1, while above the threshold it induces a decrease of 5.4%. Conclusion, therefore, is that, when the level of EWI-TR is above the 5.92 threshold level, an intervention has to come to ease the CIRP deviations, which in overall calms the markets. Finally, Panel C in Table 28 shows that, while the existence of a unique threshold is valid with 0.002 p-value, two threshold estimations of CIRP deviations and EWI-TR are not robust.

EWI-TR First Warning Dates and Related Crisis

No	EWI - TR	CIRP	Days	Crisis Name
1	19.05.2006	28.06.2006	40	CBRT rate hike
2	30.07.2007	14.08.2007	15	Subprime Crisis
3	07.10.2008	31.10.2008	24	Lehman Crisis
4	06.05.2010	01.06.2010	26	European Crisis - Greece
5	08.08.2011	10.08.2011	2	Wrong Signal
6	16.05.2012	26.06.2012	41	European Crisis
7	05.06.2013	11.07.2013	36	FED announcements
8	07.01.2016	04.02.2016	28	EM Crisis

Table 26: Date of Warnings - Date of Highest Level of CIRP Deviations

3.4 Conclusion

This paper presents an index which can be used as an early warning indicator for Turkey, which assesses a parsimonious set of macroeconomic indicators, aggregated using principal component analysis. The early warning indexes provide a useful tool to monitor Turkey's risks to sharp growth declines arising from shocks to Turkey and to inform judgment-based approaches. The analysis also suggests the sensitivity of crisis risks to varying exogenous and internal shocks of the country. In particular, Turkey as being an emerging country cannot be isolated from the sub-prime crisis of United States of America and later debt crisis of Europe.

