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Momentum, Nonlinear Price Discovery and Asymmetric Spillover: Sovereign Credit Risk and Equity Markets of Emerging Countries and

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Momentum, Nonlinear Price Discovery and Asymmetric Spillover: Sovereign Credit Risk and Equity Markets of Emerging Countries and Nonlinear Effects of Monetary Policy on Liquidity and Financial Structure

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Dedication

For the soul of my late brother Joseph K. Ngene and my mother Elizabeth W. Ngene who supported and encouraged me during their lifetime to pursue higher education and discover the sunlight pathways of hope and fulfillment

For my wife Ann W.N Mungai and Son, Cyrille J.N Mungai who sacrificed a lot, never left my side and gave me all the support I needed while pursing PhD

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Abstract

In Chapter 1, I hypothesize that there is a differential response by agents to changes in sovereign credit risk in both calm (low default risk) and turbulent (high default risk) markets conditions or regimes. This creates two time-varying states of the world. I model the two regimes using threshold cointegration and Threshold vector error correction model in three pairs from sovereign CDS, bond and equity markets for each of seventeen emerging markets. I find evidence of nonlinear cointegration in 48/51 cointegrations and momentum in 41/51cointegrations. In 49/51 combinations, positive and negative cointegration divergences adjust to equilibrium relationship at different speeds. Asymmetric short and long-run adjustments is found in 66/102 pairs. The informativeness of each asset price is regime dependent. The results largely contradict evidence provided by linear modeling. There is evidence of contagion among sovereign CDS, bond and equity markets based on asset substitution and news-based hypotheses. Therefore, dynamic interaction among assets and their price informativeness is generally regime dependent. The existence of momentum, multiple regimes, thresholds and overall evidence have important implications in portfolio rebalancing, hedging and policy intervention decisions.

In chapter 2, I hypothesize that financial intermediaries can be categorized into bank-based institutions (BBIs) and market-based institutions (MBIs). MBIs and BBIs are under different regulatory agencies. Traditionally, the Fed use only BBIs to transmit liquidity and monetary policy into real economy and financial markets yet MBIs also play important role in providing liquidity and stability in financial markets. I use two monetary policy tools under two regimes to investigate which monetary policy tool is suitable for each category of financial intermediary and under which regime. Using Threshold vector auto-regressions and regime specific impulse response functions, I find that liquidity of BBIs and MBIs respond differently to different monetary policy tools under different regimes. Moreover, monetary policies are uncertain and vary over time. The Fed cannot continue to ignore MBIs in formulating and implementing monetary policy. Monetary aggregate policy is more effective when used on MBIs during contractionary monetary policy intervention (economic downturn) while Federal fund rate is more effective when used on BBIs under expansionary monetary policy.

KEY WORDS: Threshold, Nonlinear, Price discovery, cointegration, Liquidity, Monetary Policy

Chapter 1:

Momentum, Nonlinear Price Discovery and Asymmetric Spillover: Sovereign Credit Risk and Equity Markets of Emerging Countries

I. Introduction

When financial markets are calm, there is little or no intervention by policy makers while investors don't face downside risk associated with wealth loss from decline in asset prices. This 'calm' market condition can be regarded as a state of the world or regime. An alternative state of the world or regime can be characterized by high uncertainty and turmoil in financial markets. In this state, policy makers aggressively intervene in the market and real economy to level the fluctuations and alleviate investors' fear and overreaction. Investor also takes aggressive actions to rebalance their portfolio and hedge against or minimize further wealth loss. According to Lee, Fang and Lin (2007), crises episodes such Asian crisis of 1997, internet bubble burst of year 2000 and sub-prime mortgage crisis of 2007/2008 triggered negative impact on both investors' wealth and domestic, regional or global economies. This became the foundation of acute convergence of investors' sentiments and led to the transmission of price variance among CDS, stocks and bonds across domestic and international markets.

While other financial and economic conditions may exist within the realm of the two states, it is easier to assess the singular and contrasting actions of policy makers and investors under the calm and volatile regimes. According to Mankiw and Miron (1986), the mere existence of such regimes is a testament of the uncertain environment under which agents make decisions based on the new information they receive and accordingly adjust their expectations. The two regimes occur at different times hence modeling using different market regimes captures time variation in states of the world.

In the context of multiple regimes, we can define momentum from perspective of cointegration relationship between two assets. Specifically, momentum occurs when divergence or error term in cointegration relationship displays higher intensity in one regime or direction relative to alternative regime. This is particularly apposite when the size of divergence militate the adjustment in each regime. Enders and Siklos (2001) document that momentum modeling entails intervention by policy makers to smooth intensified changes in a macro variable in one direction only. For example: Policy makers smooth large increases in inflation, government budget deficits, inflation rates, interest rates and unemployment rates among others while divergences that minimize these macro variables are unconstrained.

Investors in corporate and sovereign bonds hold risky investments and need protection against potential default. Similar to conventional insurance, the bondholders pay 'insurance' premium called credit default swap CDS) spread or premium[1] to buy protection against default by the borrower (reference entity). The payment of CDS spread transfers the risk of default from bondholder to CDS seller (Duffie, 1999 and Hull and White, 2000). Should the reference entity defaults, a swap will occur where the CDS buyer is eligible to receive the par value of the bond of contract from the seller of the CDS. Other credit events such as bankruptcy, credit rating downgrades, debt restructuring, repudiation, technical insolvency, violation of loan agreement or indenture can elicit a swap. The borrowers or reference entities can be domestic firms, foreign firms, sovereign governments and even quasi-government entities.

CDS spread is expressed as a percentage of the par value of the bond and is paid either quarterly or semi-annually. For example: If the par value of a bond is $1000,000 and

[1] The terms Spread and premium are used fairly interchangeably. In this study, I shall consistently use the term CDS spread.

the bond holder agrees to pay $8,000 quarterly($32,000 per annum) to CDS seller like AIG, CDS spread is 320 basis points. The higher the credit or default risk of reference entity, the higher the CDS spread charged by the seller and vice versa. CDS instruments are traded on over-the-counter market and CDS spread on each reference entity changes as investors' perception about credit risk changes. For example: News about government budget deficits and deteriorating fiscal policies, political instability and reduced exports will lead to increase in sovereign CDS premium. CDS is a derivative of bonds issued by reference entities. CDS premium should ideally be equal to bond spreads (bond yield less interest rate of a treasury bond of the same maturity). This exposition in substantiated further in the literature by Hull and White (2000).

Can the concept of momentum be applied in sovereign CDS, bonds and equity markets? We can infer that increase in sovereign credit default swap (CDS) premium and bond spread, both of which evince increase in default or credit risk of the sovereign government borrower (as a result of huge budget deficits and poor fiscal policies) lead to policy intervention while investors rebalance their portfolios, buy more CDS to hedge against default risk or dump the bonds and equity in their portfolios. These intensified and panicky actions of bondholders and policy makers will influence equity market, alter the short term and long term dynamic relationship among the three assets (CDS, bonds and equity) and the price informativeness of each asset. Reduction in divergences in cointegration relationships in pair-wise combinations of the three markets (CDS premium and bond spreads, CDS premium and equity and equity and bond spreads) require little or no policy intervention. In this context, momentum is likely to exist in dynamic interaction among the three markets.

I focus on Seventeen emerging markets which are geographically dispersed across four continents. I analyze the three markets of each country instead of panel for various reasons. First, according to Bekaert and Harvey (2002), emerging countries have higher default risk relative to developed countries. On the basis of Merton (1974) theory, Investors are likely to trade more on emerging markets sovereign bonds and CDS. Anecdotal evidence shows that emerging markets' CDS and bonds are more liquid than those of developed countries with low credit risk since it is the country's fundamentals as opposed to credit risk that drive the CDS premium and bond yield. Second, different countries have different levels of credit risk. I am interested in assessing how this risk is priced by different securities unique to each country. Third, the levels of market frictions, which may deter attainment of equilibrium relationship between cointegrated securities, vary across time and countries. Fourth, sovereign CDS premium, bond yield and equity prices are influenced by the fiscal policies and budget deficits of individual country. These policies are generally unique to each country which warrants the analysis to be confined to each country. Fifth, different countries have different levels of economic and financial development, political stability, financial structure, financial architecture and integration with global economy and financial market. This will influence the pricing of default risk. Lastly, cultural factors play a role in trading of securities. Chui, Titman and Wei (2010) find that the momentum effect in the stock market is stronger in countries with stronger degree of individualism, implying that cultural factors affect trading behavior.

Chan-Lau and Kim (2004) note that academic literature and study on the relationship among credit derivatives, bond, and equity markets is very small. For example: Studies by Longstaff, Mital and Neiss (2005), Norden and Weber (2004), Forte and Peña (2008), Pan and Singleton (2008), Norden and Weber (2009) and Meng, Gwilym, and Varas (2009) and Longstaff et al (2011) span the three markets. Among these studies, only Chan-Lau and Kim (2004) and Pan and Singleton (2008) have focused on sovereign CDS, bonds and equity markets albeit Chan-Lau and Kim (2004) justified extending Merton (1974) theory from a corporate to a sovereign issuer.[2] The study by Pan and Singleton (2008) covered only three emerging markets (Turkey, South Korea and Mexico).

Previous studies have focused on linear relationship among the three corporate markets[3].There has been no empirical study focusing on non-linear cointegration and price discovery among the sovereign bond market, CDS market and the equity market. Extant literature unreservedly surmises that the price discovery mechanisms are both constant and continuous under linear modeling. This is only realistic if financial markets are dominated by homogeneous agents. However, a large body of finance literature lucidly document that financial markets are dominated by heterogeneous agents. Hommes and Wagener (2009), using the seminal works of Simon (1991) and Rubinstein (1998), argue that financial markets are complex adaptive systems, dominated by incessantly interacting heterogeneous agents with "bounded rationality". The heterogeneous agents thus have limited information, cognitive abilities and finite time availability for decision-making. Against this background, rationality of agents is limited and the use of rules of thumb is highly prevalent. Therefore, financial markets become nonlinear systems

Chan-Lau and Kim (2004), using linear modeling, did not find any equilibrium price relationship between the bond and CDS markets and the equity markets for most of the

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[2]See Chan-Lau and Kim (2004) paper which illustrates how corporate credit risk modeling can be extended to sovereign bonds and credit risk.

[3]See for example Norden, Lars and M. Weber 2004, Hull, Predescu, and White (2004), Blanco, Brennan, and Marsh (2005), Berndt and Ostrovnaya (2007), Forte and Lovreta (2008), Forte (2008), Ammer and Fang (2008), Norden and Weber (2009)

sovereigns they covered. One of the possible explanations they give for their findings is nonlinearities in time series data due to high volatility of security prices and returns that characterize emerging markets (Bekaert and Harvey, 2002). Delatte et al (2010), using Smooth Transition threshold auto-regression (STAR) conclude that in a single country, price discovery pecking order may be reversed above a definite threshold of spread depending on market conditions. In fact, the market in which price discovery occurs may be dependent upon financial, economic, liquidity and other factors not captured by the linearity relationship.

Linden (2010), argue that the existing literature on the interaction of CDS and bond markets focus mainly on the pricing of risk and the role of both markets in price discovery. Gomez (2003), Cremers (2004) and Zhang (2008) argue that looking only at the relationship between credit derivatives and cash bond markets is insufficient, and suggest including equity markets as well in the analysis hence connecting CDS, bond and equity markets.

Motivated by findings of Chan-Lau and Kim (2004), the conclusion of Delatte et al (2010) and dearth of studies in non-linear price discovery, cointegration and long-run adjustment process in pairs of sovereign CDS, bond spreads and equity prices, I seek to address the following questions:

(i) Are sovereign CDS spreads, bond spreads and equity prices characterized by nonlinearities?

(ii) Does a threshold exist below or above which pair-wise cointegration will change? What is this threshold value and how does it affect nonlinear or threshold[4]cointegration, speed and magnitude of adjustment process to pair-wise equilibrium relationship and price informativeness of each security?

(iii) Does momentum exists and if it does, how does it affect cointegration and price discovery process in each regime?

(iv) The changes in CDS premium, bond spreads and equity prices lead to changes in returns associated with each security. The three securities are usually held in a portfolio by investors. During clam regime, investors generate positive returns. In the volatile regime, they generate negative returns and attempt to hedge against downside risk. Since investors rebalance their portfolios as regime changes, is there asymmetric return spillover among the three securities?

I find evidence of nonlinearities in time series data. In 49/51 possible cointegration relations, I find evidence specification error in linear regression which supports the case for nonlinear modeling. Momentum in cointegration is evident in 41/51 possible contegrations. In 51/51 pair-wise combinations, we find that positive and negative divergences adjust to equilibrium relationship at dissimilar speeds and magnitudes depending on the regime. Moreover, asymmetric short-and long-run adjustment process is found in 66/102 and 55/102 possible combinations respectively. The informativeness of each asset in a pair is asymmetric and regime dependent and generally contradict results of linear modeling. In asymmetric return spillover, I find evidence in support of asset substitution hypothesis and news-based hypothesis of financial contagions in sovereign CDS, bond and equity markets. Therefore, dynamic interaction among assets held in a portfolio shift with regime change.

[4] In this study, I use the terms nonlinearity and asymmetrical fairly interchangeably

Investors, in making decisions regarding portfolio rebalancing and hedging against downside risk need to identify when regimes change to make informed decisions while policy makers need to identify the threshold below or above which policy intervention in the market becomes necessary. Linear modeling may provide mis-specified and biased results as indicated by comparative results of linear and nonlinear modeling.

The findings were achieved through a battery of econometric tests and modeling. We first test for nonlinearities in the time series data of sovereign CDS premium, bond spreads and equity and then utilize nonlinear threshold cointegration, momentum threshold auto-regression (MTAR), and threshold vector error correction model (TVECM) to assess asymmetric short term and long run adjustment process in price discovery mechanism. Nonlinear modeling can be justified on numerous grounds. First, Marshall (1994) argues that linear VECM guarantee permanent attraction effect regardless of the size of deviation from equilibrium relationship of variables. This is premised on the assumption that agents make decisions under a single state of the world (single regime) which is not realistic.

Second, investors are usually concerned only with downside risk hence it is expected that cointegration and price informativeness of different assets in the portfolio will significantly differ between regimes that define presence and absence of downside risk.

Third, default or credit risk of sovereign borrowers is generally pegged on fiscal policies and level of budget deficits of the borrowing government. CDS buyers and sovereign bondholder are less concerned with risk of default when sovereign borrowers have low budget deficits. However, when budget deficits balloon and foreign governments' credit rating is downgraded, bondholder react by buying more protection. The CDS premium will increase while bonds prices will tumble (bond yield will increase due to higher default risk).

Stock prices will also react to credit risk and will try to price it accordingly. Therefore, non-linear modeling is justified to capture periods of low and high budget deficits.

Fourth, there exist country specific liquidity regimes as intimated by Delatte et al (2010). CDS, bonds and equities of small countries are less liquid and may be in different regime with more liquid CDS, bonds and equity of large, well-established sovereigns.

Fifth, according to Mankiw and Miron (1994), identification of different regimes through threshold modeling is a way of incorporating uncertainty and time-variation in cointegration relationships and price discovery process since regimes represent different states of the world which investors face and respond to. These states also occur at different times.

Lastly, the theory of finance suggests that there is a limit to arbitrage. Trivial deviations from long run equilibrium may not justify arbitrage process to generate profits hence there must be a threshold beyond which arbitrage becomes profitable. This requires definition of regimes of profitable and unprofitable arbitrage opportunities especially in CDS and bond markets which "playing fields" of many speculators who assess mispricing of bonds and the underlying derivative (CDS) to engage in arbitrage activities.

We contribute to the existing literature in a number of ways. First, this is the first study, to the best of our knowledge, to investigate nonlinear co-integration and short term and long run dynamic interaction of sovereign CDS premium, bond spreads and equity using a large data set of seventeen emerging markets. Two, we assess the effects of momentum (intensified reaction in one regime relative to substitute regime or direction) in cointegration and price discovery process. This accounts for asymmetry in the relationships and the role of trading adjustment costs among arbitrageurs. Three, in assessing price discovery among the three markets, we employ a unified econometric model (Threshold error correction model) and compare it with linear models to uncover contradictions and similarities. For example: Is linear price discovery more consistent with lower regime or upper regime? The sign of error correction term in different regimes can help identify which market can trigger momentum and arbitrage opportunities as regime shifts occur and presence of any price bubbles. Lastly, we implicitly incorporate 2007-8 financial crises since this period is captured as part of the “volatile” regime during which momentum is likely to occur.

The rest of the paper is organized as follows. Section II reviews the literature and develops testable hypotheses. Section III details econometric methodology. Section IV explains empirical results and findings and section V shall summarize and conclude

II. Literature Review and Hypothesis development

A. Theoretical foundation: Relationship between Bond and equity markets

The option pricing theory of Merton (1974) is the fulcrum around which the relationship between bond and equity prices revolves. According to the theory, equity is equivalent to a call option whenever a limited liability firm issues a bond or is financed by debt. By issuing a bond (assumed a zero coupon bond) and using the assets of the collateral, equity holders have theoretically ‘sold’ the firm to creditors or bondholders. Equity holders thus hold a call option to buy back and own the assets only after paying back the face value (strike price) of debt to creditors. The option life is equal to maturity period of the bond. If we define C as value of call option, S as market value of assets at maturity and F as face value (Strike price) of a zero coupon bond, then, at maturity, $C=\max(S-F, 0)$

If S-F>0, the firm's assets are worth more than the debt's face value and the call option is "in-the-money". Equity holders will exercise it by paying off the debt and 'buy back' the assets otherwise, equity is worthless, and the call option is "out-of-the-money." In Merton's capital structure framework, the face value of bond constitute a lower threshold which the value of firm's assets cannot breach. If this barrier is breached (S<F), the firm is likely to default on its debt. S-F is ideally a distance to default. As this distance is reduced, the leverage of the firm increases, credit risk rises and bond yield increases (to reflect higher credit risk) and value of equity declines further. Merton's (1974) structural model is used to estimate the probability of default (PD) of a firm and risk premium (yield of a risky bond less yield of a risk-free bond of same maturity)

Emerging markets Credit rating*[5] (Adapted[6])**

Country	Argentina	Brazil	Colombia	Mexico	Venezuela	China	Indonesia	Malaysia
Credit rating	CCC-	BBB-	BB+	BBB	B+	A+	BB-	A-
Country	Philippines	Bulgaria	Hungary	Poland	Russia	Turkey	S. Africa	Tunisia
Credit rating	BB-	BBB-	BBB	A-	BBB	BB	BBB+	BBB

When PD or credit risk is high (as characterized by high leverage and below investment-grade credit ratings, for example, all countries except China, Malaysia and Poland), there is a strong positive correlation between equity and bond prices since both prices will plummet to incorporate higher credit risk. Zhu (2006) and Realdon (2008) finds that the firm's stock price contain important information regarding default intensity especially when the default risk is high (call option is out-of- the-money) and the markets are

[5] **Laura Jaramillo and Catalina Michelle Tejada,* Sovereign Credit Ratings and Spreads in Emerging Markets: Does Investment Grade Matter?, Working Paper WP/11/44, IMF

[6] **Average sovereign long-term foreign currency rating across S&P, Moody's and Fitch. Source: Bloomberg, Standard & Poor's and Moody's Investor Services

distressed. However, equity prices are less useful conduits of conveying default risk of the firm when default risk is low. This is because equity prices will be driven primarily by firm's fundamentals and not default risk.

The co-movement of corporate stock and bond yield has been observed in a variety of other models by French and Roll (1986), Fama and French (1989, 1996), Asquith, Gertner, and Sharfstein (1994), Opler and Titman (1994), Denis and Denis (1995), Fleming and Remolona (1997), Campbell and Taksler (2003), and Vassalou and Xing (2004)). The overall evidence shows that the relationship between equity and bond yield and returns vary over time, particularly under exogenous influences. From the forgoing, I develop the following hypothesis:

Ho1; There exists time varying and nonlinear cointegration relationship between bond yield (spreads) and equity prices. The influence of exogenous factors creates momentum in one regime relative to alternative regime.