Figure 11: EWI-TR and Major Events

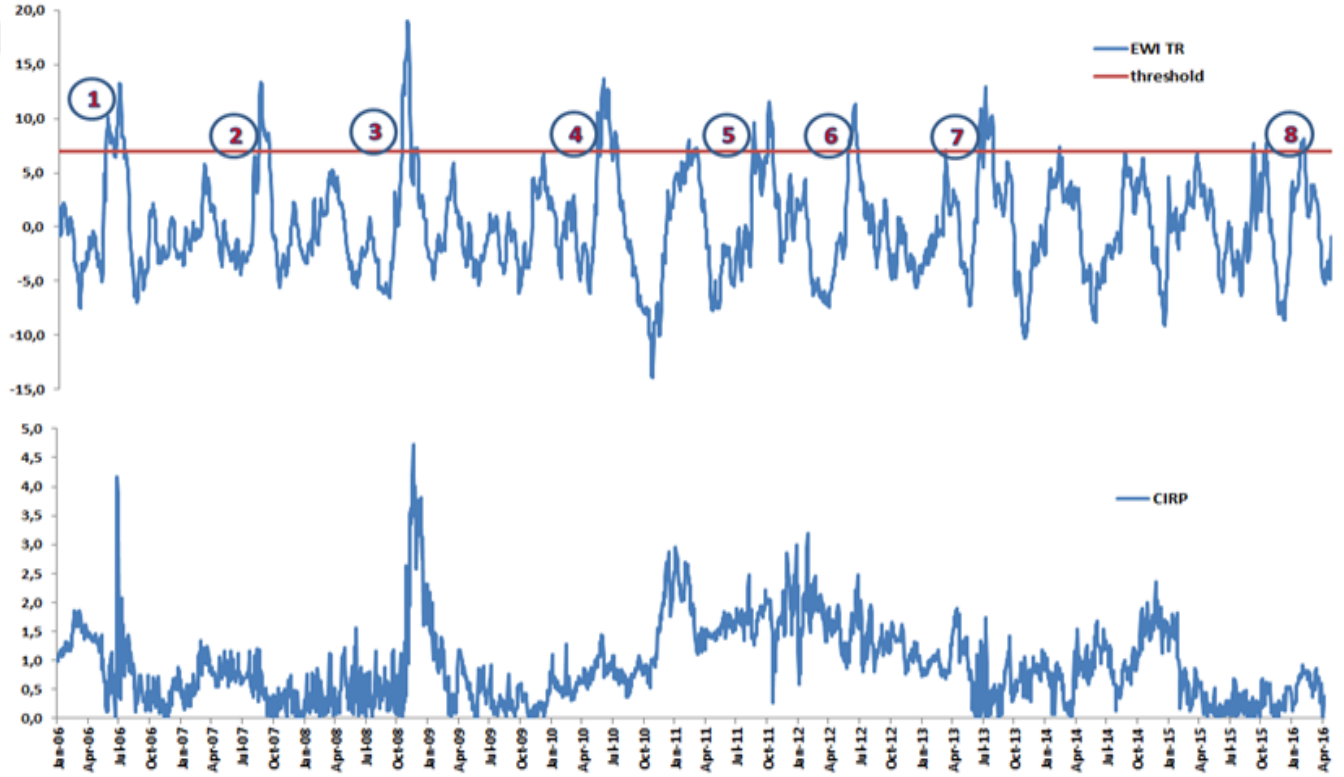


Table 27: Compilation of Key Indicators in the EWI Literature

	Summary of Relevant Early Warning Indicators				
Leading Indicator	KLR (1998)	Hawkins and Klau (2001)	Abiad (2003)	Frankel and Saravelos (2012)	Total Number
Reserves	14	18	13	5	50
Real Exchange Rate	12	22	11	3	48
GDP	6	15	1	3	25
Credit	5	8	6	3	22
Current Account	4	10	6	2	22
Money Supply	2	16	1	0	19
Exports or Imports	2	9	4	2	17
Inflation	5	7	1	2	15
Equity Returns	1	8	3	1	13
Real Interest Rate	2	8	2	1	13
Debt Composition	4	4	2	0	10
Budget Balance	3	5	1	0	9
Terms of Trade	2	6	1	0	9
Contagion	1	5	0	0	6
Political/Legal	3	2	1	0	6
Capital Flows	3	0	0	0	3
External Debt	0	1	1	1	3
Number of Studies	28	28	20	7	83

This table summarizes the number of times a particular indicator was found to be statistically significant across the reviews and additional studies cited above. The indicator listing is based on Hawkins & Klau (2000) with some modifications.

The Threshold Regression Results

Notes: This table reports results from the following threshold regression;

$$y_{it} = \mu_i + \beta_1' x_{it} I(q_{it} \leq \gamma) + \beta_2' x_{it} I(q_{it} > \gamma) + \epsilon_{it},$$

The dependent variable y_{it} is scalar, and stands for the CIRP Deviations, q_{it} is scalar and represents the threshold variable EWI-TR levels and the regressor x_{it} EWI-TR levels is a k vector. Panel A focuses on the threshold estimates and γ denotes for the threshold pension fund size. The confidence interval for the threshold parameters corresponds to the no rejection region of confidence level 95% associated with the likelihood ratio statistic for test of the threshold parameters (see Hansen, (1999)). Panel B reports the panel threshold regression results for (β_1) and (β_2). Three stars (***) denote significance at the 1% confidence level, while two stars (**) and one (*) star denote significance at the 5% and 10% confidence levels. The t-statistics in parentheses are computed with an estimator of the covariance matrix robust to heteroskedasticity. Panel C shows the test results for threshold estimates. F_1 denotes the Fisher type statistic associated with the test of null of no threshold against one threshold and F_1 corresponds to the test one threshold against two thresholds. P-values and critical values are computed from 300 simulations.

CIRP and EWI-TR

Panel A: Threshold Estimates	
EWI-TR (γ)	5.92
Residual sum of squares	186.4
Panel B: Regression Results	
Regime 1: $q_{it} \leq \gamma$	
EWI-TR (β_1)	0.0094
	(1.54)
Regime 2: $q_{it} > \gamma$	
EWI-TR (β_2)	0.5441**
	(2.84)
Panel C: Test for Threshold Estimates	
F_1 test statistic	32.4
P-value	0.002
F_2 test statistic	25.8
P-value	0.651

Table 28: The Threshold Regression Results

Chapter IV

CONCLUSION

This paper shows that an anomaly that has taken place at the very recent credit crisis. It is the deviations from the law of one price parity using covered interest rate parity (CIRP). I show across the five maturity point both in time-series and cross-sectional variations that these deviations severely violated not only in emerging markets but also in developed ones. I have found that these deviations are time varying and state dependent for both markets and come up with a reasoning that these deviations were driven by global and local factors. While for developing countries global factors are important, in emerging countries local factors turn out to be the most important reasons. Therefore, I provide an insight into how an economy is influenced by specific market conditions and how certain risk factors may cause the same arbitrage opportunity in different economies. Furthermore, I show that the economic policies during the crisis that have taken by governments and central banks were important and most importantly not only swap lines but also stress test announcements and other related news events are significant to relieve deviations. Lastly, by focusing on the country specific risk factors that were defined earlier, I come up with an early warning indicator for Turkey, and create an index that has a signaling power for the Turkish market.

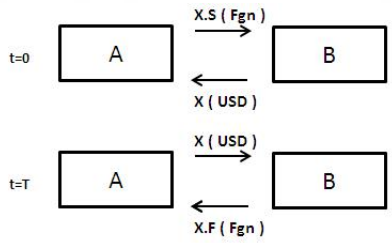
Chapter V

APPENDIX

5.1 Usage of FX Swaps

In the FX swap contracts, an agent borrows from a certain currency, and lends in different currency simultaneously. The repayment is fixed to a certain FX forward rate which is agreed at the beginning of the agreement. Since the repayment obligation serves as the collateral, the FX swaps can be regarded as FX risk-free collateralized funding. Let's assume that the transaction occurs over US dollars (USD) and South African Rand (ZAR). The contract may be represented as follows:

Figure 12: FX Swap Example



At t_0 time zero, A borrows X USD from B and lends X.S ZAR to B, where S is the FX spot rate. When the contract expires, A returns X USD to B, and B returns X.F ZAR to A, where F is the FX forward rate, determined at the beginning of the contract.

FX swaps are used to create foreign currencies for financial institutions, and also used for speculative trading. Up to one year, FX swaps are highly liquid, for the longer term contracts, popularity is increasing in recent years.