B. Relationship between CDS and Equity and CDS and bonds

Merton theory can be extended to explain the relationship between CDS premium and equity prices. When credit risk is a key concern to bondholders, investors will dump equity which will precipitate a decline in stock prices. There will also be intensified demand for CDS of the firm to insure against potential default. This will lead to increase in CDS premium. We can thus again infer that relationship between CDS premium and equity prices has to be negative (See also Zhang et al, 2008). Yu (2006) notes that the premise of capital structure arbitrage is that the theoretical relation between the CDS spread and the equity price would reign in the long run. The attainment of the long run relation implies that CDS position can cushion the loss from the equity position and vice versa. This will eliminate the arbitrage opportunities and make the CDS and equity markets more integrated and efficient in pricing default risk.

Hull and White (2000, 2001), lucidly explain that CDS spread makes the bond default risk free similar to interest rate of a par-floating treasury bond since the par value is guaranteed. If *y* is the yield to maturity of a bond and CDS premium is cost of insurance, the default risk free (rf) bond yield is *y–CDS.* If arbitrage opportunities do not exist, then, *y–CDS=rf* or equivalently, *y–rf=CDS.* The CDS is thus the price of credit and should be equal to bond spread, BYS=*y–rf* of a zero-coupon, par-floating. If markets are frictionless and payment of the CDS spread discontinues on occurrence of a credit events, CDS and BYS should exhibit a one-to-one changes in terms of price dynamics.

However, factors such as relative liquidity of each market, contract specifications under bond indentures, transaction costs, taxes, regulations and “cheapest-to-deliver” option in the CDS contract (the option which allows the CDS buyers to deliver a bond which is worth less than the one referenced in the contract if a credit event occurs) make the basis (BYS-CDS) to exist. For example: If Sovereign bonds are more liquid than CDS contracts, CDS premium will be higher than bond spreads due to illiquidity premium. Nevertheless, bidirectional liquidity migration from one market to the other will trigger divergence of CDS and bond spreads.

There are two important inferences that we can make from Merton’s theory exposition of Hull and White (2000, 2001). First, there is negative relationship between measures of credit risk (CDS premium and bond spreads) and equity prices. Second, CDS premium, bond spreads and equity prices adjust simultaneously whenever new information on credit risk is released in the market. Empirical evidence by Hull, Predescu, and White (2004), Blanco, Brennan, and Marsh (2005) and Longstaff, et al (2005) show that corporate CDS in U.S and Europe adjusts to or incorporate new credit risk information well before bond prices. Therefore, corporate CDS market leads in price discovery process. Acharya and Johnson (2007) investigate the impact of CDS innovations on stock return and financial stability. They find that negative credit news lead to shocks in equity market. They conclude that this is indicative of insider trading in the over-the –counter CDS market.

Can we employ Merton's theory and argument to emerging countries' sovereign bonds, equity and CDS markets especially given that a sovereign issuer may choose to default even when it is technically solvent? What is the pecking order of price discovery and informativeness of sovereign CDS premium, equity and bond spreads?

A Merton-type theoretical justification can be explained as follows: A country with a higher default risk will experience a decline in its stock market performance either because economic and financial fundamentals are deteriorating or because domestic and international investors are demanding higher risk premium or both. The cost of buying insurance (CDS premium) against country's potential default risk will increase. This exerts a further pressure on equity prices since sellers of credit derivatives will be shorting either bonds or equity to mitigate their exposure from potential losses or downside risk.

In summary, we expect a negative relationship between sovereign CDS premium and equity prices. Forte and Lovreta (2008) argue that credit risk in the stock market is implicit in nature since CDS and stock markets have stark differences in several fronts such as organization, participants (Longstaff et al 2005)), investor base, risk preferences, reactions to news, liquidity, and stage of development. For example: Sovereign bond market is dominated by less diverse institutional investors who tend to buy and hold bonds, not tending to react to developments in other markets. These differences among CDS, bond and equity markets are likely to cause short-term deviations from the long-term relationship.

> *Ho2: There exist a nonlinear pair-wise short term and long-term relationship among sovereign CDS premium, bond spreads and equity prices.*

C. Price discovery and Informativeness of security prices

Stein (1987) argues that the entry of new investors potentially lowers the informativeness of bond prices. This lowers the ability of pre-existing investors to conjecture asset value. This could trigger price instability and reduction in welfare benefits. According to Acharya and Johnson (2007), the opacity of the over-the-counter (OTC) CDS market potentially makes it the preferred venue for informed or insider traders seeking to hide their trades. Blanco et al. (2005) finds that corporate CDS spreads respond more rapidly to changes in perceived default risk than bond spreads. They argue that price discovery occurs in the CDS market because of (micro) structural factors that make CDS the most convenient location for trading of credit risk.

In analyzing the three corporate markets, Longstaff, et al (2005) investigates the lead-lag relationship among bond spreads, CDS spreads and stock returns. The equity and CDS markets adjust faster than bond market to new information. However, neither CDS nor equity market clearly dominates in the price discovery role. In contrast, Norden and Weber (2005, 2009) finds that equity returns lead CDS and bond spread in price discovery. CDS spreads lead bond spreads in price discovery. The CDS price leadership over bond spreads is more prevalent in US firms than European firms. CDS market is also found to be more sensitive to the stock market changes than the changes in bond market. The co-movement between CDS and stock market is increasing and strengthening in deterioration of credit quality and size of the bond. Forte and Peña (2008) employ VECM framework and stock market implied credit spreads and find that generally, equity market frequently dominates CDS and bond market in price discovery process. They attribute this outcome to relative illiquidity of the embryonic CDS market. This evidence is supported by Levy (2009) who confirms that the CDS market does not always lead the bond market in price discovery. CDS spreads are increasing in illiquidity of the CDS contracts and counterparty risk. However, when there is reduced trading (and liquidity) in the sovereign bond market, the CDS market becomes the attractive platform for investors to change the exposure in their sovereign bond portfolio. CDS contracts, unlike bond indentures, facilitate transfer of credit risk embedded in the fixed bond security. The demand for credit risk transfer (credit risk insurance) is higher the more volatile, uncertain and the higher the probability of default by the corporate entity.

There is limited research on the price discovery function of the sovereign CDS. Anecdotal evidence[7] shows that CDS has higher default risk anticipatory power than both stock and equity market. Zhang (2008) finds that Argentina's CDS could predict credit events in the country well before the rating agencies since credit rating often lags credit events. Chan-Lau and Kim (2004) perform cointegration and causality tests and price discovery analysis for the stock market, sovereign bond market, and the CDS market. They find no equilibrium relationship between sovereign bond and CDS markets while price

[7] For example, some weeks before GM's debt was downgraded to junk bond on May 5, 2005, the CDS market had anticipated the deterioration in credit quality of GM. Zhang (2008) also find evidence that CDS market anticipated default by Argentina. Again, according to *The Wall Street Journal*,
"Trading in Harrah's Contracts Surges Before LBO Disclosure," Oct. 4, 2006, Harrah experienced a dramatic spike in the CDS contracts well before the news of leveraged-buyout (LBO) were divulged to the public. However, the stock market lagged the CDS market in incorporating the LBO news.

discovery and causality tests yielded mixed results. In particular, equity markets play insignificant role in price discovery while sovereign CDS leads in price discovery in some sovereigns in the study. Ammer and Cai (2008) investigate price discovery between sovereign bonds and CDS. They find that in four out of the nine sovereigns studied, CDS market lead bond market in price discovery. They attribute the significant short run deviation between the two markets to relative liquidity and contract specifications of each market particularly the cheapest-to-deliver (CTD) option which encumbers CDS liquidity for riskier sovereigns.

Aktug, Geraldo and Bae (2008) study thirty sovereigns and find mixed evidence in which sovereign bond markets lead CDS markets in 48% of the time but lag CDS spreads in 22% of the time). Fung et al (2008) investigates the market-wide relations between the U.S. equity and CDS markets and find that there is significant bidirectional information and volatility feedback between equity market and the high-yield CDS (high credit risk). However, the equity market leads the investment-grade CDS (low credit risk) in price discovery. Investors should thus seek information from the two markets when evaluating trading, hedging and price discovery alternatives.

Chan, Fung and Zhang (2009) find that price discovery takes place primarily in the CDS market in six out of seven emerging markets. They attribute this to shallow and underdeveloped stock market while the counterpart CDS market has fewer restrictions, broader investor base, and greater information advantage. From the foregoing findings, I develop the following hypothesis

Ho3: The price discovery process is non-linear and regime dependent. Therefore, linear and nonlinear modeling will yield conflicting results

The mixed findings by individual authors and among the authors who have utilized linear modeling confirm that there is inconclusive evidence as to which market in the pair leads in price discovery.

D. Return spillover among CDS, Bonds and equity

Fama and Roll (1986) finds that asset price returns are much more volatile during weekdays than during weekends, primarily due to information flow reflected by volatility spillover between the markets. However, Fama and French (1996) and Fleming and Remolona (1997) find that the movements in bond yields and stock returns are no pure random walk. This is because bonds and equity generate fixed and variable cash flows respectively. As such, portfolio managers often regard the two assets as complements for portfolio diversification. In a bull market, both assets tend to exhibit upward trend. In a bear market, there is "flight to quality" and investors will dump equity and seek safety in bonds with fixed returns. The two assets prices will be negatively correlated.

Fama and French (1989, 1996) find that many interest rate-related instrumental variables such as term spreads, quality spreads and short-term T-Bill yields have forecasting power for time series of stock and bond returns. There are two contrasting strands of evidence regarding the nature of credit risk and volatility influence on equity returns. One view by Campbell and Taksler (2003) find that idiosyncratic firm-level volatility contributes explanatory power in cross-sectional variation in bond yields as can credit ratings. Since aggregate corporate yield spreads widen during periods of higher idiosyncratic risk, equity volatility helps to explain not only movements in corporate yield spreads, but also their longer-term upward trend. This partly explains why high-default-risk firms earn higher equity returns than low default risk firms. This view is supported by Opler and Titman

(1994) and Asquith, Gertner, and Sharfstein (1994) who find that default risk is related to idiosyncratic factors. A contrasting view by Denis and Denis (1995) and Vassalou and Xing (2004), find that corporate default risk is systemic since it varies with business cycles and macroeconomic factors. Therefore, changes in corporate bond yields (measures of credit risk) should affect firm's equity returns.

A new strand of literature on relationship between sovereign bond yield and stock returns has provided inconclusive evidence. Aburachis and Kish (1999) quantify the relationship between stock returns and bond yields for nine industrialized countries during the period 1984-1994 and provide empirical evidence that support the view that stock and bond yields do not follow a pure random walk. Elli (2002) examines the relationship between real stock returns and matched-maturity long-term bond yields for 16 countries. He finds a strong positive correlation for every country in the sample. The findings suggest that volatility of long term real stock returns and long term real bond yields are closely related.

None of the above studies have investigated the asymmetric return spillover among the sovereign CDS, bond and equity returns. I argue that the three securities are held by investors in a portfolio and investors will rebalance the portfolio as states of the world (regimes) or market conditions change. Calm regime is characterized by positive returns while a volatile regime is characterized by negative returns. Equity and bonds are usually held as substitute assets (fixed return versus variable return investment). Investors will substitute equity for bonds during volatile regime and vice versa. This is consistent with the findings by Fung et al (2008) who state that investors in the stock and CDS markets are more readily to take action under deteriorating market conditions than under normal (calm regime) market conditions. They will also sell equity and buy more CDS during volatile regime. I thus expect a return spillover or a three-way feedback among the equity, CDS and bond markets under different regimes.

In relation to the direction of return spillover, King and Wadhani (1990) proposed asset substitution hypothesis. The hypothesis asserts that derivative instruments and their underlying securities are substititutes and information favoring one market will inevitably alter the attractiveness of one security at the detriment of the other two. For example: Any news of budgeoning budget deficits and potential default on sovereign bonds by government (bad news or negative return shock) will make the bonds (and by extension, equity) less attractive and sovereign CDS more attractive as investors are buoyed to hedge against default. Moreover, because of high leverage in the CDS markets, CDS instruments are more sensitive to new information relative to bond and equity markets.Alexopoulou et al (2009) finds that the during the 2007-8 financial market turmoil, there was significant shift in the way market participants priced credit risk in corporate sector. This strengthened the price discovery role of the corporate CDS

As investors take leverage position in the unfunded CDS market, CDS spreads will increase. The positive returns shocks in the CDS market will thus transmit negative return shocks (distabilizing effects) in bond and equity markets. I thus develop the following hypothesis

Ho4: There is asymmetric short term return spillover among sovereign CDS spreads, bond spreads and equity markets returns. Positive (negative) return shocks in CDS spillover into equity and bond markets with a negative (positive) sign.

According to news-based view of spillover advanced by Campbell and Vuolteennaho (2004), stock-unique news emanating from stock market will lead to substitution effects as investors substibute stock for bonds and vice versa. Price changes in each market conveys different magnitude and uniques nature of information regarding that market or asset class. For example: Changes in stock prices generally reflect corrections of firm values due to changes in both systematic factors and firm's fundamentals. Therefore, positive stock-specific news (positive stock return shocks) will transmit negative spillover effect on the bond market (and CDS market by extension). By the same vein, positive (negative) bond-specific news or return shocks relaying aggregate economic conditions, positively (negatively) affects both equity and CDS prices and transmit the shocks into equity and CDS returns with the same sign but asymmetric effects. The asymmetric effects may be due to multiplier effects of CDS instruments. CDS derivatives enable more complex credit derivative products, such as synthetic CDOs and CDS index-related products to be weaved. Any increase in CDS volatility for any given entity may cause investors to result in these complex synthetic alternative investment assets to adjust their portfolios. This will not only intensify volatility of the CDS spreads but will also trigger asymmetric return and volatility in both equity and bond markets. It is thus the varying investment strategies and styles in the financial system that becomes the return shocks transmitting mechanism among the three markets or assets as they interact in a complex way. This also creates potential that trading in one market may potentially create momentum in the other two markets. Consistent with financial contagion and news specificity views, I hypothesize that

Ho5: Short term return spillover occurs in any one of the three markets and asymmetrically spreads to the other two markets.

III. Data and Econometric Methodology

E. Data sources and data characteristics

I use the daily closing prices of sovereign CDS premium, Emerging market bond indices (EMBI) and national stock indices of each sovereign. Different sovereigns have different starting dates but ending date is 11/02/2009. The data is provided by Datastream and JP Morgan Chase. The two sources are the main providers for of credit derivatives research data. The EMBI Global total return index consist of bond prices accrued dividends and cash payments (total returns). The index is market-value weighted, 5-year, US-dollar issued Eurobonds, Brady Bonds, traded loans and local market debt securities issued by sovereign government and quasi-sovereign entities. The minimum current face value outstanding is US$500 million. In the global credit derivative trading, the 5-year sovereign CDS contracts are among the most liquid and most actively traded securities.

Anecdotal evidence from data provided by Depository Trust and Clearing Corporation (DTCC) shows that the top six reference names are EMs sovereign CDS by gross notional value. Among the top-100 U.S dollar denominated reference entities in the CDS market, nineteen were sovereign entities. Of these nineteen, eleven were EMs sovereign CDS which account for almost 30% of the $1.46trillion trading volume of the top-100 reference names taken together.

My study covers seventeen emerging markets from four major economically diverse geographical regions. These regions are Latin America (Argentina, Brazil, Colombia, Mexico and Venezuela), Asia (China, Indonesia, Malaysia, and Philippines), Africa (Tunisia and South Africa) and Europe (Bulgaria, Hungary, Poland, Russia and Turkey, Among these sovereigns, Brazil, Philippines, Mexico and South Africa are the most liquid and frequently traded sovereign bonds.

Financial time series exhibit unique characteristics which make modeling an arduous task. Among these features are (i) volatility clustering (high volatility is oftentimes followed by high volatility while low volatility by low volatility) identified by Campbell et al., 1997 (ii) leptokurtosis or fat-tail distribution of returns, discovered in early studies by Mandelbrot (1963) and Fama (1965) and (iii)"leverage effect."

F. Econometric Methodology

i. Non-Linear and linear Unit Root Tests

In contemporary empirical finance, there is a consensus that financial time series data display nonlinearities. Therefore, traditional non-stationary (unit root) tests such as augmented Dickey Fuller (ADF) may not have enough power to identify the mean reversion nature of time series data. To this end, this study utilize a new nonlinear stationary test model developed by Kapetanios, Shin and Snell (2003, henceforth, KSS) to test whether sovereign CDS spreads, bond spreads and equity prices are nonlinear stationary.

The KSS test of nonlinear stationary of time series data attempts to detect non-stationarity in mean reversion against nonlinearity of a series using a globally stationary exponential smooth transition autoregressive (ESTAR) process. Specifically, the test is modeled as follows

$$\Delta y_t = \beta y_{t-1}\{1-\exp(-\phi y_{t-1}^2)\} + \xi_t \qquad \textbf{(i)}$$

In equation (i), $y_t$is the time series of a security and ξ_t is *i.i.d* error term~N(0, σ^2). ϕ is a non-negative transition parameter indicating the speed of transition in the ESTAR model. The model tests Ho: ϕ=0 against the alternative, H_1: ϕ>0 but the null is not testable since β

is not identified. To overcome this hurdle, KSS (2003) compute first order Taylor series approximation of the function $1-\exp(-\phi y_{t-1}^{2})$ to yield an auxiliary equivalence of equation (with augmentation) such that

$$\Delta y_t = \beta_0 + \phi y_{t-1}^{3} + \sum_{i=1}^{p} \beta_1 \Delta y_{t-1} + \eta_t \tag{ii}$$

We test the following hypotheses:

Ho: ϕ=0 (Series is nonlinear non-stationary)

Ha: ϕ<0 (Series is non-linear ESTAR stationary)

The simulated critical values for different lags, p, are in table I of KSS (2003). The non-linear unit root test will be complemented with one conventional linear unit root tests namely generalized least squares Augmented Dickey Fuller (DF-GLS) method of Elliot, Rothenberg and Stock (1996). In addition to comparative nonlinear and linear unit root tests, we also employ a battery of other nonlinear tests including the Brock, Dechert, Scheinkman and LeBaron , BDS(1996) using Z-statistic to test non-linear dependence using two and three embedding dimension. The null hypothesis is that series observations are drawn from an *i.i.d* process. We also test the null of constant conditional correlation (CCC) of residuals of any pair of the three markets. Lastly, we use Tsay (1986) test of quadratic nonlinearity where the null is linear dependence in time series data

ii. Threshold co-integration tests

Our data is characterized by nonlinearities including nonlinear unit root. Therefore, we deviate from the conventional Johansen (1988) and Johansen and Juselius (1990) cointegration tests and instead employ the threshold cointegration test of Enders and Granger (1998) and Enders and Siklos (2001). Threshold or non-linear cointegration test involves two steps. First, Co-integration equation which takes the form

$$y_t = \alpha + \beta x_t + \varepsilon_t \tag{iii}$$

ε_t is the estimated stochastic disturbance error term or residuals which represent divergence from long run relationship. These residuals $\hat{\varepsilon}_t$ are saved and then used to estimate the second equation which takes the form of threshold autoregressive (TAR) regression

$$\Delta\hat{\varepsilon}_t = I_t \theta_1 \hat{\varepsilon}_{t-1} + (1 - I_t)\theta_2 \hat{\varepsilon}_{t-1} + \sum_{i=1}^{p} \gamma_i \Delta\hat{\varepsilon}_{t-1} + \upsilon_t \tag{iv}$$