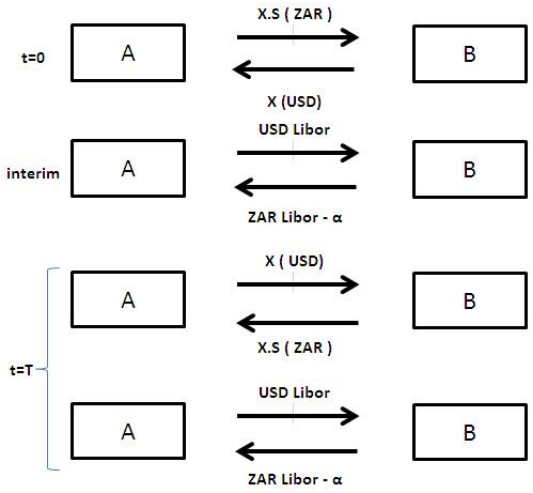
Since FX swaps and the currency swaps works same, sometimes much confused to assess the instrument. The primary differences of FX swaps from the currency swap

are (i) during the swap, no exchanges of interim interests; and (ii) at the end of the swap, the amount is different than the amount initiated at the start of the contract.

5.2 Usage of Cross Currency Basis Swap

Cross-currency basis swap is an exchange of a floating rate interest in one currency for a floating rate interest in other currency. Cross-currency basis swaps are used for the longer term with respect to FX swaps, and used to fund foreign investments and to convert foreign liabilities. They may be represented as follows:

Figure 13: Cross Currency Swap



As an example, on 8 March 2010, 1 USD is traded for 7,36 South African Rand (ZAR), and assume that there are two counterparties A and B who wish to make a cross-currency basis swap. At t_0, A borrows X.S ZAR from B, and lends B the amount of X USD, where S is the FX spot rate. During the contract term, A receives USD 3-month LIBOR from, and pays ZAR 3-month LIBOR - α to B, every three months, where α denotes the basis swap. At the end of the swap contract, A returns X.S ZAR to, and receives X USD from B, where S is the same FX spot rate as determined at the beginning of the contract. In this sense, cross-currency basis swaps serve the same economic purpose as FX swaps, only with the exception that in the former, the contract includes the exchange of floating rates. One may notice the role of α in this context. In default-free cross-currency basis swaps, both parties are guaranteed to

receive the interest rate in the corresponding currency, but when LIBOR rates are concerned, there exists a difference between the two term structure credit spreads. Since 3-month ZAR LIBOR has more credit risk than 3-month USD LIBOR, then USD LIBOR would trade fair against ZAR LIBOR minus basis.[1]

Given that LIBOR rates are used in the CIRP, I may develop a new equation using swap rates and basis swap spread levels. The following definitions are given:

S: T-year local par swap rate with fixed flows paid quarterly r: T-year local zero-coupon swap rate $\tilde{r}$: T-year foreign zero-coupon swap rate X: A swap rate of 3-month local LIBOR plus X is fair against 3-month foreign LIBOR.

Based on Tuckman and Porfirio (2003), the time T local payoff in a no-arbitrage environment can be expressed as follows:

$$S_0\left[(1+X/S)(1+r)^T - X/S\right] = F(1+\tilde{r})^T$$

or

$$\frac{S_0\left[(1+X/S)(1+r)^T - X/S\right]}{(1+\tilde{r})^T} = F \tag{12}$$

As opposed to the unobservable default rates, the new equality depends on swap rates and cross-currency market basis swap spreads. With algebraic arrangements, I may express the new equality as follows:

$$F = S_0\frac{(1+r)^T}{(1+\tilde{r})^T}\left[1+PV(X)\right] \tag{13}$$

where PV(X) is the represent value of X, or in other words, the cross currency basis swap spread. As shown previously, the deviation in covered interest rate parity is represented as follows:

$$\text{Deviation} = F(1+\tilde{r})^T - S_0(1+r)^T \tag{14}$$

Based on (6), I may then claim:

$$\text{Deviation} = F(1+\tilde{r})^T - S_0(1+r)^T = S_0(1+r)PV(X) \tag{15}$$

[1]The same logic would apply to a transaction, where USD LIBOR + α trades fair against ZAR LIBOR.

In this sense, the basis swap spread is a function of covered interest rate parity deviation. X must be zero if covered interest rate parity holds.

The cross-currency basis swap market is primarily used to fund foreign currencies and to convert currencies of their liabilities for longer than one year.

5.3 Cross Currency Basis Swap

Proposition: A cross-currency basis swap between a dollar floater and a foreign floater is worth zero.

Let r_t^i be the risk-free rates for $i = d, f$, where d denotes the dollar rate and f is the foreign rate. Let S_t be the spot rate having the following dynamics:

$$dS_t = (r_t^d - r_t^f)S_t dt + \sigma S_t dW_t, \tag{16}$$

where $\{W_t\}$ is a standard Brownian motion. The solution to this differential equation is:

$$S_t = S_0(e^{\int_0^t (r_u^d - r_u^f)du + \sigma W_t - \frac{1}{2}\sigma^2 t}). \tag{17}$$

The value of a foreign currency claim in dollars can be found by taking the expectation of the dollar discounted cash flows of the foreign claim converted into dollars. More specifically, the dollar value of a foreign floating rate note (foreign floater) at $t = 0$, which I denote as V_0 is:

$$\begin{aligned} V_0 &= \mathbb{E}[e^{-\int_0^T r_u^d du} S_T] + \int_0^T \mathbb{E}[e^{-\int_0^t r_u^d du} S_t r_t^f]dt \\ &= S_0 \mathbb{E}[e^{-\int_0^T r_u^f du + \sigma W_T - \frac{1}{2}\sigma^2 T}] + \int_0^T \mathbb{E}[e^{-\int_0^t r_u^d du} S_t r_t^f]dt, \end{aligned} \tag{18}$$

where the first term of (18) follows from inserting (17) into the equation. In addition, it can be shown that the second term equals (see Tuckman and Porfirio, 2003)):

$$\begin{aligned} \int_0^T \mathbb{E}[e^{-\int_0^t r_u^d du} S_t r_t^f]dt &= S_0 \int_0^T \mathbb{E}[e^{(-\int_0^t r_u^f du + \sigma W_t - \frac{1}{2}\sigma^2 t)} r_t^f]dt \\ &= S_0 - S_0 \mathbb{E}[e^{-\int_0^T r_u^f du + \sigma W_T - \frac{1}{2}\sigma^2 T}], \end{aligned} \tag{19}$$

which implies that

$$\begin{aligned} V_0 &= S_0 \mathbb{E}[e^{-\int_0^T r_u^f du + \sigma W_T - \frac{1}{2}\sigma^2 T}] + S_0 - S_0 \mathbb{E}[e^{-\int_0^T r_u^f du + \sigma W_T - \frac{1}{2}\sigma^2 T}] \\ &= S_0. \end{aligned} \tag{20}$$

From Tuckman and Porfirio (2003), the dollar floating rate note (foreign floater) is worth its notional amount, and from (20), the foreign floater is also worth its notional amount. This shows that a cross-currency basis swap between a dollar floater and a foreign floater is worth zero.

5.4 Garch BEKK and Garch DCC

The BEKK representation of the Garch model solves the problem of positive definiteness by developing a general quadratic form for the conditional covariance equation. This may be shown as follows:

$$H_t = C^{'}C + A^{'}\Psi_{t-1}\Psi_{t-1}^{'}A + G^{'}H_{t-1}G$$

where;

$$H_t = \begin{bmatrix} h_{11,t} & h_{12,t} \\ h_{21,t} & h_{22,t} \end{bmatrix}, C = \begin{bmatrix} c_{11} & c_{12} \\ 0 & c_{22} \end{bmatrix}, \Psi = \begin{bmatrix} \epsilon_{1t} \\ \epsilon_{2t} \end{bmatrix}, A = \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix}, G = \begin{bmatrix} g_{11} & g_{12} \\ g_{21} & g_{22} \end{bmatrix}$$

where H is the conditional variance-covariance matrix, C is constant, A is the Arch coefficient matrix and G is the Garch coefficient matrix. The quadratic nature of the RHS of the equation ensures that H is positive-definite. The statistical significance of Garch parameters g_{ii} is indicative of the extent of volatility clustering and if their sum with Arch parameters (a_{ii}) exceeds unity, this implies a tendency for volatility to increase over time. Bollerslev (1990) suggested constant conditional correlations model, which restricts the correlation between two asset returns to be constant over time. Nevertheless, in the light of rejection of constant correlation (Bera & Kim, 2002), (Engle, 2002) proposed the Garch-DCC Model, which includes the dynamic conditional correlation factor. The model is as below:

$$\begin{aligned} D_t^2 &= diag(w_i) + diag(\kappa_i) \circ r_{t-1}r_{t-1}^{'} + diag(\lambda_i) \circ D_{t-1}^2 \\ \epsilon &= D_t^{-1}r_t \\ Q_t &= S \circ (II' - A - B) + A \circ \epsilon_{t-1}\epsilon_{t-1}^{'} + B \circ Q_{t-1} \\ R_t &= diagQ_t{}^{-1}Q_t diagQ_t{}^{-1} \end{aligned}$$

Where R is the correlation matrix, $\circ$ is the Hadamard Product and D is the variance-covariance matrix. Second equation expresses the assumption that each of the assets follows a univariate Garch process.

5.5 Sphericity and Stability Tests

In the principal component analysis, the population covariance matrix Ψ can be expressed as

$$\Psi = \Upsilon\Theta\Upsilon',$$

where Υ is an orthogonal eigenvector matrix with elements $\gamma_{ii} > 0$, and Θ is a diagonal eigenvalue matrix with elements $\phi_{11} \geq ... \geq \phi_{nn}$. Likewise, the sample covariance matrix ψ can simply be shown as $\psi = \upsilon\theta\upsilon'$, where, in accordance with the population, the elements of the orthogonal eigenvector matrix are $\alpha_{ii} > 0$, and the elements of the diagonal eigenvalue matrix are $\lambda_{11} \geq ... \geq \lambda_{nn}$.

This relationship is derived from the fact that the eigenvector matrices are orthogonal, or in other words, $\upsilon\upsilon' = I$, where I is the identity matrix. The given orthogonality condition makes it possible to express the sample covariance matrix as follows:

$$\Psi\Upsilon = \Upsilon\Theta \Rightarrow \Psi\Upsilon\Upsilon' = \Upsilon\Theta\Upsilon'.$$

Then,

$$\Psi I = \Upsilon\Theta\Upsilon' \Rightarrow \Psi = \Upsilon\Theta\Upsilon'.$$

The expression is unique if the eigenvalues ϕ_{ii} are all *distinct*. (Anderson, 1963) states that if population is uniquely represented, then the sample characteristic values are assumed to be the maximum likelihood estimates of the population.