υ_t is *i.i.d* white noise with zero mean. I_t is Heaviside indicator while τ is the threshold values such that

$$I_t = \begin{cases} 1 \text{ if } \hat{\varepsilon}_{\text{t-1}} \geq \tau) \\ 0 \text{ if } \hat{\varepsilon}_{\text{t-1}} < \tau) \end{cases} \tag{v}$$

For υ_t to be stationary, *I(0),* then, -2<(θ_1 , θ_2)<0 otherwise series *x* and *y* will most certainly not converge in the long run. The larger of the t-statistic of θ_1 and θ_2, usually called the t_{max} is also used to test for cointegration such that a significantly negative t_{max} is an indication that θ_1<0 and θ_2<0. We test for co-integration as follows:

Ho: $\theta_1 = \theta_2 = 0$ *(No co-integration/ equilibrium relationship between x and y=*Φ test*)*

Ho: $\theta_1 = \theta_2$ *(There is symmetric adjustment to equilibrium relationship between x and y)*

To make the decision regarding the null of "no co-integration", we compare generated F-statistic with non-standard F-critical values (commonly denoted as Φ test) provided by Enders and Siklos (2001). The null of symmetric relationship between x and y is based on the standard F-distribution.Evaluation of equation "(iii)' and '(iv)" evince how deviation from long run equilibrium [captured by ε_t in equation (iii)] can explain the threshold effects in the cointegration relationship. In the long run, x and y should converge such that $\hat{\varepsilon}_t$=0. If $\hat{\varepsilon}_t$ is above (below) equilibrium, it has to calibrate downwards (upwards) in the next period (day) by $\theta_1\,\hat{\varepsilon}_{t-1}\,(\theta_2\,\hat{\varepsilon}_{t-1})$ to remain in equilibrium path.

iii. Momentum in co-integration relationship

Can the adjustment process of the residuals, from equation (iv) be dynamic? Enders and Granger (1998) and Caner and Hansen (1998) suggest that if we permit the Heaviside indicator, I_t, to rely on the first difference of residuals ($\Delta\hat{\varepsilon}_t$) as an alternative to levels ($\hat{\varepsilon}_t$) we can develop Momentum-Threshold Autoregressive (M-TAR) version of equation (iv) in which the Heaviside indicator, $I_{t,}$ now takes the following form:

$$I_t = \begin{cases} 1\,\text{if } \Delta\hat{\varepsilon}_{t-1} \geq \tau) \\ 0\ \text{ if } \Delta\hat{\varepsilon}_{t-1} < \tau) \end{cases} \tag{vi}$$

The implication of M-TAR is that correction mechanism dynamic since using $\Delta\hat{\varepsilon}_{t-1}$, it is possible to assess if the momentum of the series is larger in a given direction relative to momentum in the alternative direction. In such a scenario, M-TAR can efficiently capture largeand smooth changes in a series. Specifically, unlike TAR model which shows the 'depth' of the swings in equilibrium relationship (For example, are negative (positive) divergences from equilibrium path more prolonged than positive (negative) divergences?), M-TAR can capture spiky adjustments in the equilibrium relationship since it permits decay in the relationship to be captured by $\Delta \hat{\varepsilon}_{t-1}$ instead of $\hat{\varepsilon}_{t-1}$

iv. Non-linear price discovery Threshold Error correction model (ECM).

Engle and Granger (1987) developed the linear error correction model (ECM) for any two times series data which are both non-stationary and cointegrated. The linearity assumption of the model is too restrictive and implausible. In fact, Hall, Anderson and Granger's (1992), in analyzing cointegration of treasury bill yields found that the linear ECMs remain stable during periods of short term interest targeting by Federal Reserve but the model exhibit instability during episodes of monetary policy regime changes. To overcome these limitations, Balke and Fomby (1997) took the idea of threshold (non-linear) auto-regression (TAR) of Tong (1978) and developed threshold cointegration which was further refined by Enders and Granger (1998) and Enders and Siklos (2001).

There has been proliferation of research utilizing TVECM. [8]The rationale for surge in the use of non-linear models can be explained from two main perspectives. First, Anderson (1997) argue that using non-linear as opposed to linear error correction models potentially permits transaction costs to be incorporated into empirical modeling. Arbitrageurs in CDS, bond and equity markets usually incur trading adjustment costs which may partly explain why any two markets (for example, CDS and bond markets) experience transient divergence from their long-run or equilibrium. A prolonged divergence from equilibrium relationship may be triggered by external shocks not related to adjustment costs.

[8] See, for example, Anderson, (1997); Obstfeld and Taylor (1997); Tsay, (1998); Enders and Granger, (1998); Franses and van Dijk, (2000b), Lo and Zivot, (2001); Trinkler and Wolf, 2003, Vavra and Goodwin, (2005), Chang and Chiu (2007); Sheffel (2008); Ihle and Cramon-Taubadel (2008) among others.

This rational is predominantly attractive to research in purchasing power parity, pricing relationship between derivative instrument and underlying asset, differential pricing of similar commodities in different markets and other fundamental relationships. Second, there is evidence of non-linearity in financial series data. Stock and Watson (1999) and Scheffel (2008) find that non-linear models such as neural networks (NNs), threshold autoregressive (TAR) and smooth transition error correction model (STECM) have superior in-sample performance albeit their out-of-sample forecasting accuracy has been wanting, perhaps because of their a-theoretic nature as the models are not grounded on fundamental economic theory. However, proponents of nonlinear error correction models argue that the models can be overtly explained by economic theory of financial arbitrage in the presence of transaction costs.

The TVECM can be explained as follows:From the cointegration equation (iii), we denote the lagged deviation from long run equilibrium as z_{t-1}

$$z_{t-1} \equiv \hat{\varepsilon}_{t-1} = \hat{y}_{t-1} - \hat{\alpha} - \beta\hat{x}_{t-1} \tag{vii}$$

However, z_{t-1} can be above or below the threshold, τ. Therefore, for any two series *x* and *y*, the TVECM takes the following form:

$$\Delta y_t = \alpha_1 + \begin{cases} \lambda_{11} z_{t-1}^{+} + \sum_{i=1}^{P} \theta^{+} \Delta y_{t-i} + \sum_{i=1}^{P} \delta^{+} \Delta x_{t-i} + \pi_{1t} \\ \lambda_{21} z_{t-1}^{-} + \sum_{i=1}^{P} \theta^{-} \Delta y_{t-i} + \sum_{i=1}^{P} \delta^{-} \Delta x_{t-i} + \pi_{2t} \end{cases} \tag{viiia}$$

$$\Delta x_t = \alpha_2 + \begin{cases} \alpha_{11} z_{t-1}^{+} + \sum_{i=1}^{P} \gamma^{+} \Delta y_{t-i} + \sum_{i=1}^{P} \psi^{+} \Delta x_{t-i} + \upsilon_{1t} \\ \alpha_{21} z_{t-1}^{-} + \sum_{i=1}^{P} \gamma^{-} \Delta y_{t-i} + \sum_{i=1}^{P} \psi^{-} \Delta x_{t-i} + \upsilon_{2t} \end{cases} \tag{viiib}$$

Where π_{it} and υ_{it} are *i.i.d* white noise disturbance and $P_i$is lag order. As explained a prior, the error correction term can be explained in terms of Heaviside indicator, $I_{t.}$. Specifically,

$$I_t = \begin{cases} 1 \text{ if } z^{+}_{t-1} \geq \tau) \\ 0 \text{if } z^{=}_{t-1} < \tau) \end{cases} \qquad \text{(ix)}$$

This study adopts the grid search for threshold using Chang (1993) approach. Specifically, this involves sorting the residuals, $z_{t-1} \equiv \hat{\varepsilon}_{t-1}$, in ascending order such that $\hat{\varepsilon}_1 < \hat{\varepsilon}_2 \ldots\ldots \hat{\varepsilon}_T$ (where T is number of observations of residuals) and trimming the lower and upper 5%-15% of the observations. If π represents the trimming parameter and the probability of threshold, $P \in (0,1)$, then $0.05 < \pi < 0.15$ and [$\pi \prec P(z_{t-1} \prec \tau) \prec 1-\pi$]. The grid search for the threshold is then conducted on the remaining 70 to 90 % of the observations. The threshold,τ, yielding the lowest RSS is the consistent and optimal threshold, τ*.

Financial markets perform the important function of price discovery. Lehmann (2002) defines price discovery as the efficient and timely adjustment of market prices to incorporate new information implicit in investor trading. Therefore, we expect one market to adjust first to new information (price leadership role) while the other market lags in adjustment information relating to credit risk. Long-run price discovery implies that a change in price series can predict the persistent change in price of the other instrument(s) since there is a common stochastic trend.

To test for long-run price discovery and cointegration in the upper regime, we assess the statistical significance and sign of the parameters λ_{11} and α_{21}. The two measure the speed of adjustment to new information above the threshold (upper regime). Likewise, λ_{12} and α_{22} measure the speed of adjustment to long run equilibrium in the lower regime. Engle and Granger, (1987) postulated that the existence of cointegration means that at least one market has to adjust to new information before the other market. This test complements any inconclusive evidence provided by the co-integration equations (iii) and (iv).

We then test for speed of adjustment or price discovery for each regime as follows: If both λ_{11} and α_{21} (λ_{12} and α_{22}) are statistically significant, then both markets *y* and *x* respond to new credit risk information at the same time (price discovery takes place in both markets) in the upper (lower) regime when the Heaviside indicator, $I_t=1(I_t=0)$. If λ_{11} *(y)* is significantly negative while α_{21} *(x)* is positive and insignificant, then, *y* adjusts to new information to clear misalignment or pricing discrepancy with *x.* Therefore, price discovery occurs in market *x* in the upper regime*.* Similarly, if α_{21} *(x)* is significantly negative while λ_{11} *(y)* is insignificantly positive, *x* adjust to new credit risk information and *y* leads in price discovery in the upper regime. The same arguments and tests are then replicated for lower regime when Heaviside indicator, $I_t=0$*.* If λ_{11} and α_{21} (λ_{12} and α_{22}) have the same sign, this is indicative of potential bubbles or burst in security prices.

v. Asymmetric Return Spillover across markets

In this section, I model return spillover among the CDS, bond and equity markets. The joint process governing spillover of daily returns of the three markets is represented by the following system of equations

$$r_{c,t} = \lambda_{10} + \lambda_b^+ r_{b,t-1}^+ + \lambda_b^- r_{b,t-1}^- + \lambda_c^+ r_{c,t-1}^+ + \lambda_c^- r_{c,t-1}^- + \lambda_e^+ r_{e,t-1}^+ + \lambda_e^- r_{e,t-1}^- + \varepsilon_{c,t} \qquad \text{(xia)}$$

$$r_{b,t} = \lambda_{20} + \lambda_b^+ r_{b,t-1}^+ + \lambda_b^- r_{b,t-1}^- + \lambda_c^+ r_{c,t-1}^+ + \lambda_c^- r_{c,t-1}^- + \lambda_e^+ r_{e,t-1}^+ + \lambda_e^- r_{e,t-1}^- + \varepsilon_{b,t} \qquad \text{(xib)}$$

$$r_{e,t} = \lambda_{30} + \lambda_b^+ r_{b,t-1}^+ + \lambda_b^- r_{b,t-1}^- + \lambda_c^+ r_{c,t-1}^+ + \lambda_c^- r_{c,t-1}^- + \lambda_e^+ r_{e,t-1}^+ + \lambda_e^- r_{e,t-1}^- + \varepsilon_{e,t} \qquad \text{(xic)}$$

In the above system of equations,

$r_{i,t-1}^{+} = \max(0, r_{i,\ t-1})$ and $r_{i,t-1}^{-} = \mathrm{Min}\ (r_{i,\ t-1}, 0)$ where $i = c,\ b\ and\ e$

$$\varepsilon_{\text{t-1}} = \begin{bmatrix} \varepsilon_{c,t-1} \\ \varepsilon_{b,t-1} \\ \varepsilon_{e,t-1} \end{bmatrix} \sim Student - t[0,\ h_t, \kappa]$$

Where $r_{c,t}$, $r_{b,t-1}$ and $r_{e,t-1}$ are sovereign CDS, bond and equity returns respectively. The returns are continuously compounded such that $r_{i,t} = \dfrac{\ln(p_t)}{\ln(p_{t-1})} * 100$. The returns $r_{c,t}$, $r_{b,t-1}$ and $r_{e,t-1}$ exhibit fat tail distribution hence we assume the conditional distribution of ε_t is best represented by student-t distribution. In this case, $E_{t-1}(\varepsilon_t) = 0$ and $E_{t-1}(\varepsilon_t \varepsilon_t') = h_t$. κ is the degrees of freedom and $2 < \kappa < \infty$.

In equations (xia), (xib) and (xic), the returns of any of the three markets at time *t-1*enter the information set at time t. This implies that, for example, the conditional returns of CDS market, $r_{c,t}$, are influenced by own lagged returns, $r_{c,t-1}$, and the lagged positive and negative returns of bond and equity markets ($r_{i,t-1}^{+}$ and $r_{i,t-1}^{-}$) respectively. This also applies to conditional returns of sovereign bonds and equity returns. The inclusion of own lagged returns is imperative to mitigate the potential for misinterpreting serial return dependence as return spillover.I test for asymmetric return spillover as follows:

$$Ho : \lambda_i^{+} = \lambda_i^{-} \text{ (Return spillover is symmetric)}$$
$$H_1 : \lambda_i^{+} \neq \lambda_i^{-} \text{ (Return spillover is asymmetric)}$$

If either λ_i^{+} or λ_i^{-} is statistically significant, there is return spillover. Moreover, if λ_i^{+} and λ_i^{-} are statistically significant and $\lambda_i^{+} \neq \lambda_i^{-}$, then return spillover is asymmetric. As long as there is return spillover whether symmetric ($\lambda_i^+ = \lambda_i^-$) or asymmetric ($\lambda_i^+ \neq \lambda_i^-$), arbitrage opportunities are extant where investors in one market will potentially exploit information from the other two markets. Consistent with news-based hypothesis of contagion, this would create momentum trading in other two markets

IV. Empirical results

G. Descriptive statistics

Table I provides the summary statistics of sovereign CDS premium, bond spreads and equity returns. The results indicate that equity returns have the lowest volatility (standard deviation) while the bond returns exhibit highest standard deviation with exception of Argentina, Colombia and Venezuela where CDS returns have the highest standard deviation. This observation could be explained by the fact that the few institutional sovereign bondholders 'buy and hold' the bonds while they trade on CDS which requires no funding, can be shorted and have few or no binding constraints. The bond market thus become more illiquid and thinly traded, which could partly explain the high volatility relative to CDS and equity rreturns.

The mean returns vary among sovereign bonds, CDS and equity. For example: In Thailand CDS has the highest mean returns but the second highest standard deviation. In all cases, the coefficient of variation of equity return is positive since the mean returns are positive. Malaysia has the highest coefficient of variation (CV=259.80) of bond returns primarily due to high volatility of bond returns while Thailand has the lowest CV of bond returns (-499.27) due to high volatility couple with low returns.

Table 1: Descriptive Statistics

This table summarizes descriptive statistics touching on measures of central tendency (Mean), measure of dispersions (Standard deviation, SD and coefficient of variation, CV), measures of distribution shape (skew and Kurtosis), test of normal distribution (Jacque-Berra, JB), tests of empirical distribution of the mean and standard deviation using Z-statistic(Mu(z) and sigma(z)) and a measure of association (Correlation). The correlation of returns (ln(pt/pt-1)) of sovereign bond spreads, CDS spreads and equity are to the right of the diagonal while correlation coefficients of price movements (levels) of the three series is to the left of the diagonal. Obs is the number of observations

									Correlations			
Argentina	**Mean**	**SD**	**CV**	**Skew**	**Kurtosis**	**JB**	**mu(z)**	**sigma(z)**	**Bond**	**CDS**	**Equity**	**Obs**
Bond	0.00088	0.0486	55.06	1.761	22.70	25.39	0.708	*55.15	1.000	0.099	-0.270	1522
CDS	0.01185	0.1709	14.42	0.978	19.84	18.22	*2.808	*55.15	0.973	1.000	-0.073	1522
Equity	0.00083	0.0235	28.34	-0.389	9.53	2.74	1.377	*55.15	-0.225	-0.226	1.000	1522
Brazil												
Bond	-0.00190	0.2086	-109.89	0.120	17.70	17.44	-0.158	*62.23	1.000	0.085	-0.157	1937
CDS	-0.00049	0.0532	-108.53	-0.721	39.96	110.43	-0.581	*62.23	0.823	1.000	-0.225	1937
Equity	0.00089	0.0257	28.81	-0.290	9.85	3.82	1.528	*62.23	-0.802	-0.472	1.000	1937
Colombia												
Bond	-0.00059	0.0349	-59.63	0.339	8.27	2.07	-0.705	*59.41	1.000	0.092	-0.297	1766
CDS	-0.00089	0.0438	-49.39	1.114	23.95	32.66	-0.851	*59.41	0.948	1.000	-0.143	1766
Equity	0.00135	0.0196	14.51	-0.401	12.23	6.31	*2.896	*59.41	-0.879	-0.860	1.000	1766
Mexico												
Bond	0.00317	0.2164	68.19	0.623	16.01	13.78	-1.023	*62.23	1.000	0.164	-0.130	1937
CDS	0.00099	0.0477	48.04	2.623	34.00	79.80	-0.078	*62.23	0.922	1.000	-0.440	1937
Equity	0.00066	0.0185	28.00	0.239	10.65	4.74	1.166	*62.23	-0.689	-0.539	1.000	1937
Venezuela												
Bond	-0.00057	0.0237	-41.57	0.561	12.02	6.08	-1.01	*59.41	1.000	0.260	-0.040	1766
CDS	-0.00031	0.0346	-110.10	0.952	10.64	4.56	-0.384	*59.41	0.765	1.000	-0.019	1766
Equity	0.00115	0.0133	11.59	0.490	12.32	6.47	3.068*	*59.41	-0.574	-0.081	1.000	1766
China												
Bond	0.00936	0.2254	24.07	0.727	12.07	6.21	0.173	*59.43	1.000	0.031	-0.044	1767
CDS	0.00090	0.0472	52.58	0.293	16.91	14.26	1.022	*59.43	0.870	1.000	-0.388	1767
Equity	0.00102	0.0206	20.12	0.205	9.47	3.09	**2.088	*59.43	-0.027	0.043	1.000	1767
Indonesia												
Bond	0.01102	0.2139	19.42	1.074	12.53	4.93	*3.149	*49.76	1.000	0.021	0.039	1239
CDS	0.00224	0.0749	33.46	0.700	11.24	3.61	1.477	*49.76	0.519	1.000	-0.216	1239
Equity	0.00094	0.0225	23.87	-0.031	9.26	2.02	1.474	*49.76	-0.199	-0.277	1.000	1239
Malaysia												
Bond	0.00109	0.2834	259.80	0.155	8.92	2.83	-1.215	*62.23	1.000	0.064	-0.008	1937
CDS	0.00098	0.0490	49.89	0.990	13.22	8.74	0.882	*62.23	0.798	1.000	-0.367	1937
Equity	0.00036	0.0103	28.39	-0.501	11.66	6.13	1.55	*62.23	-0.499	-0.248	1.000	1937
Philippines												
Bond	0.00033	0.0425	130.23	0.976	10.17	4.10	0.324	*59.70	1.000	0.483	-0.214	1783
CDS	-0.00011	0.0345	-319.65	0.609	11.63	5.64	0.04	*59.70	0.954	1.000	-0.341	1783