This is the place where sphericity test comes in. It will be tested whether the sample eigenvalues λ_{ii} (which from now on I will simply denote as λ_i) are significantly different from each other, and whether the expression is indeed unique. There are two types of sphericity conditions, namely univariate sphericity and multivariate sphericity.

Univariate Sphericity:

The univariate sphericity condition, which is designed for a single group, holds if and only if;

$$\Upsilon\Psi\Upsilon' = \phi I.$$

The ϕ is a scalar greater than 0. Univariate sphericity implies that there is a single common eigenvalue that represents the entire population covariance matrix. This simply means that ϕ_{11}= ... = $\phi_{nn} = \phi$.

Multivariate Sphericity:

The multivariate sphericity condition assumes sphericity not only in the population covariance matrix and in a single occasion, but across different occasions as well, where Ψ_1=...=Ψ_j for a number of j occasions.

The null hypothesis is that sphericity condition holds in the sample. There are various types of sphericity tests concerning univariate or multivariate sphericity conditions. Mauchly (1940) proposed a way to test the hypothesis of whether a normal n-variate sample is chosen from a normal n-variate population for which correlations are all zero and variances are all equal. Bock (1975) proposed a two-stage method where first the null hypothesis that $\Upsilon\Psi\Upsilon'$ is a diagonal matrix is tested, and second, the homogeneity of the variance is tested. Suguira (1972) and Nagao (1973) also proposed tests where sphericity depends on the ratio $\sum\lambda_i^2/(\sum\lambda_i)^2$. In their paper, Robey & Barcikowski (1987) discuss the advantages and disadvantages of these various tests.

At this point, there is an important question to ask: What is the asymptotic distribution of the test statistic? Mauchly (1940) shows that for large samples, $-2N\log(L_{sn})$ is distributed approximately like χ^2 with degrees of freedom of $n(n-1)/2$, where L_{sn} is the test-statistic, and N is the number of observations. The

test statistic of Bock (1975) is also distributed approximately as χ^2 with degrees of freedom of $n(n-1)/2$, which is in accordance with Mauchly.

Bibliography

Abiad, A. (2003). Early warning systems: A survey and a regime-switching approach. *IMF Working Papers*, *32*.

Acharya, V. V., & Merrouche, O. (2010). Precautionary hoarding of liquidity and inter-bank markets: evidence from the sub-prime crisis. *NBER Working Paper Series*.

Acharya, V. V., & Pedersen, L. H. (2005). Asset pricing with liquidity risk. *Journal of Financial Economics*, *77*, 375-410.

Adrian, T., & Shin, H. S. (2010). Liquidity and leverage. *Journal of Financial Intermediation*, *19*(3), 418-437.

Afonso, G., Kovner, A., & Schoar, A. (2011). Stressed, not frozen: The federal funds market in the financial crisis. *Journal of Finance*, *66*(4), 1109-1139.

Aggarwal, R., Inclan, C., & Leal, R. (1999). Volatility in emerging stock markets. *Journal of Financial and Quantitative Analysis*, *34*(1), 33-55.

Agmon, T., & Bronfeld, S. (1975). The international mobility of short-term arbitrage capital. *Journal of Business Finance and Accounting*, *2*, 269-278.

Aizenman, J., & Pasricha, K. P. (2009). Selective swap arrangements and the global financial crisis: Analysis and interpretation. *NBER Working Paper Series*.

Akram, F., Rime, D., & Sarno, L. (2008). Arbitrage in the foreign exchange market: Turning on the microscope. *Journal of International Economics*, *76*(2), 237-253.

Alexander, C. O., & Leigh, C. T. (1997). On the covariance matrices used in value at risk models. *The Journal of Derivatives*, *4*(3), 50–62.

Aliber, R. Z. (1973). The interest rate parity theorem: A reinterpretation. *Journal of Political Economy*, *81*, 1451-1459.

Amatatsu, Y., & N., B. (2008). Covered interest parity and the relative effectiveness

of forward and money market hedging. *Bank of Japan Working Paper Series*(07-E-12).

Amihud, Y., & Mendelson, Y. (1986). Asset pricing and the bid/ask spread. *Journal of Financial Economics*, *17*, 223-249.

Anderson, T. W. (1963). Asymptotic theory for principal component analysis. *The Annals of Mathematical Statistics*, *34*(1), 122–148.

Baba, N. (2009). Dynamic spillover of money market turmoil from fx swap to cross-currency swap markets: Evidence from the 2007-2008 turmoil. *Journal of Fixed Income*, *18*(4), 24-38.

Bai, J., & Collin-Dufresne, P. (2011). The cds-bond basis during the financial crisis of 2007-2009. *SSRN Working Paper*.

Baillie, R. T., Booth, G. G., Tse, Y., & Zabotina, T. (2002). Price discovery and common factor models. *Journal of Financial Markets*, *5*, 309-321.

Baker, M., & Stein, J. (2004). Market liquidity as a sentiment indicator. *Journal of Financial Markets*, *7*(3), 271-299.

Baker, M., & Wurgler, J. (2007). Market liquidity as a sentiment indicator. *Journal of Economic Perspectives*, *21*(2), 129-151.

Bansal, R., & Yaron, A. (2005). Risks for the long run: A potential resolution of asset pricing puzzle. *Journal of Finance*, *59*(4), 1481-1509.

Beachy, B. (2012). A financial crisis manual causes, consequences, and lessons of the financial crisis. *Global Development and Environment Institute Working Paper*, *12*(06).

Bera, A. K., & Kim, S. (2002). Testing constancy of correlation and other specifications of the bgarch model with an application to international equity returns. *Journal of Empirical Finance*, *9*(2), 171-195.

Bernanke, B. (2009). The crisis and the policy response. *The Stamp Lecture of the London School of Economics, London, England*.

Bernanke, B., & Gertler, M. (1989). Agency costs, net worth, and business fluctuations. *American Economic Review*, *79*(1), 14-31.

BIS. (2010). The functioning and resilience of cross-border funding markets. committee on the global financial system publications. *Bank of International Settlements*(37).

Blanco, R., Brennan, S., & Marsh, I. W. (2005). An empirical analysis of the dynamic relation between investment-grade bonds and credit default swaps. *Journal of Finance*, *60*(5), 2255-2281.

Blenman, L. P. (1991). A model of covered interest arbitrage under market segmentation. *Journal of Money, Credit and Banking*, *23*(4), 706-717.

Bock, M. E. (1975). Minimax estimators of the mean of a multivariate normal distribution. *The Annals of Statistics*, 209–218.

Bollerslev, T. (1990). Modelling the coherence in short-run nominal exchange rates: A multivariate generalized arch model. *Review of Economics and Statistics*, *72*(3), 498-505.

Bollerslev, T., Engle, R. F., & Wooldridge, J. M. (1988). A capital asset pricing model with time-varying covariances. *Journal of Political Economy*, *96*, 116-131.

Borio, C. E. (2008). The financial turmoil of 2007-?: a preliminary assessment and some policy considerations.

Brunnermeier, M., Nagel, S., & Pedersen, L. (2008). Carry trades and currency crashes. *NBER Working Paper Series*.

Brunnermeier, M., & Pedersen, L. H. (2009). Market liquidity and funding liquidity. *Review of Financial Studies*, *22*(6), 2201-2238.

Buraschi, A., Sener, E., & Menguturk, M. (2011). The dynamics of limits to arbitrage: An empirical investigation. *Working Paper, Imperial College London and Ozyegin University*.

Campbell, J. Y., & Cochrane, J. H. (1999). By force of habit: A consumption-based

explanation of aggregate stock market behavior. *Journal of Political Economy*, *107*(2), 205-251.

Campbell, J. Y., & Taksler, G. B. (2003). Equity volatility and corporate bond yields. *Journal of Finance*, *58*, 2321-2349.

Chan, K.-S. (1993). Consistency and limiting distribution of the least squares estimator of a threshold autoregressive model. *The annals of statistics*, 520–533.

Christensen, J. H. E., Lopez, J. A., & Rudebusch, G. D. (2009). Do central bank liquidity facilities affect interbank lending rates? *Working Paper, Federal Reserve Bank of San Francisco*.

Coffey, N., Hrung, W., & Sarkar, A. (2009). Capital constraints, counterparty risk and deviations from covered interest rate parity. *Working Paper, The Federal Reserve Bank of New York*.

Collin-Dufresne, P., Goldstein, R. S., & Martin, J. S. (2001). The determinants of credit spread changes. *The Journal of Finance*, *56*(6), 2177–2207.

Constantinides, G. M. (1986). Capital market equilibrium with transaction costs. *Journal of Political Economy*, *96*, 842-862.

De Long, J. B., Shleifer, A., Summers, L. H., & Waldmann, R. J. (1990). Noise trader risk in financial markets. *Journal of Political Economy*, *98*(4), 703-738.

Diebold, F. X., & Li, C. (2006). Forecasting the term structure of government bond yields. *Journal of Econometrics*, *130*, 337-364.

Domowitz, I., Glen, J., & Madhavan, A. (1998). Country and currency risk premia in an emerging market. *Journal of Financial and Quantitative Analysis*, *33*(2), 189-216.

Dooley, M., & Hutchison, M. (2009). Transmission of the u.s. subprime crisis to emerging markets: Evidence on the decoupling-recoupling hypothesis. *Journal of International Money and Finance*, *28*(8), 1331-1349.

Duffie, D. (2010). Asset price dynamics with slow-moving capital. *Journal of Finance*,

65, 1238-1268.

Duffie, D., & Huang, M. (1996). Swap rates and credit quality. *Journal of Finance*, *51*, 921-950.

Engle, R. (2002). Dynamic conditional correlation: A simple class of multivariate generalized autoregressive conditional heteroskedasticity models. *Journal of Business and Economic Statistics*, *20*(3), 339-350.

Engle, R., & Kroner, K. (1995). Multivariate simultaneous generalized arch. *Econometric Theory*, *11*, 122-150.

Ericsson, J., Jacobs, K., Oviedo, R., et al. (2009). The determinants of credit default swap premia. *Journal of Financial and Quantitative Analysis*, *44*(1), 109–132.