Equity	0.00077	0.0167	21.77	-0.293	8.21	2.04	***1.939	*59.70	-0.883	-0.848	1.000	1783
Thailand												
Bond	-0.00031	0.1543	-499.27	0.075	27.34	37.58	-1.346	*55.15	1.000	0.238	-0.025	1522
CDS	0.00172	0.0463	26.88	1.273	26.16	34.43	1.59	*55.15	0.938	1.000	-0.097	1522
Equity	0.00003	0.0149	583.53	-0.757	15.85	10.61	0.067	*55.15	-0.698	-0.693	1.000	1522
Bulgaria												
Bond	0.00232	0.2322	100.27	1.464	20.85	26.42	0.439	*62.23	1.000	-0.005	-0.037	1937
CDS	0.00093	0.0463	49.98	0.813	19.69	22.69	0.88	*62.23	0.897	1.000	-0.108	1937
Equity	0.00077	0.0153	19.97	-0.418	10.23	4.27	**2.204	*62.23	-0.686	-0.611	1.000	1937
Hungary												
Bond	0.00731	0.1640	22.45	1.746	16.37	15.42	*2.648	*62.23	1.000	0.057	-0.039	1937
CDS	0.00199	0.0481	24.20	1.052	14.53	11.09	***1.934	*62.23	0.866	1.000	-0.350	1937
Equity	0.00083	0.0236	28.63	0.322	14.06	9.90	1.537	*62.23	-0.438	-0.222	1.000	1937
Poland												
Bond	-0.00519	0.2054	-39.60	-0.325	15.84	13.34	-1.111	*62.23	1.000	0.064	-0.047	1937
CDS	0.00153	0.0495	32.43	1.086	11.01	5.56	1.432	*62.23	0.948	1.000	-0.318	1937
Equity	0.00063	0.0212	33.90	0.011	8.04	2.05	1.299	*62.23	-0.309	-0.313	1.000	1937
Russia												
Bond	-0.00635	0.2181	-34.35	-0.087	11.33	5.60	-1.281	*62.23	1.000	0.096	-0.101	1937
CDS	0.00061	0.0447	73.16	1.481	18.58	20.29	0.602	*62.23	0.717	1.000	-0.449	1937
Equity	0.00084	0.0267	31.98	0.158	18.01	18.18	1.375	*62.23	-0.861	-0.656	1.000	1937
Turkey												
Bond	0.00039	0.1006	255.44	0.799	14.57	11.02	-0.287	*62.23	1.000	0.382	-0.314	1937
CDS	0.00001	0.0363	3027.50	1.100	9.93	4.27	0.015	*62.23	0.928	1.000	-0.568	1937
Equity	0.00108	0.0285	26.33	0.033	7.49	1.63	***1.671	*62.23	-0.870	-0.792	1.000	1937
S. Africa												
Bond	-0.00221	0.2344	-106.28	0.603	12.55	7.48	-0.414	*62.23	1.000	0.042	-0.080	1937
CDS	0.00062	0.0391	63.56	1.216	11.29	6.02	0.684	*62.23	0.793	1.000	-0.427	1937
Equity	0.00067	0.0198	29.77	-0.192	7.86	1.92	1.479	*62.23	-0.719	-0.378	1.000	1937
Tunisia												
Bond	0.00154	0.1400	90.87	0.364	22.30	27.70	0.628	*59.70	1.000	0.078	-0.041	1783
CDS	0.00151	0.0911	60.53	2.315	48.90	158.10	**2.053	*59.70	0.660	1.000	-0.022	1783
Equity	0.00073	0.0050	6.85	-0.264	13.63	8.42	*6.157	*59.70	-0.238	0.400	1.000	1783

The results characterize the high risk (volatility) associated with emerging markets. The low returns and high volatility could be as a result of thin trading and low liquidity which characterize security returns in emerging markets. This may be one of the causes of nonlinearities in the data.The shape of distribution as epitomized by skewness and kurtosis is consistent with stylized facts of financial series returns. There is asymmetrical distribution of returns in all three markets of each country since skewness is either positive or negative. An interesting feature of Eastern Europe countries except Bulgaria (Hungary, Poland, Russia and Turkey) together with Mexico and Venezuela is that they have positive skew of equity returns. All the rest of eleven emerging markets have negative skew of equity return (mean return less than median returns). All bond returns (except for Poland) and CDS returns (except for Brazil) exhibit positive skew implying that the mean return is greater than median returns.

The asymmetry in return distribution is also supported by Jacque-Berra statistic which tests the null of normal distribution of returns. The null is decisively rejected due to high statistical significance of JB statistic (non-normal distribution of returns). However, JB is highly sensitive to extreme returns. To this end, I compute empirical distribution of the mean (mu(z)) and standard deviation (sigma(z)). Both statistics are asymptotic normal hence Z-statistic. The null hypothesis is normal distribution. The standard deviations of returns of bond spread, CDS premium and equity for each of the seventeen countries are non-normally distributed and exhibit nonlinear dependence (statistically significant z-statistic which decisively rejects null). The mean equity returns of Colombia, Venezuela, China, Philippines, Bulgaria and Tunisia exhibit non-normal distribution. This is the same case with CDS spread returns of Argentina, Hungary and Tunisia as well as bond spread return of Indonesia and Hungary.

All the returns exhibit leptokurtic (fat tail) distribution (Black, 1976) since Kurtosis is greater than 3 in all cases. Except for Colombia, Venezuela, Malaysia and Russia, equity returns exhibit the lowest leptokurtic distribution.

The CDS premium and bond spreads exhibit strong positive correlation which is as high as 97.3% for Argentina and as low as 51.9% for Indonesia. This is justified since both CDS and bond spreads price the same credit risk. As postulated by Merton (1974) and Campbell and Taksler (2003), bond yield (spreads) and equity prices on one hand and CDS premium and equity on the other exhibit inverse relationship. This has important implication about the leverage and default risk of emerging markets. If default risk is high, bond spreads and CDS premium will increase while equity prices will decline to incorporate the reduction in distance to default or increased probability of default. This seems to characterize emerging markets as having high default risk.

Returns of both markets are also positively correlated for all countries albeit weakly relative to prices. Both equity and bond returns and equity and CDS returns are negatively correlated since investors include equity (variable income security)and bonds (fixed income security) as substitute assets to hedge against decline in prices and returns of each other.

H. Model Pre-specifications: Tests of asymmetry andnonlinearities

The summary results in table 2(a) capture the salient features inherent in the behavior of security returns and asymmetry in series observations. Taken together with measures of distributional shape (skewness and Kurtosis), and dynamic conditional correlation test, the indicators will assist in the design and adoption of asymmetric modeling in return spilloverand nonlinear cointegration and price discovery process.

Table 2(a): Asymmetry Indicators and Model Pre-specification Tests

In this table, SBT, NSBT, PSBT and JBT are Engle and Ng (1993) bias tests which are initial indicators of asymmetry in volatility. Specifically, SBT is the sign bias test defined as $\varepsilon_{i,t}^2 = c + bS_{i,t-1}^{-} + \upsilon_{i,t}$. NSBT is the negative size bias test defined as $\varepsilon_{i,t}^2 = c + bS_{i,t-1}^{-}\varepsilon_{i,t-1} + \upsilon_{i,t}$. PSBT is the positive size bias test defined as $\varepsilon_{i,t}^2 = c + bS_{i,t-1}^{+}\varepsilon_{i,t-1} + \upsilon_{i,t}$.

JBT is the joint bias test where $\varepsilon_{i,t}^{2} = c + b_1 S_{i,t-1}^{-}\varepsilon_{i,t-1} + b_2 S_{i,t-1}^{+}\varepsilon_{i,t-1} + b_3 S_{i,t-1}^{-} + \upsilon_{i,t}$

$\varepsilon_{i,t}$ is the residual (observation less mean), $S_{i,t-1}^{-}$ = 0 if $\varepsilon_{i,t-1}$<0 and zero otherwise. $S_{i,t-1}^{+}$ =1 if $\varepsilon_{i,t-1}$>0 and zero otherwise. For SBT, NSBT and PSBT, we check for statistical significance of coefficient *b* using *t-statistic.*JBT utilizes F statistic for a joint test that of the null *b1= b2= b3=0.*ARCH (1) and ARCH (2) is the Engle (1982) test of an autoregressive conditional heteroskedasticity (ARCH) effect whose Ho is: No ARCH (Conditional heteroskedasticity) effects in the series. LB (10) and LB^2 (10) are the Ljung-Box Q statistics of serial correlation (up to 10 lags) of residuals and squared residuals respectively. The Ho is: No autocorrelation. *, ** and *** means significant at 1%, 5% and 10% respectively. CCC is constant conditional correlation test of Engle and Sheppard (2001).Its Ho is constant conditional correlation while Ha is dynamic conditional correlation using F-statistic. B/C, B/E and C/E refer to CCC test for sovereign bond and CDS residuals, sovereign bonds and equity residuals and sovereign CDS and equity residuals.

Argentina	**SBT**	**PSBT**	**NSBT**	**JBT**	**ARCH(1)**	**ARCH(2)**	**LB(10)**	**LB^2(10)**	**CCC**	**F-Stat**
Bond	*-5.609	*32.063	*4.440	*13.306	**2.016	*5.762	*43.91	*144.06	CCC: B/C	**2.40
CDS	*-6.256	*20.455	*5.192	*9.523	1.104	0.871	*54.05	*94.98	CCC: B/E	*5.27
Equity	**-2.05	*6.314	*-2.708	**1.041	0.007	*15.123	13.45	*450.80	CCC: C/E	*3.55
Brazil										
Bond	*-5.124	*18.940	*3.860	*9.536	0.193	1.033	*40.58	*121.36	CCC: B/C	*16.25
CDS	*-5.087	*17.501	*4.789	*9.642	0.185	0.361	6.27	6.58	CCC: B/E	*6.25
Equity	*-3.905	*15.570	1.489	*7.685	1.297	*93.393	**21.12	*832.35	CCC: C/E	*12.17
Colombia										
Bond	*-3.530	*12.353	-0.247	*7.374	1.667	*18.494	6.02	*238.74	CCC: B/C	*16.55
CDS	*-3.396	*7.767	***1.897	*3.749	0.614	*8.171	*43.11	*60.44	CCC: B/E	*6.68
Equity	*3.525	*3.031	*-11.730	*6.289	1.568	*137.075	*51.72	*533.56	CCC: C/E	*9.80
Mexico										
Bond	*-6.506	*21.695	*3.655	*8.083	0.828	0.802	***14.69	*59.06	CCC: B/C	*9.97
CDS	*-5.767	*14.387	*3.662	*4.427	0.266	*23.751	*36.13	*207.59	CCC: B/E	*34.94
Equity	*-3.571	*15.913	**-1.977	*10.972	1.613	*19.022	8.78	*450.49	CCC: C/E	*7.59
Venezuela										
Bond	*-4.941	*36.029	***1.841	*7.260	1.939	*25.901	*31.31	*288.32	CCC: B/C	*6.47
CDS	*-5.253	*31.267	*10.708	*5.907	0.186	***2.410	**23.76	**25.33	CCC: B/E	*7.04
Equity	1.607	*13.581	*-27.480	*6.226	1.777	*5.599	*71.30	*48.64	CCC: C/E	*4.48
China										
Bond	*-4.290	*14.640	***1.723	*5.871	0.105	*19.787	**21.97	*135.81	CCC: B/C	*39.18
CDS	*-4.543	*17.923	*4.041	*7.732	0.31	**5.8201	***17.99	12.288	CCC: B/E	*48.02
Equity	*-4.737	*10.130	*4.359	*5.661	1.61	*19.572	**19.62	*251.23	CCC: C/E	*3.95
Indonesia										
Bond	*-2.901	*8.775	0.263	*2.201	0.389	0..208	**20.42	3.76	CCC: B/C	*2.85
CDS	*-5.897	*13.137	*4.848	*2.612	***2.175	1.186	**21.19	**31.28	CCC: B/E	0.52
Equity	**-2.382	*11.733	*-3.558	*4.377	0.914	*8.422	**23.65	*57.19	CCC: C/E	*6.59
Malaysia										
Bond	*-5.341	*18.110	0.279	*8.098	1.25	*20.105	**26.22	*52.26	CCC: B/C	0.30
CDS	*-4.531	*8.063	*3.920	*2.649	1.923	*19.866	*31.28	*76.71	CCC: B/E	**2.04
Equity	*-7.936	*19.549	**2.004	*11.757	1.276	*9.1902	*29.52	*48.26	CCC: C/E	*6.91
	Philippines									

Bond	-0.065	*5.302	*-5.907	*6.181	***3.087	*27.918	5.21	*127.82	CCC: B/C	*7.46
CDS	-1.14	*5.266	*-3.137	*3.080	***2.055	*22.603	***14.97	*147.98	CCC: B/E	*9.23
Equity	*-5.030	*15.813	-0.097	*8.735	1.897	*27.933	*29.72	*145.5	CCC: C/E	*6.17
Thailand										
Bond	*-4.394	*16.120	*2.987	*4.830	0.211	*4.655	*50.95	*289.49	CCC: B/C	*12.78
CDS	*-4.628	*12.123	*4.392	*3.863	***2.431	1.235	*27.29	**29.76	CCC: B/E	*4.26
Equity	*2.664	*3.307	*-20.958	*7.785	0.005	1.508	***18.03	13.48	CCC: C/E	*18.74
Bulgaria										
Bond	*-5.383	*19.506	*3.393	*8.751	1.411	0.909	14.14	*31.33	CCC: B/C	*10.54
CDS	*-4.403	*12.496	*3.354	*5.935	***2.083	1.731	13.59	*30.84	CCC: B/E	*2.83
Equity	*-2.849	*12.060	-0.203	*7.281	*7.113	*5.883	*61.69	*66.03	CCC: C/E	*14.77
Hungary										
Bond	*-4.628	*20.754	*2.551	*10.820	0.739	0.79	***18.60	*70.13	CCC: B/C	*6.24
CDS	*-6.203	*18.031	*5.952	*9.662	3.362***	*7.265	10.06	*35.58	CCC: B/E	*3.65
Equity	0.349	*8.114	*-5.274	*7.403	1.297	*93.393	***21.12	*832.35	CCC: C/E	*9.57
Poland										
Bond	*-3.720	*14.055	**-2.386	*9.982	1.193	*4.685	13.52	*47.96	CCC: B/C	*17.37
CDS	*-4.799	*11.010	*4.105	*6.350	***2.293	**3.786	9.57	**26.06	CCC: B/E	*8.13
Equity	*-4.812	*16.728	-0.464	*9.155	0.16	*22.938	***14.97	*466.73	CCC: C/E	*19.61
Russia										
Bond	*-4.604	*14.061	*3.690	*9.812	0.226	*4.208	***18.50	*73.67	CCC: B/C	*20.46
CDS	*-4.754	*13.058	*3.534	*4.981	0.775	*35.251	***14.88	*86.52	CCC: B/E	*15.03
Equity	*-6.803	*14.531	**2.373	*8.170	0.803	*12.891	13.3	*149.72	CCC: C/E	*20.03
Turkey										
Bond	*-6.168	*23.632	*3.482	*12.004	0.91	***2.258	12.85	*37.05	CCC: B/C	*56.47
CDS	*-6.587	*19.547	*5.068	*8.530	***2.457	*15.986	*42.99	*157.64	CCC: B/E	*68.42
Equity	*-4.234	*8.502	*-4.464	*5.753	0.701	*6.124	***22.78	*123.42	CCC: C/E	*75.94
S. Africa										
Bond	*-5.802	*14.903	0.929	*6.733	1.426	1.104	***16.23	*57.55	CCC: B/C	*8.98
CDS	*-3.840	*12.967	*2.669	*4.972	***2.626	1.894	**27.33	*57.99	CCC: B/E	*12.73
Equity	*-2.774	*7.496	*-7.331	*7.629	1.513	*62.869	***22.60	*393.02	CCC: C/E	*62.50
Tunisia										
Bond	***-1.72	*12.265	*-3.922	*5.412	1.694	*6.325	**25.48	*120.83	CCC: B/C	*4.30
CDS	*-4.145	*13.791	*2.778	*6.051	0.119	0.081	*42.38	*71.19	CCC: B/E	*6.83
Equity	*-3.389	*9.458	0.741	*7.624	0.071	*6.575	*117.46	*125.21	CCC: C/E	**1.84

The Ljung-Box Q statistics (LB (10) and LB^2 (10)) test the presence of inter-temporal dependence of residuals and squared residuals up to tenth order. The null hypothesis is that there is serial independence of residuals. The first order serial dependence in security returns is symptomatic of non-synchronous trading in security returns while second order serial dependence in residuals indicates ARCH effects and volatility clustering.

The bond spreads of Colombia, Philippines, Bulgaria and Turkey exhibit weak serial dependence in residuals (Insignificant LB Q-statistic) while CDS spreads of Argentina, Brazil, and Bulgaria as well as Russia equity show weak or no serial dependence of residuals. However, these series exhibit strong serial dependence using squared residuals (Significant LB^2 (10) Q-statistic). ARCH (1) and ARCH (2) are the Engle's (1982) LM test of ARCH effects. The null is that there are no ARCH effects.

The bond spreads of Bulgaria, Indonesia, Hungary, Mexico and S. Africa do not exhibit ARCH effect up to order two (Insignificant LM statistic) while the CDS spreads of Indonesia, Argentina, Tunisia and Thailand do not have ARCH effects up to order two. Only Thailand's equity returns do not exhibit Arch effects. However, these series still exhibit other features of asymmetry necessary for modeling return and volatility spillovers. Specifically, the joint bias test (JBT) of Engle and Ng (1993) decisively provide evidence of asymmetry since all F-statistics are significant.

Moreover, apart from Indonesia and S. Africa's bond spreads, the series exhibit asymmetry since negative size bias test (NSBT), positive size bias test (PSBT) and sign bias test (SBT) all have significant t-statistic. SBT, NSBT, PSBT and JBT afford strong evidence for the need to adopt an ARCH/GARCH type model in assessing volatility spillover among the three markets or assessing asymmetry in return shock spillovers.

Lastly, the constant conditional correlation or covariance (CCC) test[9] of Engle and Sheppard (2001) tests the null hypothesis of constant conditional correlation. That is: whether covariances between residuals of any two series are constant or dynamic over time. Table 2(b) results indicates that at any conventional significance level, only residuals of Indonesia bonds and equity and Malaysia's bonds and CDS residuals have constant conditional correlation since the F-statistic is jointly insignificant. The remaining 49/51 series exhibit dynamic conditional correlation of residuals (F-statistic is jointly significant). The dynamic conditional covariance of residuals of any two markets is important for modeling nonlinear relationships, asymmetric volatility and return spillover.

Table 2(b) provides various tests of nonlinearities in data including Ramsey RESET test of specification errors in regression equations in cointegrating equations. Using the linear DF-GLS unit root test, only sovereign CDS spreads of Poland are weakly stationary (t-statistic weakly significant at 10%). All the other series for all countries are linearly non-stationary.

Table 2(b): Nonlinear modeling tests: Nonlinear Unit root and Nonlinear Indicators

This table summarizes linear and non-linear unit root tests and BDS nonlinearity test. DF-GLS is the t-statistic of Dickey-Fuller Generalized least squares unit root test. It test Ho is: unit root. Critical values are 2.566, 1.941 and 1.616 at 1%, 5% and 10% significant levels. KSS in the t-statistic of Kapetanios, Shin and Snell (2003) test using demeaned series (DM) and detrended series (DT). The Ho is: Series is non-linear and non-stationary. The critical values are non-asymptotic normal distribution and are provided at the bottom of table 2(b). BDS is the Brock, Dechert, Scheinkman and LeBaron (1996) Z-statistic to test non-linear dependence using 2 and 3 (BDS (2) and BDS (3)) embedding dimension with ε/σ=0.9. The Ho is that series observations are drawn from an iid process and Ha is non-linear dependence. Tsay test of nonlinearity tests the Ho that all coefficients are equal to zero (linear dependence in time series data) The Ha is non-linear dependence in time series data. C.E is the cointegrating equation. C, E and B are CDS premium, equity prices and Bond spreads respectively. C/B, for example, is the cointegration equation: $CDS = c + \beta_1 BYS + \varepsilon$. RESET (2) is the Ramsey (1969) Regression Specification Error Test with 2 additional regressors to test for nonlinearity and misspecifications in cointergating equation. Example: $CDS = c + \beta_1 BYS + \beta_2 CDS^2 + \beta_3 CDS^3 + \varepsilon$ The F-Statistic tests the null $\beta_2 = \beta_3 = 0$

[9] Specifically, this test involves extracting two series of residuals (regress y on x and get residuals and then regress x on y and get the residuals), get the product of the two residuals and then regress the product on its own 10 lags. The Joint F-statistic (and its P-value) is used to make decision.