Estrella, A., & Hardouvelis, G. A. (1991). The term structure as a predictor of real economic activity. *The Journal of Finance*, *46*(2), 555–576.

Eun, C. S., & Sabherwal, S. (2003). Cross-border listings and price discovery: evidence from u.s. listed canadian stocks. *Journal of Finance*, *58*(2), 549-575.

Fama, E. F. (1970). Efficient capital markets: A review of theory and empirical work. *Journal of Finance*, *25*(2), 385-417.

Fama, E. F. (1991). Efficient capital markets: Ii. *Journal of Finance*, *46*(5), 1575-1617.

Feldhütter, P., & Lando, D. (2008). Decomposing swap spreads. *Journal of Financial Economics*, *88*(2), 375–405.

Fletcher, D., & Taylor, L. W. (1996). Swap covered interest parity in long-date capital market. *Review of Economics and Statistics*, *78*, 530-538.

Fluery, B. (1988). *Common principal components and related multivariate models.*

Flury, B. (1988). *Common principal components & related multivariate models.* John Wiley & Sons, Inc.

Fong, W. M., Valente, G., & Fung, J. K. W. (2010). Covered interest arbitrage profits: The role of liquidity and credit risk. *Journal of Banking and Finance*,

34(5), 1098-1107.

Fontaine, J. S., & Garcia, R. (2009). Bond liquidity premia. *Working Paper, Bank of Canada*.

Forbes, K., & Rigobon, R. (2002). No contagion, only interdependence: Measuring stock market co-movements. *Journal of Finance*, *57*(5), 2223-2261.

Frankel, J., & Saravelos, G. (2012). Can leading indicators assess country vulnerability? evidence from the 2008–09 global financial crisis. *Journal of International Economics*, *87*(2), 216–231.

Frankel, J. A. (1992). Measuring international capital mobility: A review. *American Economic Review*, *82*(2), 197-202.

Frenkel, J., & Levich, R. M. (1975). Covered interest parity: Unexploited profits? *Journal of Political Economy*, *83*(2), 325-338.

Gabaix, X., Krishnamurthy, A., & Vigneron, O. (2007). Limits of arbitrage: Theory and evidence from the mortgage-backed securities market. *Journal of Finance*, *62*(2), 557-596.

Garleanu, N., & Pedersen, L. H. (2010). Margin-based asset pricing and deviations from the law of one price. *Working Paper, University of California, Berkeley*.

Goetzmann, W., Lingfeng, L., & Rouwenhorst, G. (2005). Long-term global market correlations. *Journal of Business*, *78*, 1-38.

Goldberg, L. S., Kennedy, C., & Miu, J. (2010). Central bank dollar swap lines and overseas dollar funding costs. *Federal Reserve Bank of New York Staff Papers*(429).

Gonzalo, J., & Granger, C. W. J. (1995). Estimation of common long-memory components in cointegrated systems. *Journal of Business and Economic Statistics*, *13*, 27-35.

Greenspan, A. (2008). Banks need more capital. *The Economist. Retrieved from http://www.economist.com/node/12813430*.

Griffoli, T. M., & Ranaldo, A. (2011). Limits to arbitrage during the crisis: funding liquidity constraints and covered interest parity. *Working Paper, The Swiss National Bank*.

Gromb, D., & Vayanos, D. (2010). Limits of arbitrage: The state of the theory. *Working Paper, The Paul Woolley Centre*.

Grossman, S. J., & Stiglitz, J. E. (1976). Information and competitive price systems. *American Economic Review*, *66*, 246-252.

Hansen, B. E. (1996). Inference when a nuisance parameter is not identified under the null hypothesis. *Econometrica: Journal of the econometric society*, 413–430.

Hansen, B. E. (1999). Threshold effects in non-dynamic panels: Estimation, testing, and inference. *Journal of econometrics*, *93*(2), 345–368.

Harvey, A., Ruiz, E., & Shephard, N. (1994). Multivariate stochastic variance models. *Review of Economic Studies*, *61*, 247-264.

Hasbrouck, J. (1995). One security, many markets: Determining the contributions to price discovery. *Journal of Finance*, *50*(4), 1175-1199.

Hatzius, J., Hooper, P., Mishkin, F. S., Schoenholtz, K. L., & Watson, M. W. (2010). *Financial conditions indexes: A fresh look after the financial crisis* (Tech. Rep.). National Bureau of Economic Research.

Hawkins, J., & Klau, M. (2000). Measuring potential vulnerabilities in emerging market economies.

IMF. (2008). *World economic outlook*.

Kaminsky, G., Lizondo, S., & Reinhart, C. M. (1998). Leading indicators of currency crises. *Staff Papers-International Monetary Fund*, 1–48.

Keynes, J. (1923). A tract on monetary reform. *Macmillan, London*.

Kiyotaki, N., & Moore, J. (2002). Evil is the root of all money. *American Economic Review*, *92*(2), 62-66.

Krishnamurthy, A. (2010). How debt markets have malfunctioned in the crisis.

Journal of Economic Perspectives, *24*(1), 3-28.

Laloux, L., Cizeau, P., Bouchaud, J.-P., & Potters, M. (1999). Noise dressing of financial correlation matrices. *Physical review letters*, *83*(7), 1467.