Argentina	DF-GLS	KSS-DM	KSS-DT	BDS(2)	BDS(3)	Tsay Test	Order	C.E	RESET(2) F-stat	Obs
Bond	-0.98	-1.255	-1.746	10.767*	13.858*	*2.709	18	C/B	*674.52	1522
CDS	-0.428	-1.012	-1.256	8.36*	8.433*	*32.19	0	C/E	*80.05	1522
Equity	-1.465	-1.425	-1.667	9.637*	13.21*	2.341	1	E/B	*122.22	1522
Brazil										
Bond	0.693	-0.649	-1.127	22.009*	23.342*	*7.821	17	C/B	*3318.06	1937
CDS	-1.337	-0.848	-0.954	10.356*	11.83*	*48.46	31	C/E	*996.36	1937
Equity	0.206	-1.069	-1.939	10.583*	14.851*	*4.559	19	E/B	*1324.29	1937
Colombia										
Bond	0.254	-2.368	-2.139	8.494*	12.581*	1.44	3	C/B	*39.61	1766
CDS	0.345	-2.1	-2.088	9.133*	12.338*	*17.4	32	C/E	*257.00	1766
Equity	0.842	-0.799	-1.608	14.167*	16.839*	*8.556	4	E/B	*191.71	1766
Mexico										
Bond	-1.355	-2.302	-1.982	-0.023	-0.031	4.442*	7	C/B	*170.98	1937
CDS	-1.808	-1.925	-1.867	10.662*	13.025*	18.01*	28	C/E	*20.71	1937
Equity	-0.246	-1.384	-1.535	12.473*	14.943*	2.492***	2	E/B	*141.73	1937
Venezuela										
Bond	0.231	-2.396	-1.269	9.169*	12.134*	6.854*	2	C/B	*12.45	1766
CDS	-0.523	-0.599	-0.79	8.741*	10.867*	7.76*	13	C/E	*220.69	1766
Equity	1.024	-1.163	-1.31	12.681*	14.054*	29.46*	6	E/B	*110.94	1766
China										
Bond	-1.698	-1.899	-2.224	17.31*	17.602*	2.522*	13	C/B	*286.00	1767
CDS	-1.522	-1.449	-1.26	10.693*	14.183*	21.95*	29	C/E	*41.38	1767
Equity	0.113	-0.785	-0.9	8.252*	13.306*	3.464***	1	E/B	*11.48	1767
Indonesia										
Bond	-1.423	-1.797	-2.016	18.201*	20.022*	4.746*	30	C/B	*348.69	1239
CDS	-1.662	-1.911	-2.414	5.381*	6.634*	18.35*	21	C/E	*17.52	1239
Equity	-0.214	-1.243	-1.249	7.692*	9.762*	1.378	2	E/B	*15.57	1239
Malaysia										
Bond	-1.224	-2.917***	-2.4	-0.023	-0.031	0.6133	3	C/B	*91.79	1937
CDS	-1.162	-1.559	-1.644	11.787*	14.582*	25.65*	29	C/E	*46.09	1937
Equity	0.028	-0.804	-1.168	7.777*	11.714*	7.204**	4	E/B	*24.02	1937
Philippines										
Bond	-0.151	-2.772***	-1.699	8.975*	13.974*	6.299*	11	C/B	*22.66	1783
CDS	-0.318	-1.567	-1.343	15.539*	17.851*	10.18*	20	C/E	*368.43	1783
Equity	-0.06	-1.115	-1.453	7.531*	10.143*	2.056***	2	E/B	*93.18	1783
Thailand										
Bond	-1.367	-1.303	-1.68	21.143*	23.742*	15.46*	28	C/B	*763.32	1522
CDS	-1.348	-1.256	-1.541	15.156*	15.611*	39.87*	30	C/E	*1504.25	1522
Equity	-1.299	-1.309	-1.525	11.609*	13.611*	8.678*	3	E/B	*156.98	1522
Bulgaria										
Bond	-0.672	-1.958	-1.783	21.66*	23.506*	1.44	3	C/B	***2.72	1937

CDS	-0.46	-0.974	-1.045	10.672*	12.268*	17.4*	32	C/E	*268.24	1937
Equity	-1.2	-0.487	-0.284	14.267*	15.796*	8.556*	4	E/B	*48.07	1937
Hungary										
Bond	-1.6	-1.046	-1.306	18.234*	20.107*	3.592*	22	C/B	*488.01	1937
CDS	-1.098	-0.938	-1.128	10.098*	11.421*	64.24*	0	C/E	*37.51	1937
Equity	-0.491	-1.438	-1.318	12.254*	14.096*	3.002*	5	E/B	*25.99	1937
Poland										
Bond	-0.757	-1.679	-1.892	23.086*	24.499*	1.499	3	C/B	*106.81	1937
CDS	-1.666***	-0.658	-0.695	13.437*	14.795*	40.29*	25	C/E	*17.58	1937
Equity	-0.477	-1.288	-1.425	7.519*	10.641*	2.32***	2	E/B	*151.39	1937
Russia										
Bond	0.292	-1.288	-1.157	21.132*	22.902*	0.7074	1	C/B	*15.77	1937
CDS	-1.394	-1.017	-0.985	17.434*	18.655*	18.97*	32	C/E	*303.77	1937
Equity	-0.505	-1.093	-1.544	9.065*	12.22*	4.283*	22	E/B	*539.48	1937
Turkey										
Bond	0.825	-1.004	-1.299	18.682*	21.544*	2.651**	2	C/B	*912.60	1937
CDS	-1.101	-1.023	-1.643	14.788*	17.064*	8.622*	22	C/E	*789.02	1937
Equity	-0.348	-1.397	-1.662	7.655*	9.84*	3.377***	1	E/B	*351.35	1937
S. Africa										
Bond	-1.194	-2.055	-1.471	21.837*	22.682*	2.386*	32	C/B	*55.20	1937
CDS	-1.637	-1.29	-1.414	13.968*	14.52*	17.48*	20	C/E	0.61	1937
Equity	-0.267	-1.74	-1.722	8.934*	13.573*	5.693*	5	E/B	*34.10	1937
Tunisia										
Bond	0.231	-2.551	-1.69	21.814*	22.446*	3.307*	7	C/B	2.11	1783
CDS	-0.523	-1.408	-1.666	7.807*	8.72*	7.835*	29	C/E	*717.36	1783
Equity	1.024	1.387	-0.224	15.705*	17.027*	0.00406	1	E/B	**4.48	1783

Asymptotic critical values for the kss test: Significance level Case 1 Case 2 Case 3

Significance level	Case 1	Case 2	Case 3
1%	–2.82	–3.48	–3.93
5%	-2.22	-2.93	-3.40
10%	-1.92	-2.66	--3.13

Notes: Case 1, Case 2 and Case 3 refer to the underlying model with the raw data, the demeaned data and the detrended data, respectively. These values apply for both serially uncorrelated and correlated cases. The critical values are reproduced from KSS. *(2003, p. 364).*

Using the KSS non-linear unit root test, only sovereign bond spreads of Malaysia and Philippines are weakly non-linear stationary when the series are demeaned. However, all the de-trended series for all countries shows insignificant t-statistic implying that the null of non-linear non-stationary cannot be rejected. This supports the need for threshold cointegration and price discovery tests of the sovereign bond spreads, CDS and equity.

BDS statistic follows a standard normal distribution and hence uses Z-statistic in testing whether series observations exhibit non-linear dependence. Brock and Sayers (1988) recommend that ε/σ should be selected to fall between 0.5 and 2 and embedding dimensions, m, to range between two to five. In this study, we select ε/σ=0.9 and report BDS test with 2 and 3 dimensions. Apart from Mexico and Malaysia sovereign bond spreads, the Z-statistics are statistically significant. This means that the series observations are not drawn from identically and independently process. Put differently, there is strong evidence of non-linear dependence in time series data in 49/51 series (51=17 emerging market countries*3 series each) at both 2 and 3 embedding dimensions. Tsay test by Tsay (1986) is a non-linear test which focuses on quadratic serial dependence in the data. It complements the BDS test. Tsay test has a null of linear dependence and provides the appropriate lag order. The CDS spreads of all the seventeen countries exhibit non-linear (quadratic) serial dependence since we reject the null in all cases. The equity of Argentina, Indonesia and Tunisia, much like the bond spreads of Colombia, Malaysia, Bulgaria, Poland and Russia have linear dependence (We fail to reject null). In sum, 42/51 series, on the basis of this test, have nonlinear dependence. Both BDS and Tsay tests conclude that Malaysian bond spread have linear serial dependence.This evidence provides additional incentive to apply non-linear methodology in testing cointegration and price discovery mechanisms among the three markets in emerging countries.

Previous studies have used regression equation to test cointergation relationship between two series x and y. Ramsey (1969) and Ramsey and Alexander (1984) developed a simple test to assess if a regression equation is mis-specified or has nonlinear relationship. For example: A simple regression such as $CDS = c + \beta_1 BYS + \varepsilon$ could be tested by first running the regression and saving the fitted values of y. A second test regression is run with powers of the fitted values such as $CDS = c + \beta_1 BYS + \beta_2 CDS^2 + \varepsilon$ (RESET=1) or $CDS = c + \beta_1 BYS + \beta_2 CDS^2 + \beta_3 CDS^3 + \varepsilon$ (RESET=2). The F-statistic tests the hypothesis that the coefficients on the powers (β_2 and β_3) of fitted values are all zero. Ramsey and Alexander (1984) showed that the RESET test could discover specification error in regression equation which nevertheless had passed all other mis-specification tests. I test for mis-specification in cointegration equations of any two combinations of the three securities (CDS premium, bond spreads and equity prices. Results from table 2(b) indicate there are nonlinear cointegration relations in 49/51 possible cointergation pairs. The exception are CDS premium and equity (South Africa) and CDS premium and bond spreads (Tunisia) which exhibit simple linear relationship since the coefficients of the powers are statistically insignificant. This evidence provides additional rational for nonlinear cointegration, speed of adjustment to equilibrium relationship and price discovery mechanism.

I. Asymmetric return spillover

Table 3 presents interesting results. First, in all individual countries, there are multiple positive or negative return shocks spillovers from one market to the other. Moreover, the three markets are jointly significant (Using F-statistic) which indicate that Sovereign bonds, CDS and equity markets respond to own and each other's return shocks. This has important implications.

Table 3: Asymmetric return spillover

This table summarizes, using t-statistic, asymmetric return spillover among sovereign bond (b), CDS (c) and equity (e) markets. The equation

$r_{i,t} = \lambda_{10} + \lambda_b^- r_{b,t-1}^- + \lambda_b^+ r_{b,t-1}^+ + \lambda_c^- r_{c,t-1}^- + \lambda_c^+ r_{c,t-1}^+ + \lambda_e^- r_{e,t-1}^- + \lambda_e^+ r_{e,t-1}^+ + \varepsilon_{i,t}$ is used to derive the results. $r_{i,t}$ is the return of each market computed as ln(Pt+1/Pt). I use Newey-West method to correct for both heteroskedasticity and serial auto-correlation up to seven lags. λ_i^- and λ_i^+ are parameters to be estimated. $r_{i,t-1}^-$ and $r_{i,t-1}^+$ are lagged negative and positive returns decomposed from $r_{i,t}$. In each of the three rows for each country, $r_{b,t}$ $r_{c,t}$ and $r_{e,t}$ is the dependent variable respectively. Panels A, B, C and D capture emerging markets in Latin America, Asia, Europe and Africa respectively. *, ** and *** is statistical significance at 1%, 5% and 10% significance level.

	λ_b^-	λ_b^+	λ_c^-	λ_c^+	λ_e^-	λ_e^+	λ_{i0}	F-Stat
Panel A:	***Latin***	***America***						
Argentina:								
Bond	2.575*	2.392**	-1.322	0.622	-0.063	-0.390	0.702	*11.237
CDS	-2.025**	-2.488**	-2.278**	-1.957***	0.493	0.711	1.342	*9.986
Equity	2.734*	-0.143	-0.533	0.402	-0.331	0.189	1.111	*3.078
Brazil:								
Bond	3.147*	2.551**	0.522	0.221	-0.284	0.553	0.602	*15.131
CDS	-2.070**	-1.424	0.078	-1.818***	-3.611*	-2.210**	0.822	*28.093
Equity	2.441**	1.769***	0.091	0.072	-0.469	0.556	0.163	*8.512
Colombia:								
Bond	2.931*	3.537*	-0.097	-0.436	-1.124	-0.836	0.880	*18.624
CDS	-5.388*	-6.451*	-0.181	0.754	-5.542*	-4.483*	1.009	*140.297
Equity	3.102*	0.499	0.523	-0.266	0.519	1.360	1.791***	*7.472
Mexico:								
Bond	3.430*	1.739***	1.002	0.192	-1.015	2.570**	-0.177	*40.723
CDS	-2.592*	-1.383	-0.770	-1.210	-0.318	-2.197**	1.714	*22.394
Equity	1.054	1.269	1.173	-0.419	-0.005	1.563	0.492	*5.173
Venezuela:								
Bond	2.604*	0.420	-3.415*	-4.913*	1.065	1.544	1.570	*82.819
CDS	-2.153**	-1.90***	1.526	-0.288	-1.474	-0.275	0.232	*6.382
Equity	2.332**	-0.385	0.639	-1.593	-0.451	3.850*	0.443	*12.050
Panel B:	***Asia***							
China:								
Bond	-0.539	-1.095	-2.128**	-1.183	-0.325	-0.332	0.969	**1.927
CDS	0.256	3.193*	-0.925	0.222	0.796	-1.408	-0.869	*5.218
Equity	0.403	-0.558	-0.171	-1.793***	-0.458	0.793	1.534	*2.591
Indonesia:								
Bond	3.929*	0.555	-1.464	-2.525**	-0.383	2.212**	-0.097	*21.262
CDS	-1.623	-0.865	-2.824*	-2.703*	-0.396	-1.623	-0.751	*13.607
Equity	2.289**	0.193	-0.304	-1.966**	0.598	2.683*	0.963	*7.317
Malaysia:								
Bond	-0.737	1.370	0.884	-1.634	1.197	1.470	1.950***	*10.078
CDS	-0.375	2.155**	-2.422**	1.407	1.340	-2.111**	-1.920***	*5.243
Equity	0.382	-2.599*	1.149	-3.038*	-0.208	4.100*	1.852***	*10.948
Philippines:								
Bond	3.219*	1.301	-0.649	-1.864***	-2.298**	1.132	-0.393	*43.739
CDS	-1.815***	-0.381	-0.287	0.876	3.199*	-1.849***	1.298	*10.560
Equity	0.563	1.061	-1.433	-5.886*	-0.675	2.017**	1.254	*30.694
Thailand:								
Bond	1.509	5.520*	5.283*	-0.218	0.744	1.880***	0.188	*54.173
CDS	-0.376	-6.731*	-5.515*	2.886*	-2.384**	-1.867***	-2.759*	*46.974

Equity	2.020**	1.974**	1.953***	-0.543	-1.537	1.866***	-1.047	*10.306
Panel C:	***Europe***							
Bulgaria:								
Bond	-1.026	0.594	0.975	-3.055*	1.808***	-1.058	2.919*	*8.809
CDS	-0.383	-0.962	-0.674	-0.053	-1.86***	1.542	-1.072	**1.727
Equity	1.992**	0.412	0.396	-2.322**	1.331	2.233**	2.523**	*9.701
Hungary:								
Bond	1.517	1.086	1.131	-2.351*	-0.284	-0.233	1.561	*18.346
CDS	-0.739	-0.299	-0.975	-0.326	-2.266**	-2.218**	0.077	*6.127
Equity	2.112**	-0.526	-1.202	-1.124	0.660	1.519	1.327	*12.072
Poland:								
Bond	1.960***	-0.345	1.681***	-1.211	-0.600	1.725***	2.015**	*3.973
CDS	-0.444	1.349	-2.232**	-0.435	-2.673*	-2.426*	-1.165	*6.983
Equity	-0.553	-0.048	-0.618	-1.017	1.689***	0.816	0.710	*3.136
Russia:								
Bond	0.916	0.607	-0.596	-2.074**	1.388	-0.258	2.465*	*18.743
CDS	-0.976	-1.618	0.014	-0.156	-1.80***	-0.291	-0.466	*8.483
Equity	2.240**	-1.096	-0.798	-0.618	0.152	1.033	1.074	*6.779
Turkey:								
Bond	-0.109	-0.014	-2.714*	-2.805*	-1.576	-0.744	1.240	*39.159
CDS	-1.776***	0.262	1.597	-0.482	-0.505	-1.272	0.274	*7.271
Equity	-0.614	-0.521	-2.195**	-3.065*	-2.282**	0.092	0.378	*13.439
Panel D:	***Africa***							
S. Africa:								
Bond	2.763*	2.260**	-0.006	-1.869***	1.563	0.970	1.528	*24.802
CDS	-3.142*	-2.885*	0.826	-2.061**	-2.823*	-0.840	0.884	*43.708
Equity	2.561*	0.747	0.451	-0.268	0.666	0.552	1.242	*6.377
Tunisia:								
Bond	-0.438	-2.790*	-0.659	0.056	1.753c	1.015	2.803*	*5.141
CDS	-0.364	0.652	-2.576*	-2.113**	-0.816	1.860***	-1.406	*19.903
Equity	0.722	-0.203	-0.912	-0.153	1.492	4.181*	1.882***	*16.123

The first implication interconnected markets create potential for participants in any of the three markets to engage in arbitrage trading by exploiting information in one market and trading in the other market.. The existence of such arbitrage opportunities means the three markets are inefficient. In fact, the mere existence of statistical significance of negative and positive return shocks means that current returns are still responding to past (lagged) information. Second, all $\lambda_i^- \neq \lambda_j^+$. Therefore, the return spillover process is asymmetric. Positive and negative return shocks have nonlinear or asymmetric effects on current returns of each security. Third, the absence of any significant spillover could indicate that either the market is efficient (henceit has already incorporated past (lagged) own positive and negative return shocks) or the sovereign has low default risk hence returns are influenced by fundamentals of the country and not credit risk. This seems to be the case of China and Malaysia, both of which have A- credit rating and few spillovers among the three markets. However, no market has all statistically insignificant t-statistic implying that all the three markets are inefficient in incorporating past information or news.

In majority of the emerging market countries, negative return shocks have higher impact on the current compared to positive return shocks. For example: In all countries except Tunisia, Colombia, Malaysia and Thailand, negative bond returns shocks have higher t-statistic than the t-statistic of positive bond returns. This provides additional evidence that investors react more to “bad” news than to “good” news (Black 1976 and Glostein et al 1993) in the markets not only in the equity market but also in the sovereign CDS and bond markets. In Brazil, lagged negative and positive bond returns shocks significantly influence current bond returns (t=3.147 and t=2.551 respectively) but negative lagged returns (bad news) have strong influence. Lagged negative and positive CDS and equity returns do not influence current bond returns. Current CDS returns are significantly influenced by negative lagged bond returns (t=2.07), positive lagged CDS returns (t=-1.818) and both negative and positive lagged equity returns (t=-3.611 and -2.210 respectively).