Lamoureux, C. G., & Lastrapes, W. (1990). Persistence in variance, structural change and the garch model. *Journal of Business and Economic Statistics*, *2*, 225-234.

Lee, C., Shleifer, A., & Thaler, R. H. (1991). Investor sentiment and the closed-end fund puzzle. *Journal of Finance*, *46*(1), 75-109.

Lehmann, B. N. (2002). Some desiderata for the measurement of price discovery across markets. *Journal of Financial Markets*, *5*, 259-276.

Levi, M. D. (1977). Taxation and abnormal international capital flows. *Journal of Political Economy*, *85*(3), 635-646.

Litterman, R. B., & Scheinkman, J. (1991). Common factors affecting bond returns. *The Journal of Fixed Income*, *1*(1), 54–61.

Longstaff, F. A. (2010). The subprime credit crisis and contagion in financial markets. *Journal of Financial Economics*, *97*, 436-450.

Longstaff, F. A., Pan, J., Pedersen, L. H., & Singleton, K. J. (2008). How sovereign is sovereign credit risk? *American Economic Journal: Macroeconomics, forthcoming*, *97*.

Ludvigson, S. C., & Ng, S. (2009). Macro factors in bond risk premia. *Review of Financial Studies*, *22*(12), 5027-5067.

Lustig, H., Roussanov, N., & Verdelhan, A. (2011). Common risk factors in currency markets. *Review of Financial Studies*, *24*(11), 3731-3777.

Lyons, R. K. (2001). New perspective on fx markets: Order-flow analysis. *International Finance*, *4*(2), 303-320.

Mauchly, J. W. (1940). Significance test for sphericity of a normal n-variate distribution. *The Annals of Mathematical Statistics*, *11*(2), 204–209.

McAndrews, J., Sarkar, A., & Wang, Z. (2008). The effect of the term auction facility

on the london interbank offered rate. *Federal Reserve Bank of New York Staff Report*(335).

McCauley, R. N., & McGuire, P. M. (2009). Dollar appreciation in 2008: Safe haven, carry trades, dollar shortage and overhedging. *Bank of International Settlement Quarterly Review*, 85-93.

McCormick, F. (1979). Covered interest arbitrage: Unexploited profits? comment. *Journal of Political Economy*, *87*(2), 411-417.

Nagao, H. (1973). Asymptotic expansions of the distributions of bartlett's test and sphericity test under the local alternatives. *Annals of the Institute of Statistical Mathematics*, *25*(1), 407–422.

Obstfeld, M., Shambaugh, J. C., & Taylor, A. M. (2009). Financial instability, reserves, and central bank swap lines in the panic of 2008. *American Economic Review*, *99*(2), 480-486.

Pan, J., & Singleton, K. J. (2008). Default and recovery implicit in the term structure of sovereign cds spreads. *Journal of Finance*, *63*(5), 2345-2384.

Pastor, L., & Stambaugh, R. (2003). Liquidity risk and price discovery. *Journal of Political Economy*, *111*(3), 642-685.

Phillips, P. C., & Sul, D. (2007). Bias in dynamic panel estimation with fixed effects. *Journal of Econometrics*, *137*(1), 162-188.

Robey, R. R., & Barcikowski, R. S. (1987). Sphericity tests and repeated measures data.

Scherer, K. P., & Avellaneda, M. (2002). All for one and one for all? a principal component analysis of latin american brady bond debt from 1994 to 2000. *International Journal of Theoretical and Applied Finance*, *5*(1), 79-106.

Shleifer, A. (2000). Inefficient markets. *Oxford University Press, New York*.

Shleifer, A., & Vishny, R. W. (1997). The limits of arbitrage. *Journal of Finance*, *52*, 35-55.

Stoll, H. (1978). The supply of dealer services in securities markets. *Journal of Finance*, *33*, 1133-1151.

Suguira, N. (1972). Locally best invariant test for sphericity anr the limiting distribution. *Annals of Mathematical Statistics*, *43*, 1312–1326.

Taylor, J. B., & Williams, J. C. (2009). A black swan in the money market. *American Economic Journal: Macroeconomics*, *1*(1), 58-83.

Taylor, M. P. (1989). Covered interest arbitrage and market turmoil. *Economic Journal*(99), 376-391.

Tsay, R. (2002). Analysis of financial time series. *Wiley Interscience, New Jersey, ss*, *23*(26), 86–87.

Tuckman, B., & Porfirio, P. (2003). Interest rate parity, money market basis swaps, and cross-currency basis swaps. *Lehman Brothers, LMR Quarterly*, *2004*(Q2).

Wachter, J. A., & Warusawitharana, M. (2009). Predictable returns and asset allocation: Should a skeptical investor time the market? *Journal of Econometrics*, *148*(2), 162-178.

Wurgler, J., & Zhuravskaya, E. (2002). Does arbitrage flatten demand curves for stocks? *The Journal of Business*, *75*(4), 583-608.

Yu, J., & Yuan, Y. (2011). Investor sentiment and the mean-variance relation. *Journal of Financial Economics*, *100*, 367-381.

Zhu, Y., & Avellaneda, M. (1997). An e-arch model for the term structure of implied volatility of fx options.