This summary provides evidence in support of substitution hypothesis of King and Wadhani (1990) and news-based hypothesis of Campbell and Vuolteennaho (2004).Specifically, I find that in indonesia, Turkey, Bulgaria, and Philippines, the sign of positive CDS return shocks (λ_C^+) negatively and significantly influence both equity and bond returns. However, in Venezuela, China, Malaysia and S. Africa, positive CDS return shocks negatively and significantly spillover to equity markets only. In Hungary, positive CDS return shocks negatively and significantly influence the bond returns. This supports the asset substitution hypothesis. The mere existence of statistically significant and insignificant return spillovers with both positive and negative signs indicates the convoluted nature of the relationship of the three markets. Asymmetry also mean that each market returns are influenced by the fundamentals of that particular market and trading in one market can trigger momentum in the other market. For example: Increase in default risk activates CDS buying and disposal of equity thus opposite trading momentum in both markets. This confirms the news-based hypothesis.

J. Threshold autoregressive (TAR) or momentum threshold autoregressive (MTAR)

Before testing nonlinear cointegration and asymmetric adjustment to long-run equilibrium relationship between any two markets (CDS, equity and bonds), I first estimate the threshold values though grid search and consistent use of Chan's method. I trim the first and last 15% of ordered observations to eliminate outliers and estimate the threshold values on the remaining 70%. Threshold values can estimated through either Akaike information criterion (AIC), Swartz Bayesian information criterion (BIC or SIC) and minimization of sum of squared residuals (SSR). The lower the measure is, the better the model. Table 4 presents the model selection using BIC. In 41/51 possible cointegrations, BIC selects MTAR. In all cointergations involving CDS premium and equity and bond spreads and equity, BIC selects MTAR modeling. The CDS-bond spreads of Colombia, Mexico, China, Indonesia, Malaysia, Philippines, Bulgaria, Hungary, Poland and Tunisia require TAR modeling according to BIC selection and the rest of the countries' CDS-bond spreads require MTAR modeling. Four out of five Asian and three out of five Europe sovereigns in the sample do not require MTAR in

CDS-bond spreads. This is an interesting observation that requires further investigation. The selection of MTAR by CDS-equity spreads and equity-bond spreads provide partial evidence that each spread is characterized by autoregressive decay that depends on whether the spread is increasing or decreasing. There is intensified trading by investors in volatile regimes which may reverse dynamic relationship among the three securities, speed of adjustment to new information (Delatte et al, 2010) and even the price informativeness of each security.

K. Non-linear cointegration asymmetric adjustment and momentum

We now employ the model identified in table 4 in establishing whether non-linear cointegration and asymmetric adjustment to long-run equilibrium relationship exists. Table 5 provides summary results. Hypothesis Ho_1 tests the null of nonlinear cointegration. Thailand, Poland and Turkey do not exhibit non-linear cointegration in any combination of the three markets (CDS and bonds, CDS and equity and equity and bonds). Mexico, China and Philippines also exhibit non-linear cointegration between CDS and equity on one hand and equity and bond spreads on the other. The absence of nonlinear cointegration could be attributed to a number of possible reasons.

Table 4: Threshold values and Selection between TAR and MTAR

In table 4, CDS is credit default swap. TAR is the threshold auto regressive (TAR) model while MTAR is momentum threshold auto regressive. TH is the threshold value selected using Bayesian Information criterion (BIC). The * indicates the model (TAR or MTAR) selected by BIC. The lower the BIC is, the better the model.

	CDS and BONDS				CDS and EQUITY				EQUITY and BONDS			
	TAR		MTAR		TAR		MTAR		TAR		MTAR	
Country	TH	BIC	TH	BIC	TH	BIC	TH	BIC	TH	BIC	TH	BIC
Argentina	155.78	12141.03	-7.22	12134.61*	1501.34	13440.53	-43.74	13416.01*	1144.39	12386.5	-41.46	12375.46*
Brazil	-180.50	14607.16	13.42	14606.45*	490.33	16491.41	-38.97	16482.08*	541.36	16032.6	41.29	16019.61*
Colombia	-43.72	9589.579*	8.18	9620.77	-180.32	10034.86	-10.28	9912.517*	180.38	9192.41	9.66	9173.31*
Mexico	-19.40	8719.956*	-5.75	8750.90	1320.39	16836.79	-37.04	16812.71*	1129.94	16765.3	49.44	16745.54*
Venezuela	-140.33	12381.61	14.44	12355.03*	5413.48	22253.57	-230.06	22234.83*	5307.05	22251.6	-216.74	22233.26*
China	-18.73	7010.797*	-4.90	7022.27	37.82	5825.10	1.06	5811.04*	-56.09	6774.64	5.45	6759.26*
Indonesia	104.52	7237.565*	-10.08	7253.83	-131.57	7855.42	7.08	7808.39*	94.93	6702.26	-8.02	6653.35*
Malaysia	31.87	8581.726*	5.75	8593.99	-83.61	8451.61	3.89	8388.95*	-91.24	7854.93	-6.30	7836.48*
philippine	42.85	8580.224*	-7.96	8601.62	-112.46	9471.07	8.10	9377.262*	-94.36	8549.25	7.90	8500.66*
Thailand	-28.75	7579.07	6.28	7477.709*	133.16	7800.54	-8.30	7734.67*	-219.90	9447.13	12.22	9306.66*
Bulgaria	-32.13	9048.282*	6.71	9055.42	492.82	10589.12	9.51	10503*	394.30	10298.2	-7.45	10254.94*
Hungary	36.44	8914.098*	-5.82	8917.90	246.64	11613.71	10.19	11542.76*	241.25	11195.8	-12.85	11170.75*
Poland	-35.22	7684.756*	-4.08	7692.54	348.32	11650.60	-14.74	11632.15*	236.47	11602.1	5.82	11596.23*
Russia	12.72	9939.68	5.55	9879.313*	493.74	12991.79	8.71	12911.7*	484.19	12224.9	15.66	12208.02*
Turkey	57.57	10550.31	7.07	10381.22*	-365.96	12193.85	-16.62	12155.08*	-333.53	11582	-14.11	11565.54*
S. Africa	31.48	9283.35	-5.18	9271.472*	-120.59	10309.21	6.43	10274.52*	143.29	9243.10	-8.48	9238.43*
Tunisia	32.87	7872.485*	-5.67	7882.81	-141.64	9745.99	-6.96	9716.57*	-123.63	9805.49	11.11	9760.06*

We now employ the model identified in table 3 in establishing whether non-linear cointegration and asymmetric adjustment to long-run equilibrium relationship exists. Table 4 provides summary results. Hypothesis $Ho_1(\theta_1=\theta_2=0)$ tests the null of non-linear cointegration. I find 28/51 possible nonlinear cointegration relationships. All countries except Turkey have at least 2 out of 3 possible nonlinear cointegrations. The absence of non-linear cointegration could be attributed to a number of possible reasons. First, non-linear modeling is not appropriate for Turkey and hence we should employ linear modeling. Second, one or more of the three markets are highly illiquid such that minimal or no trading occurs. This is not unusual because of the structure of CDS market and nature of sovereign bondholders. Sovereign CDS market is is dominated by large institutional investors who trade in over-the-counter market. These investors may just buy and hold sovereign bonds as they observe the fundamentals of the reference entity. As such, the bond market may become very illiquid coupled thin trading. Third, the stock index or sovereign bond index are unsuitable proxies for evaluating credit risk (Chang-Lau and Kim, 2004). Fourth, and most plausible reason, could be that the countries have low sovereign debt levels (Low credit risk) to which equity and bond prices do not respond since their distance to default is very high.This is consistent with Merton (1974) explanation that equity prices react more to changes in credit risk for highly leveraged (high default risk) firms (countries). Anecdotal evidence shows that these countries have relatively better credit rating (low credit risk, low leverage and high distance to default). In general, only three countries do not exhibit any non-linear cointegration in the pairwise combination of the three markets. Lastly, it is notably possible that the forces of market frictions such as transaction costs, regulations in equity markets and taxes are too strong to allow investors to engage in arbitrage opportunities which, once exhausted, would allow the markets to regain their long run equilibrium relationship.

Turning to hypothesis Ho_2, we allow θ_1 and θ_2 to take dissimilar values to recognize that positive and negative deviations from long run equilibrium relationship can be adjusted for at different speeds. I find existence of asymmetrical equilibrium relationship irrespective of the TAR or MTAR model, since coefficients θ_1 and θ_2 are statistically different from zeroin 49/51 possible cointegration relationships. When applying MTAR model, rejection of Ho2 in table 5 confirms the divergence from equilibrium relationships exhibit higher momentum in one of the two alternative directions (upper and lower regime). In these pairs of the markets, adjustment varies with the magnitude of the error term and positive and negative deviations from long run equilibrium relationship can be adjusted for at different speeds and sizes.

The rational for observation is on a number of possible explanations. First, the changes in sovereign CDS spreads depend on the size of the government budget deficits. Small budget deficits do not require any intervention and the CDS spreads and equity prices remain calm. However, huge and spiraling government budget deficits require aggressive interventionary policies to smooth them and prevent default (See Enders and Siklos, 2001). CDS and equity prices will experience high volatility as huge deficits increases probability of default (distance to default is short and the borrower is about to breach the debt barrier or threshold such as case of Greece, Italy, Ireland, Spain and EU in general).

Second, sovereign bond holders are only concerned with down-side risk hence they reacts more in the face of market convulsions by buying more CDS to hedge against possible default (bad news). As CDS premium increases, stock prices will be plunging in response to increased credit risk. Third, the liquidity of the market plays a significant role. CDS prices, unlike bonds, can be easily shorted, do not require any funding, are not constrained by contract indentures and tend to be highly liquid relative to the bonds and equity markets. Sovereign bonds and CDS of large, well known countries with established history tend to be more liquid relative with buoyed trading relative to bonds and CDS of small countries. Therefore, momentum of CDS and bonds of large countries tend to be higher. Forth, investors react sharply in rebalancing their portfolios which constitute bonds, CDS and equity. Equity prices and CDS premium have negative relationship in volatile market conditions. This may intensify trading as investors liquidate their positions hence reinforcement of momentum in such periods.

Table 5: Non-linear cointegration and asymmetric adjustment to long-run equilibrium

In this table, CDS, BS and EQ represent credit default swaps, bond spreads and equity prices or index. TAR and MTAR is threshold autoregressive and momentum threshold autoregressive models as selected in table 5. DW is Durbin Watson statistics which tests the null of no serial correlation in error term. Ho1 tests the null of linear cointegration using non-standard F-statistic while Ho2 tests the null of symmetric adjustment to long-run relationship between series x and y. Ho3 is a joint test of the sum of coefficients θ_1 and θ_2 in the TAR equation (iv) and (v) $\Delta\hat{\varepsilon}_t = I_t\theta_1\hat{\varepsilon}_{t-1} + (1-I_t)\theta_2\hat{\varepsilon}_{t-1} + \nu_t$. In MTAR model, we use the first difference of the regressors. Ho2 and Ho3 are based evaluated using the Standard F-statistic.*, ** and *** is 1%, 5% and 10% significance level.

Country	Variables	Model	θ_1	θ_2	DW	Ho1 $\theta_1=\theta_2=0$	Ho2 $\theta_1=\theta_2$	Ho3: $\theta_1=-\theta_2$
Argentina	CDS and BS	MTAR	**-0.0830	-0.0079	1.99	***3.08	*5.43	*10.71
	CDS and EQ	MTAR	-0.0337	*-0.1345	2.01	**3.85	*8.11	**1.59
	EQ and BS	MTAR	-0.0026	**0.0679	2.00	1.87	***1.98	*6.23
Brazil	CDS and BS	MTAR	**-0.00855	-0.002	1.99	**3.85	1.54	*2.54
	CDS and EQ	MTAR	**0.07015	0.0266	1.99	***2.41	*5.06	*6.34
	EQ and BS	MTAR	0.0346	*-0.0829	2.00	1.08	*4.57	0.9500
Colombia	CDS and BS	TAR	-0.0160	***-0.063	2.00	***2.71	1.68	*126.58
	CDS and EQ	MTAR	*-0.3111	*-0.2127	1.98	**4.47	*63.36	*10.00
	EQ and BS	MTAR	-0.0243	*-0.1291	2.00	**4.67	*9.20	**1.86
Mexico	CDS and BS	TAR	-0.0184	**-0.0814	1.99	**4.69	*2.87	*19.32
	CDS and EQ	MTAR	*-0.1256	**-0.07374	1.99	1.31	*10.01	*15.79
	EQ and BS	MTAR	*-0.1111	**-0.0713	1.99	0.75	*7.93	*24.46
Venezuela	CDS and BS	MTAR	-0.0292	*-0.2043	2.02	*13.76	*18.27	**1.28
	CDS and EQ	MTAR	*-0.1084	***-0.054	1.98	*11.37	*5.85	**1.06
	EQ and BS	MTAR	0.1049	***-0.055	1.98	*11.04	*5.63	*13.97
China	CDS and BS	TAR	*-0.0236	**-0.0364	2.18	0.64	*11.62	*14.41
	CDS and EQ	MTAR	*-0.0946	*-0.1091	2.02	0.09	*9.34	*14.41
	EQ and BS	MTAR	-0.0494	*-0.1328	2.01	***3.26	*10.04	*10.84
Indonesia	CDS and BS	TAR	*-0.0339	-0.0029	1.98	*15.24	*11.88	*41.82
	CDS and EQ	MTAR	-0.198	*-0.1856	2.03	0.04	*23.09	*41.15
	EQ and BS	MTAR	*-0.1029	*-0.2488	1.97	*7.08	*23.37	*31.53
Malaysia	CDS and BS	TAR	*-0.0422	*-0.0208	2.00	**3.66	*16.37	*52.97
	CDS and EQ	MTAR	*-0.1021	*-0.2250	1.98	*7.48	*32.45	*4.75
	EQ and BS	MTAR	-0.016634	**-0.0821	2.00	2.09	*3.32	*31.44
Philippines	CDS and BS	TAR	*-0.0488	**-0.0176	1.96	*6.93	*17.39	*92.37
	CDS and EQ	MTAR	*-0.1932	*-0.2538	2.00	1.70	*49.35	*42.37
	EQ and BS	MTAR	*-0.1853	*-0.1286	1.99	1.38	*21.27	*106.90
Thailand	CDS and BS	MTAR	*-0.2864	*-0.2283	2.01	1.36	*53.49	*64.46
	CDS and EQ	MTAR	*-0.2351	*-0.1684	2.03	1.76	*32.86	*144.85
	EQ and BS	MTAR	*-0.3301	*-0.2657	2.03	1.70	*72.48	**1.11
Bulgaria	CDS and BS	TAR	0.0212	**-0.0692	2.00	**3.96	*8.83	*68.92
	CDS and EQ	MTAR	*-0.1456	*-0.2338	2.02	**3.73	*42.09	*36.82
	EQ and BS	MTAR	*0.1059	*-0.1683	2.01	1.90	*20.21	*18.71

Hungary	CDS and BS	TAR	*-0.0291	***-0.012	1.80	***3.00	*10.98	*63.49
	CDS and EQ	MTAR	*0.1384	*-0.2184	1.99	***3.20	*34.35	*19.20
	EQ and BS	MTAR	**0.0900	*-0.1123	2.00	0.23	*10.55	*11.99
Poland	CDS and BS	TAR	**-0.0093	*-0.0157	1.96	0.80	*6.04	*16.49
	CDS and EQ	MTAR	*-0.0832*	*-0.1007	2.00	0.15	*8.33	*1.84
	EQ and BS	MTAR	-0.000275	**-0.0623	2.01	1.88	**2.07	*67.00
Russia	CDS and BS	MTAR	*-0.2378	*-0.1279	2.00	*6.05	*36.06	*71.99
	CDS and EQ	MTAR	*-0.1585	*-0.2234	2.00	2.08	*39.44	*7.71
	EQ and BS	MTAR	0.0071	*-0.1212	2.00	*6.09	*8.60	*202.11
Turkey	CDS and BS	MTAR	*-0.3404	*-0.2772	2.00	2.11	*105.67	*36.82
	CDS and EQ	MTAR	*-0.1670	*-0.1070	2.01	1.76	*18.81	*14.02
	EQ and BS	MTAR	***-0.0611	*0.1086	2.00	1.10	*7.65	*17.71
S. Africa	CDS and BS	MTAR	*-0.2212	0.0317	2.02	*31.57	*26.80	*15.36
	CDS and EQ	MTAR	*0.2021	-0.0234	1.98	*24.46	*17.40	*3.494
	EQ and BS	MTAR	0.032	0.05301	2.00	0.21	**1.82	*44.38
Tunisia	CDS and BS	TAR	*-0.0738	**-0.0173	2.13	*17.05	*23.84	*26.09
	CDS and EQ	MTAR	*-0.1519	*-0.0889	2.01	1.79	*13.81	*38.10
	EQ and BS	MTAR	*-0.1849	*-0.1066	2.00	***2.75	*19.57	*38.11

L. Short term Asymmetric Adjustment process

In the next two sections, we use the following equation to analyze asymmetry in short run and long run adjustment processesin upper (+) and lower (-) regime. The short-run adjustment of y_t $(\mathrm{x_t})$ depends on parameters $\theta^+, \theta^-, \delta^+$ and δ^- $(\gamma^+, \gamma^-, \psi^+$ and $\psi^-)$. This implies that in the short run, the dynamics of y_t $(\mathrm{x_t})$ depends on its own past dynamics or/and the lagged outcome of x_t $(\mathrm{y_t})$.

$$\Delta y_t = \alpha_1 + \begin{cases} \lambda_{11} z_{t-1}^+ + \sum_{i=1}^{P} \theta^+ \Delta y_{t-i} + \sum_{i=1}^{P} \delta^+ \Delta x_{t-i} + \pi_{1t} \\ \lambda_{21} z_{t-1}^- + \sum_{i=1}^{P} \theta^- \Delta y_{t-i} + \sum_{i=1}^{P} \delta^- \Delta x_{t-i} + \pi_{2t} \end{cases} \text{OR } \Delta x_t = \alpha_2 + \begin{cases} \alpha_{11} z_{t-1}^+ + \sum_{i=1}^{P} \gamma^+ \Delta y_{t-i} + \sum_{i=1}^{P} \psi^+ \Delta x_{t-i} + \upsilon_{1t} \\ \alpha_{21} z_{t-1}^- + \sum_{i=1}^{P} \gamma^- \Delta y_{t-i} + \sum_{i=1}^{P} \psi^- \Delta x_{t-i} + \upsilon_{2t} \end{cases}$$

From the two equations, I test for the null $\theta^{+} = \theta^{-}$ ($\gamma^{+} = \gamma^{-}$) or $\delta^{+} = \delta^{-}$ ($\psi^{+} = \psi^{-}$) when y_t (x_t) is the dependent variable. Rejection of any of the null hypotheses is indicative of asymmetry in short run adjustment process. Table 6 present the results. There is short run asymmetric adjustment process in 21/34, 23/34 and 21/34 cointegration relations between CDS premium and bond spreads, CDS premium and equity prices and equity prices and bond spreads respectively. All countries except China [Which has the lowest (highest) default risk (credit rating) shows asymmetry in short run dynamic short run adjustment process in the two regimes. Overall, the results show that the markets are informative with regard to credit risk in either upper or lower regime. This is certainly because most investors in the sovereign bond markets are institutional investors who buy and hold the bond and only operate in the CDS market where short selling is easier and contract specifications and indentures do exist. It could also be that investors respond to fundamentals such as government fiscal policies (which take time) before trading in the bond market.

M. Asymmetric long run adjustment and price discovery process

The use of threshold vector error correction model takes care of uncertainty in price discovery process and ensures that this process is also time-varying since two regimes occur at different times. It also allows the adjustment process of y_t (x_t) to vary according to positive and negative divergences from equilibrium relationship in each regime.

Table 6: Short term asymmetric adjustment

In this table BYS, CDS and EQU are bond spreads, credit default swap premium and equity respectively. (+) and (–) represent upper and lower regime. We test three pairs of short-term asymmetric adjustment process namely bond spreads and CDS, equity and CDS and equity. The short term asymmetric adjustment process is tested through Ho: $\theta^{+} = \theta^{-}$ (all lags of y in upper regime=all lags of y in the lower regime) and $\delta^{+} = \delta^{-}$ (all lags of x in upper regime=all lags of x in the lower regime)

Country	CDS and BONDS	F-Stat	EQUITY and CDS	F-Stat	Bonds and EQUITY	F-Stat
Argentina	BYS+=BYS-	0.113	EQU+=EQU-	***2.874	BYS+=BYS-	***3.469
	CDS+=CDS-	**4.454	CDS+=CDS-	*22.918	EQU+=EQU-	0.167
Brazil	BYS+=BYS-	*12.71	EQU+=EQU-	***3.382	BYS+=BYS-	**4.90
	CDS+=CDS-	***3.366	CDS+=CDS-	*38.471	EQU+=EQU-	0.921
Colombia	BYS+=BYS-	**4.571	EQU+=EQU-	0.229	BYS+=BYS-	**3.813
	CDS+=CDS-	**5.476	CDS+=CDS-	0.384	EQU+=EQU-	0.001
Mexico	BYS+=BYS-	0.966	EQU+=EQU-	***2.791	BYS+=BYS-	0.12
	CDS+=CDS-	*7.979	CDS+=CDS-	*10.776	EQU+=EQU-	0.043
Venezuela	BYS+=BYS-	**4.368	EQU+=EQU-	*27.561	BYS+=BYS-	*30.769
	CDS+=CDS-	***3.658	CDS+=CDS-	**5.157	EQU+=EQU-	***2.672
China	BYS+=BYS-	0.397	EQU+=EQU-	0.054	BYS+=BYS-	***3.286
	CDS+=CDS-	0.589	CDS+=CDS-	0.058	EQU+=EQU-	1.255
Indonesia	BYS+=BYS-	*8.018	EQU+=EQU-	2.028	BYS+=BYS-	0.174
	CDS+=CDS-	*21.383	CDS+=CDS-	*7.21	EQU+=EQU-	*6.641
Malaysia	BYS+=BYS-	0.332	EQU+=EQU-	*18.809	BYS+=BYS-	0.523
	CDS+=CDS-	***2.620	CDS+=CDS-	***3.427	EQU+=EQU-	*10.009
Philippines	BYS+=BYS-	0.973	EQU+=EQU-	***2.981	BYS+=BYS-	0.33
	CDS+=CDS-	0.011	CDS+=CDS-	1.377	EQU+=EQU-	0.873
Thailand	BYS+=BYS-	0.071	EQU+=EQU-	*7.65	BYS+=BYS-	*7.165
	CDS+=CDS-	**5.991	CDS+=CDS-	0.159	EQU+=EQU-	*6.158
Bulgaria	BYS+=BYS-	***2.654	EQU+=EQU-	*10.148	BYS+=BYS-	*7.641
	CDS+=CDS-	***2.663	CDS+=CDS-	1.084	EQU+=EQU-	***2.231
Hungary	BYS+=BYS-	*20.16	EQU+=EQU-	*11.102	BYS+=BYS-	*11.449
	CDS+=CDS-	***2.957	CDS+=CDS-	**5.016	EQU+=EQU-	***3.445
Poland	BYS+=BYS-	0.931	EQU+=EQU-	*6.92	BYS+=BYS-	***3.459
	CDS+=CDS-	***2.971	CDS+=CDS-	*6.65	EQU+=EQU-	0.000
Russia	BYS+=BYS-	2.334	EQU+=EQU-	**5.263	BYS+=BYS-	**5.938
	CDS+=CDS-	**5.944	CDS+=CDS-	***2.542	EQU+=EQU-	*7.742
Turkey	BYS+=BYS-	0.199	EQU+=EQU-	***3.626	BYS+=BYS-	0.142
	CDS+=CDS-	0.408	CDS+=CDS-	2.118	EQU+=EQU-	***3.156
S. Africa	BYS+=BYS-	***3.546	EQU+=EQU-	1.89	BYS+=BYS-	***3.222
	CDS+=CDS-	*5.810	CDS+=CDS-	*8.021	EQU+=EQU-	*12.012
Tunisia	BYS+=BYS-	*7.845	EQU+=EQU-	***3.854	BYS+=BYS-	***2.734
	CDS+=CDS-	0.151	CDS+=CDS-	1.297	EQU+=EQU-	0.003

If the error correction term in the upper regime Z+ =ECT+= $x_{t-1} - \alpha_0 - \alpha_1 y_{t-1}$, then, a positive (negative) shock to y_t will result in x_t being below (above) the equilibrium relative to y_t such that $x_{t-1} < \alpha_0 + \alpha_1 y_{t-1}$ ($x_{t-1} > \alpha_0 + \alpha_1 y_{t-1}$). Therefore, x_t will require upward (downward) adjustment to track y_t, correct the price discrepancy or deviation and restore equilibrium relationship with y_t. The same logic can be applied with respect to positive and negative shock to x_t in any of the two regimes. This captures nonlinearity in error correction process and price discovery process. In tables 7(a), 7(b) and 7(c), the null hypothesis, ECT+=ECT- tests the symmetric long-run adjustment of y (CDS or bond spreads or equity) to long run equilibrium relationship. If ECT+≠ECT-, there is asymmetry in long run adjustment process. Looking at table 7(a) and focusing on Argentina, we can conclude that

1)The long run adjustment process is asymmetric in the CDS market (rejects null ECT+=ECT-) but symmetric in the bond market (fail to reject the null ECT+=ECT-)

2) In the upper regime denoted by ECT+, price discovery takes place in the bond market since CDS ECT+ is statistically significant while BS ECT+ is insignificant.

3) In the lower regime, ECT- for both BS and CDS is insignificant hence neither BS nor CDS move to restore equilibrium relationship since during normal times, these relationship is extant and need no restoration or the markets are too illiquid or market frictions prevent the markets from attaining equilibrium relationship

4) In a single regime model (linear ECT), price discovery takes place in the CDS market since BS ECT is statistically significant and has the opposite (positive) sign of CDS ECT. These results contradict the findings of TVECM.

An interesting finding occurs in panel B of table 7(a). Specifically, Bulgaria, Hungary, Poland and Philippines exhibit symmetric long-run adjustment process in the bond market (BS) since we fail to reject the null ECT+=ECT- . This supports evidence in previous tables where

(i) The countries' CDS-bond spreads were modeled using TAR as selected by BIC

Table 7(a): Non-linear price discovery between CDS and Bond spreads BS

This table provides summary information on asymmetrical price discovery between CDS and bond spreads. BS and CDS are bond spreads and credit default swap. DW is Durbin Watson statistic which test the null of no (zero) autocorrelation in the residuals. LB(4) is the Ljung-Box statistic which test the null of no autocorrelation in residuals up to four lags. ECT+ and ECT- is the error correction term (speed of adjustment parameter) in upper and lower regime respectively. Each series (BS and CDS) adjusts to long-run equilibrium relationship under two regimes (above and below the threshold. The null hypothesis, Ho: ECT+=ECT- is a test of asymmetry in error or deviation adjustment process. *, ** and *** is 1%, 5% and 10% significance level. Linear ECT is the error correction term in a linear model which assumes a single regime.

Panel A	**Country**	**Argentina**	**Brazil**	**Colombia**	**Mexico**	**Venezuela**
BS	ECT+	-0.0028309	*-0.00799	0.002065	-0.004909	*0.0067144
	ECT-	0.0002761	**0.003839	*0.021946	*0.029354	-0.0004134
Ho:ECT+=ECT-	F-stat	0.62	*21.804	**5.006	**5.233	*9.492
LB(4) & DW		0.90 & 1.99	1.00 & 1.99	0.98 & 1.99	0.98 & 2.00	0.98 & 2.00
CDS	ECT+	*-0.040415	**-0.011363	*-0.037174	*-0.056087	*0.016354
	ECT-	-0.005688	-0.003846	**-0.026217	*0.027189	*-0.009543
Ho:ECT+=ECT-	F-stat	*8.348	***2.43	0.538	*24.167	*32.665
LB(4) & DW		0.01 & 2.03	0.99 & 1.99	0.00 & 2.00	0.77 & 2.00	0.92 & 2.02
Linear ECT	BS	*0.02834	*-0.008896	*-0.032107	***-0.0124	*-0.015064
	CDS	-0.001093	0.000245	0.00507	*0.018633	-0.001132
Panel B		**China**	**Indonesia**	**Malaysia**	**Philippines**	**Thailand**
BS	ECT+	*0.041695	-0.0027931	**0.012457	-0.005144	*-0.38943
	ECT-	**0.023778	-0.0009758	**0.01673	-0.006101	**0.03892
Ho:ECT+=ECT-	F-stat	1.352	0.102	0.191	0.261	*16.742
LB(4) & DW		1.00 & 1.99	1.00 & 2.00	1.00 & 2.00	0.21 & 2.04	0.89 & 2.03
CDS	ECT+	**-0.013797	*-0.0206911	-0.00852	-0.002536	*-0.167004
	ECT-	-0.008101	***-0.01165	-0.002252	*-0.054335	0.005653
Ho:ECT+=ECT-	F-stat	0.263	0.943	0.349	*10.023	*17.57
LB(4) & DW		1.00 & 2.02	1.00 & 1.99	0.00 & 2.09	0.10 & 2.01	0.86 & 2.02
Linear ECT	BS	-0.003817	-0.001827	*-0.017867	*-0.027531	-0.010234
	CDS	*0.036276	**0.00242	*0.021948	0.008467	0.003592
Panel C		**Bulgaria**	**Hungary**	**Poland**	**Russia**	**Turkey**
BS	ECT+	*0.017513	0.00279	0.004889	-0.0009391	*0.018292
	ECT-	0.006101	*-0.017892	**0.017777	0.0070418	-0.001144

Ho:ECT+=ECT-	F-stat	***2.098	***2.851	***2.761	1.901	*8.517
LB(4) & DW		1.00 & 2.00	0.95 & 1.99	0.88 & 1.99	0.90 & 1.99	0.99 & 1.98
CDS	ECT+	**-0.011735	**-0.011626	-0.0022752	*-0.015555	0.00521
	ECT-	-0.002225	*-0.027667	0.0008117	0.007667	*-0.012987
Ho:ECT+=ECT-	F-stat	1.061	**4.322	0.283	**5.046	***3.445
LB(4) & DW		0.58 & 2.00	0.05 & 1.99	0.90 & 1.99	0.00 & 2.00	0.90 & 1.99
Linear ECT	BS	***-0.007954	-0.00385	**-0.006273	*-0.013937	***-0.009897
	CDS	*0.017576	*0.023218	*0.016126	*0.007761	**0.008694
Panel D		**S. Africa**	**Tunisia**			
BS	ECT+	0.002596	-0.002405			
	ECT-	**0.017733	***-0.010737			
Ho:ECT+=ECT-	F-stat	*5.845	**4.037			
LB(4) & DW		0.98 & 2.03	0.95 & 1.99			
CDS	ECT+	0.005146	-0.00633			
	ECT-	*-0.028943	**0.012494			
Ho:ECT+=ECT-	F-stat	*13.876	0.709			
LB(4) & DW		1.00 & 2.00	0.99 & 2.00			
Linear ECT	BS	*-0.018108	*0.86273			
	CDS	*0.015526	**0.06159			

(ii) The countries showed linear cointegration in at least two pairs of the market among the three markets.

(iii) The countries had positive skew in returns

I find asymmetry in long run adjustment process in 21/34 possible regimes. In the upper regime (ECT+), price discovery takes place in the bond market in Colombia, Mexico, Indonesia, Hungary and Russia. In the lower regime, CDS leads in price discovery in Brazil, China, Malaysia, Thailand and Poland. In a linear ECT, price discovery takes place in CDS market in all the five Latin American countries. In Malaysia, Thailand, Bulgaria, Poland, Russia, S. Africa and Tunisia, both CDS and bond markets are sources of price discovery under a single regime or linear VECM. There are contradictions between the threshold model and linear model as to where price discovery takes place.

Table 7(b) summarizes asymmetric long run adjustment process and price discovery when cointegration relationship is based on CDS premium and equity prices.In 17/34 possible long run adjustments, we find asymmetry. Therefore, long run adjustment is regime-dependent. In relation to price discovery, Venezuela, China and Tunisia indicate that price discovery takes place in equity market in the upper regime. This is consistent with the linear model. In the lower regime, only Tunisia and Indonesia offer the leadership in price discovery as equity market which is consistent with linear model. All the rest of evidence between linear and non-linear price discovery is contradictory but in support of non-linear model. In lower regime, five countries (Mexico, Venezuela, China, Philippines and Turkey) shows that neither CDS nor equity prices move to restore equilibrium relation (insignificant adjustment coefficients) while another five countries (Colombia, Thailand, Bulgaria, Russia and South Africa) offer similar evidence in upper regime. This is either because the markets are illiquid or long-run equilibrium relationship between CDS and equity exists hence no need to disturb that equilibrium or market frictions forces deter price informativeness of either CDS or equity market.

Table 7(c) offers more evidence in support of asymmetric long run adjustment process when we assess cointegration relationship between equity and bond markets. Also, different regimes have different markets that lead in price discovery. Specifically, we find 17/34 asymmetric long run adjustment processes implying that the presence of regimes determines the equilibrium relationship between equity prices and bond spreads. In relation to price discovery and informativeness of either equity prices or bond spreads, three countries (Colombia, Venezuela and Turkey) offer equity as price discovery leader which is consistent with linear VECM in lower regime. In 6/17(7/17) countries, price discovery occurs in equity (bond) market in upper regime. In sum, the existence of two regimes make price discovery to be regime-dependent unlike the linear price discovery.

Table 7(b): Asymmetrical price discovery between CDS and Equity

This table provides summary information on asymmetrical price discovery between CDS and equity. CDS is the credit default swap. DW is Durbin Watson statistic which test the null of no (zero) autocorrelation in the residuals. LB(4) is the Ljung-Box statistic which test the null of no autocorrelation in residuals up to four lags. ECT+ and ECT- is the error correction term (speed of adjustment parameter) in upper and lower regime respectively. Each series (BS and CDS) adjusts to long-run equilibrium relationship under two regimes (above and below the threshold. The null hypothesis, Ho: ECT+=ECT- is a test of asymmetry in error or deviation adjustment process. *, ** and *** is 1%, 5% and 10% significance level. Linear ECT is the error correction term in a linear model which assumes a single regime.

Panel A		**Argentina**	**Brazil**	**Colombia**	**Mexico**	**Venezuela**
CDS	ECT+	-0.0004157	**-0.00515	-0.0011639	-0.0030380	*-0.013988
	ECT-	*-0.01536	*-0.017459	-0.0009236	-0.007678	-0.00989
Ho:ECT+=ECT-	F-stat	*9.274	*8.33	0.028	0.515	0.158
LB(4) & DW		0.11 & 2.00	0.22 & 2.04	1.00 & 2.00	0.00 & 2.01	0.00 & 2.00
Equity	ECT+	-0.000394	-0.00229	0.001192	**0.0027776	-0.003992
	ECT-	0.000284	-3.04E-06	*-0.00386	-0.000245	0.001522
Ho:ECT+=ECT-	F-stat	0.575	0.156	*7.269	**4.412	0.622
LB(4) & DW		0.75 & 2.00	0.74 & 2.00	0.99 & 2.00	0.53 & 2.00	0.82 & 2.00
Linear ECT	CDS	*1.04047	-0.0001	*-0.016375	**-0.006804	*-0.003489
	EQUITY	**-0.05115	***0.00018	**-0.00567	-0.027535	-0.005821
Panel B		**China**	**Indonesia**	**Malaysia**	**Philippines**	**Thailand**
CDS	ECT+	**-0.01227	*0.025067	*-0.008194	*0.0274985	-0.0051440
	ECT-	0.001001	**-0.01046	*-0.248408	0.0002024	-0.006101
Ho:ECT+=ECT-	F-stat	*6.539	*11.497	*149.973	*9.714	0.006
LB(4) & DW		0.21 & 2.00	0.67 & 2.01	0.31 & 2.06	0.54 & 1.99	0.03 & 2.05
Equity	ECT+	0.0110775	0.000713	0.005172	**-0.008365	-0.002536
	ECT-	0.0008269	0.00148	*0.791326	-0.001942	*-0.003946
Ho:ECT+=ECT-	F-stat	1.061	0.023	*23.839	***2.879	0.159
LB(4) & DW		0.01 & 2.01	0.67 & 2.01	0.98 & 2.01	1.00 & 2.00	1.00 & 2.00
Linear ECT	CDS	*-0.009494	*-0.035907	**-0.00680	**-0.009607	*-0.025197
	EQUITY	-0.000715	-0.00539	*-0.003126	*-0.003993	*-0.021171
Panel C		**Bulgaria**	**Hungary**	**Poland**	**Russia**	**Turkey**
CDS	ECT+	0.0000932	**-0.01374	*0.028761	-0.0074140	0.0001013
	ECT-	**-0.00207	*-0.00834	**-0.00836	***-0.02320	9.64E-05
Ho:ECT+=ECT-	F-stat	*4.402	0.56	*27.19	1.306	0.000
LB(4) & DW		0.84 & 1.99	0.00 & 1.98	0.99 & 1.98	0.19 & 2.04	0.92 & 1.99

Equity	ECT+	-0.0004742	0.01398	0.0009039	-0.006571	***0.0008375
	ECT-	0.0049845	-0.00499	0.0027286	**-0.040081	-0.001704
Ho:ECT+=ECT-	F-stat	1.763	*4.194	0.141	***3.107	**4.926
LB(4) & DW		0.50 & 2.00	0.59 & 2.00	1.00 & 2.00	0.98 & 1.99	1.00 & 1.99
Linear ECT	CDS	-0.002351	*-0.015439	**-0.00597	*-0.007212	-0.002741
	EQUITY	*-0.011108	**-0.01752	**-0.02555	-0.003422	***-0.0025
Panel D		**S. Africa**	**Tunisia**			
CDS	ECT+	0.0017950	*-0.004448			
	ECT-	*-0.040512	*0.0558			
Ho:ECT+=ECT-	F-stat	*37.822	*14.339			
LB(4) & DW		0.91 & 2.00	0.93 & 1.99			
Equity	ECT+	-0.00244	0.011664			
	ECT-	-0.001256	-0.09867			
Ho:ECT+=ECT-	F-stat	0.081	0.19			
LB(4) & DW		1.00 & 2.00	0.21 & 1.96			
Linear ECT	CDS	**-0.01025	**-0.00489			
	EQUITY	*-0.007394	-0.00176			

Table 7(c): Asymmetrical price discovery between equity and bond spreads

This table provides summary information on asymmetrical price discovery between CDS and equity. BS is the bond spreads. DW is Durbin Watson statistic which test the null of no (zero) autocorrelation in the residuals. LB(4) is the Ljung-Box statistic which test the null of no autocorrelation in residuals up to four lags. ECT+ and ECT- is the error correction term (speed of adjustment parameter) in upper and lower regime respectively. Each series (BS and CDS) adjusts to long-run equilibrium relationship under two regimes (above and below the threshold. The null hypothesis, Ho: ECT+=ECT- is a test of asymmetry in error or deviation adjustment process. *, ** and *** is 1%, 5% and 10% significance level. Linear ECT is the error correction term in a linear model which assumes a single regime.

Panel A		**Argentina**	**Brazil**	**Colombia**	**Mexico**	**Venezuela**
BS	ECT+	0.0001612	***0.0030451	0.0004577	**-0.2415	**0.009237
	ECT-	-0.0018313	-0.0006683	***-0.01126	9.52E-03	**-0.004317
Ho:ECT+=ECT-	F-stat	0.965	**4.007	***2.934	**4.558	*7.552
LB(4) & DW		0.97 & 2.01	0.38 & 2.00	1.00 & 2.00	0.97 & 2.00	0.30 & 2.00
Equity	ECT+	0.0004409	-0.001273	**-0.00731	***-0.0329	-0.0084
	ECT-	*-0.02078	-0.002332	0.0050743	-0.002508	8.75E-05
Ho:ECT+=ECT-	F-stat	*14.294	0.046	1.415	***2.637	***2.262
LB(4) & DW		0.97 & 2.01	0.65 & 2.00	0.96 & 2.01	0.60 & 2.00	0.98 & 2.00
Linear ECT	BS	**-0.00496	**-0.004056	*-0.008262	-0.001835	**-0.004823
	EQUITY	-0.000231	0.001044	-0.004487	***-0.0003	-0.0000181
Panel B		**china**	**Indonesia**	**Malaysia**	**Philippines**	**Thailand**
BS	ECT+	** -0.00524	-0.003314	0.0004957	-0.001381	-0.026919
	ECT-	*-0.031179	-0.001377	**-0.000457	0.008851	0.002002

Ho:ECT+=ECT-	F-stat	*5.711	0.075	*7.306	0.929	1.325
LB(4) & DW		0.78 & 2.01	0.50 & 2.00	0.82 & 2.00	0.98 & 1.99	0.31 & 2.00
Equity	ECT+	0.001455	-0.002076	-0.003645	***-0.0026	**-0.02113
	ECT-	0.034804	*-0.017963	-0.000809	-0.007532	*-0.007031
Ho:ECT+=ECT-	F-stat	***2.373	*6.505	0.819	0.1071	***2.201
LB(4) & DW		0.00& 2.01	0.10 & 1.98	0.88 & 2.00	0.10 & 1.99	0.96 & 2.00
Linear ECT	BS	-0.001165	-0.00055	-0.001679	*-0.007054	*-0.006734
	EQUITY	*-0.016556	*-0.003338	-0.004231	-0.005574	*-0.016599
Panel C		**Bulgaria**	**Hungary**	**Poland**	**Russia**	**Turkey**
BS	ECT+	0.237	**-0.0208645	**-0.007566	*-0.030355	***0.018471
	ECT-	-0.0009749	0.0002724	**-0.018075	0.003563	**-0.005349
Ho:ECT+=ECT-	F-stat	-0.0017949	**5.273	1.563	*14.494	**4.406
LB(4) & DW		0.22 & 2.01	0.92 & 1.99	0.92 & 1.99	0.47 & 2.02	0.93 & 1.99
Equity	ECT+	**-0.0075	***0.035603	0.0016258	0.0004104	***-0.03962
	ECT-	-0.002064	***-0.008018	0.0102636	**-0.00387	0.00384
Ho:ECT+=ECT-	F-stat	1.178	**4.499	1.091	0.737	**4.647
LB(4) & DW		0.45 & 2.00	0.55 & 1.99	0.55 & 1.99	0.99 & 1.99	0.95 & 1.99
Linear ECT	BS	*-0.001751	-0.002168	**-0.005436	***-0.0036	*-0.007025
	EQUITY	-0.000299	*-0.004248	***-0.00136	-0.000496	-0.000163
Panel D		**S. Africa**	**Tunisia**			
BS	ECT+	0.002544	**-0.0027609			
	ECT-	-0.010526	0.1126989			
Ho:ECT+=ECT-	F-stat	1.146	0.136			
LB(4) & DW		0.03 & 1.99	1.00 & 1.99			
Equity	ECT+	***-0.0057	0.02058			
	ECT-	-0.010088	*-45.96876			
Ho:ECT+=ECT-	F-stat	0.203	*25.787			
LB(4) & DW		0.46 & 2.00	0.21 & 2.02			
Linear ECT	BS	**-0.00722	-0.000591			
	EQUITY	***-0.0061	**0.000876			

V. Conclusion

According to Chan-Lau and Kim and Chang (2004), bond spreads and equity prices may be characterized by a nonlinear relationship that linear modeling cannot capture. To this end, I investigate if sovereign CDS premium, bond spreads and equity prices are characterized by nonlinearities and errors in modeling specifications. I find evidence of nonlinearities and misspecification in cointegration relationship using simple linear regression equations. I proceed to investigate nonlinear pairwise cointegration relationship among sovereign CDS premium, bonds spreads and equity prices. I not only find existence of threshold but also a clear evidence of momentum whereby the divergence from long term equilibrium between any two series evince more momentum in one direction relative to substitute direction. In 41/51 spreads, MTAR modeling was identified as the appropriate modeling tool in investigating nonlinear cointegration. I find evidence of asymmetric cointegration in 28/51 possible pair-wise cointegrations. In 49/51 pair-wise cointegrations, I find that positive and negative divergences from long run relationship can be corrected for at dissimilar speeds.

All countries with TAR modeling and positive skew in returns, especially Eastern Europe nations, exhibit symmetric cointegration relation and price discovery process. Interestingly, these countries also exhibit positive skew in their CDS spreads, bond spreads and equity returns. The absence of non-linear cointegration may indicate that the countries have very low credit risk. Therefore, equity prices and bond spreads respond fundamentals of each country and not to credit risk information. (Ismailescu and Kazemi, 2010). Other possible reason could be illiquidity of the markets, the need for linear as opposed to non-linear modeling and severe market frictions which prevent utilization of arbitrage opportunities to achieve long run equilibrium relationship between markets. These frictions occur in both regimes.

I find evidence of asymmetric short run (long run) adjustment in 66/102 (66/102) pairs of the markets. Every country (except China) in the sample has at least two short run and long run asymmetric adjustment processes. The price discovery and speed of adjustment to new information is generally regime specific. Latin American countries have the highest number of asymmetric price adjustments followed by Asia, Eastern Europe and then Africa. CDS has the highest number of asymmetric adjustment to long run equilibrium process followed by bond spreads and lastly equity. There seems to be measured evidence in Colombia, China, Turkey, Tunisia and Venezuela indicating that whenever price discovery occurs in equity market (Irrespective of regime) under non-linear price discovery, price discovery also occurs in equity market using linear VECM.

This study can be extended to new frontiers. For example: Why are most of divergences (12/17 countries) between CDS and bond spreads supported by TAR and not MTAR? Why do Eastern Europe countries exhibit positive skew in returns, symmetric cointegration relationships yet all of them are supported by TAR modeling? Anecdotal evidence indicates that they don't have better credit rating than the sample countries covered in this study. The study can also be extended to investigate the role of liquidity in non-linear cointegration, adjustment process and price discovery process.

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Chapter 2:

Non-linear Effects of Monetary Policy on Liquidity and Financial Structure

I. Introduction

Central banks have traditionally relied on banking institutions to transmit monetary policy and liquidity into the real economy. Central banks control the lending and borrowing activities of banking institutions via reserve requirements and adjusting the inter-bank borrowing rate which is used as an anchor when setting the lending and borrowing rate of commercial banks, credit unions and savings institutions. The open market operations (sale and repurchase of treasury bills and bonds) also significantly affect liquidity of banking institutions which invest heavily in these government securities.In U.S, commercial banks, credit unions and saving institutions are under control of Federal Reserve Bank (Fed henceforth). I classify them as bank-based institutions (BBIs).

Institutions such as security dealers and brokers (SBDs), finance companies (FCs), Asset-backed securities (ABS) firms which "collateralize" non-real estate loans, receivables, leases, credit card receivables, auto loans and student loans among others and government securities enterprises, GSEs (Fannie Mae, Freddie Mac, Ginnie Mae and Farmer Mac) deal with tradable securities which they give as collateral for borrowing (tradable liabilities) and accept the same securities when lending (tradable assets). Examples of ABS firms include Citibank, Sears, Roebuck, Unisys, Merrill Lynch, and Salomon Brothers. The bulk of these securities are marked to market on daily basis. The prices of the securities are affected by short term interest rate which is used as discounting rate.The short term rate depends on the Federal fund rate, FFR, which is used as a benchmark for lending and borrowing by all institutions). FFR thus has indirect effect on the prices of ‘collateralized securities used by the four categories of institutions.

These institutions provide much needed liquidity[10] in the economy yet the Fed cannot directly ‘use’ them as conduits of transmitting liquidity into the economy since they are regulated by different agencies. SBDs and Asset-backed Securities (ABS) firms are regulated by Securities Exchange Commission (SEC). FCs are largely unregulated. GSEs, created by the Congress to provide liquidity and stability in secondary mortgage markets, are regulated by U.S department of Housing and Urban development (HUD). ABS, FCs, GSEs and SBD are classified as market-based institutions (MBIs). The demarcation of financial intermediaries into MBIs and BBIs defines financial structure in this study.

A. *Theoretical Foundation*

This study is based on financial accelerator model of Bernanke, Gertler and Gilchrist (1999). During economic boom which is characterized by expansionary or loose monetary policy (lower interest rate, more supply of liquidity and/or reduced reserve requirements),surplus economic units (savers) willingly extend credit to deficit economic units (borrowers such as financial intermediaries, firms and individuals) since they (savers) can withstand the risk they face. Moreover, financial markets are able to efficiently price the risk (including risk premium) savers face and compensate them accordingly. Money is cheap and readily available. This creates a positive feedback loop where financial intermediaries (BBIs and MBIs) borrow more (low funding risk) and lend more. This leads to expansion and strengthening of the balance sheets(Adrian and Shin, 2008, 2009) due to lower perceived

[10]Liquidity here is defined as supply of credit into the real economy by financial intermediaries. The alternative definition for this study could be conversion of illiquid balance sheet assets such as mortgage loans into liquid and tradable assets.

risk and higher profits from increased lending. Succinctly, there is increased supply of liquidity in the economy as funds flow from savers to borrowers.

However, in stressful and more uncertain financial and economic conditions punctuated by contractionary or ‘tight’ monetary policy, financial intermediaries, just like other borrowers, find it difficult and costly to acquire funds from savers (increased funding risk). Their ability to lend is also diminished primarily due to either shortage of funds to lend or, according to Brunnermeier and Pederson (2009), there is ‘flight to quality’ by both lenders and savers where lending is concentrated only to high credit-worthy customersor toward securities with low margin requirements due to reduced funding liquidity. While riskier financial intermediaries borrow at a premium, the riskiest financial intermediaries cannot borrow (or lend) on any term. Adrian and Shin (2008) and Kahn (2010) shows that balance sheet contracts as borrowing and lending volume decline while liquidity dissipates. This is essentially an adverse feedback loop effects of financial accelerator model. If financial intermediaries cannot lend, profits will decline and balance sheet will weaken. It is thus safe to conclude that liquidity of both MBIs and BBIsheavilydepends on the expansion and contraction of the balance sheet and the resulting profitability.

B. Why Non-linear Modeling?

Most studies in monetary policy and liquidity are based on linear relationship between policy and liquidity in different economic regimes (see for example, Adrian and Shin, 2008 and Jovanovic and Zimmermann, 2010). However, the magnitude and intensity of monetary policy actions are non-linear across different economic cycle and financial conditions (Morgan, 1993). The actions are inherently more pronounced during economic recession. A small and transient deviation in macro variables such as liquidity, interest rate, inflation and government budget deficits during normal economic times usually require mild policy interventions.During economic boom, the build-up of financial imbalance(persistent increase in asset prices or/and liquidity) is slow. The monetary policy response of the Fed is infrequent, slow, measured and less interventionary. For example: The persistently slow increase in FFR between 2003 and 2006 even as asset prices soared.

Events such as sudden "dry up" of liquidity that could destabilize financial system, economic activities or trigger recession call for more quick, aggressive and interventionary policy actions. For example: The former chairman of Fed, Alan Greenspan, aggressively slashed Federal fund rate. This lender support to Jovanovic and Zimmermann (2010) assertion that it is hard for any Central bank to signal its readiness and mettle in combating financial markets uncertainty shocks without substantial reduction in short term interest rate. During the financial turbulence episode of 2007-8, the Fed dramatically and unprecedentedly decreased FFR by 325 basis points between the summer of 2007 and January 2009. The Federal Open Market Committee (FOMC) made major buy-back of long term Treasury bonds which caused significant decline in the yields of Treasury bonds in addition to indirectly pumping liquidity into the market (Doh, 2010). In October 2008, the Fed started paying interest on bank reserves while the U.S Treasury provided liquidity support through the Capital Purchase Program (CPP) of Troubled Assets Relief Program (TARP) of 2008-10 to buy toxic assets of nine financial institutions with the aim of "cleaning" their balance sheets to mitigate contraction in lending[11]. In November 2008, Term Asset-backed Loan

[11]These banks included JP Morgan, Morgan Stanley, State Street, Wells Fargo, Bank of America, Citigroup, Goldman Sachs, Merrill Lynch and Bank of New York Mellon.

Facility (TALF) was launched and in February 2009, financial stability plan (FSP) was established.

From the foregoing, it seems credible that the Fed also mind about the aggregate liquidity of financial markets, a reason why Garcia (1989) clearly describe how central banks use monetary policy during financial crisis to ease market illiquidity. Bernanke (2009) confirms this view by stating that the Fed provided liquidity to private banking sector to manage the recent financial crisis since pure interest rate cuts to satisfactorily reduce the spiral effects of financial markets shocks and distress on the real economy were ineffective.

Bernanke (2009) thus admitted that “In historical comparison, this policy response stands out as exceptionally rapid and proactive.” Taylor (2010) calls this response one of the “great deviations” punctuated by more interventionist, less rules-based, and less predictable macroeconomic policy actions during and post-2007-8 financial crisis. The monetary policy (among other actions[12]) divergedfrom the practice of at least the previous two decades. Mishkin (2009) argues that if the FED had not taken numerous abrasive monetary actions in the wake of 2007-8 financial crises, economic recession would have deteriorated, financial markets instability amplified and quick recovery of the U.S. economy jeopardized. However, Taylor (2007) and Kahn (2010) argue that asset price bubbles will arise whenever there is excess liquidity in financial markets. The lengthy period of very low Federal fund rates that preceded dotcom bubble burst in year 2000 and the low interest rates during 2003-2006 precipitated the housing price bubble of 2007. This cycle of events will certainly be repeated given the current very low Federal fund rate (0-0.25% since 2008) in the face of financial market uncertainty and rising inflation.

[12] See Taylor (2010) for the list of the Great Deviation and detailed discussion thereof.

If we take economic boom as the regime during whichthe liquidity of MBIs and BBIs build-up and another regime during which the drying-up of liquidity israpid and accompanied by aggressive policy intercession, there must be a threshold which divides these regimes and make monetary policy stance have dissimilar or nonlinear effects in the two regimes. Specifically, the effect of monetary policy stances on liquidity of MBIs and BBIs is expected to be non-linear.

I identify the threshold that separates two regimes. Using Federal fund short term interest rate deviation (FFDEV) and growth in money base or monetary aggregate (BMG) as monetary policy instruments, this study aims to investigate how monetary policy stance affects liquidity of MBIs (LIQMBI) and BBIs (LIQBBI) under different regimes. Specifically, I attempt to answer the following questions:

(a) Does a statistically significant threshold level of monetary policy stance exist above (below) which monetary policy stance affects liquidity of BBIs and MBIs differently? Put differently, is there a statistically significant non-linear effect of monetary policy stance on liquidity?

(b) Do different monetary policy stances have different effects on market-based liquidity (LIQMBI) and Bank-based liquidity (LIQBBI) below and above the threshold? If so, which monetary policy tool is more suitable for BBIs and MBIs for each regime?

(c) Does monetary policy affect MBIs liquidity more than BBIs liquidity? The Fed hastraditionally relied on BBIs as conduits of monetary policy and liquidity transmission. If any of the monetary stances has higher impact on LIQMBI (which is beyond the control of Fed), should the Fed include MBIs as conduits of transmitting monetary policy and liquidity in the economy to make monetary policy more effective?

I find that monetary policies tools, whether FFDEV or BMG are fraught with uncertainty and time variation as a result of existence of multiple regimes. Liquidity of BBIs (LIQBBI) and MBIs (LIQMBI) respond differently not only to different monetary policy instruments under different regimes but also to financial market conditions and degree of real economic activities. LIQMBI respond more to monetary aggregate policy (BMG) shocks during contractionary monetary policy intervention (economic downturn) relative to expansionary monetary policy intervention. However, LIQBBI is generallymore responsive to FFDEV shocks under expansionary monetary policy as opposed to contractionary monetary policy. I conclude that the Fed cannot continue to ignore MBIs if it expects in formulate and implement more broad-based and effective monetary policy. It should consider the changing nature and structure of financial intermediaries and the associated financial innovations.

I contribute to existing literature in three main ways. First, my study empirically investigates the presence of threshold in two different measures of monetary policy stance and non-linear effects of the stances on liquidity of different structures of financial intermediaries.I use threshold vector autoregressive (TVAR) model. Second, this study uses higher frequency (monthly) data and covers twenty four years. It does not narrowly focus on 2007-8 financial crises. The mere existence of regimes and threshold implicitly indicates uncertainty and time variation inherent in monetary policy since different regimes occur in different times. Third, I investigate the effects of monetary policy stance on different structures of financial intermediaries (market-based and bank-based institutions). This is important because MBIs and BBIs fall under different regulatory authorities yet MBIs provide much need liquidity and stability in financial markets.

The rest of the study is organized as follows; Section II reviews the literature and develops the hypotheses to be tested. Section III describes the data and econometric methodology. Section IV details empirical evidence and section V concludes.

II. Literature review and Hypothesis development

C. Liquidity and leverage

The BBIs hold a proportionately large share of their assets in form of book value loans which are not marked to market to capture changes in liquidity, credit risk, business and financial cycles. The funding of BBI is majorly through insured demand deposits. During economic and financial downturn, the market values of financial assets of BBIs loans are less than the book value hence there will be overvaluation equity (financial assets less financial liabilities). Conversely, during economic and financial boom, the market values of BBIs' financial assetsare higher than the book value hence there is undervaluation of equity. This argument suggest that liabilities and equity of BBIs will exhibit higher volatility than assets while leverage (Assets/ (assets-liabilities) and assets are either inversely related or have very low positive correlation.[13]

The lending and funding activities of MBIsdepend on repurchase agreements (repos) and reverse repos. In case of a repo, a financial institution (borrower) sells a security such as Treasury bill and bond to another party (lender) to raise capital at, say $100. However, the

[13] See Adrian and Shin (2008)

seller agrees to buyback the security at a specified future date and price, say $120. The security buyer (lender) earns $20 interest income. The tradable security can thus be construed as collateral for the loan borrowed by the seller the liabilities. The same transaction from the perspective of the security buyer (lender) is reverse repo. Therefore, MBIs will have a disproportionately large portion of their assets as reverse repos (Lenders) and corresponding liabilities of repos. Both repos (liabilities) and reverse repos (assets) are marked to market. The changes in market prices of reverse repos and repos reflect the changes in financial assets and financial liabilities of the MBIs. Changes in prices of repos and reverse repos determine the trading positions (Long or short) MBIs will take in financial market. Assets and liabilities of MBIs are thus highly liquid and marketable.

From the forgoing, volatility of assets and liabilities of MBIs track each other over time. In contrast to BBIs, there is a positive relationship between assets and leverage. The pro-cyclical nature of this relationship has important implications. An increase in the price of reverse repos will trigger an increase in demand for repos and the MBI balance sheet will expand. Any rewinding of trading positions in repos and reverse repos (due to external shocks) will lead to immediate contraction of the balance and the effect is more magnified on the asset side. This means assets decline more than liabilities and equity is wiped out. Liquidity will eventually disappear.[14] Acharya and Viswanathan (2011) find that the buildup of leverage in financial market during economic boom can help explain why adverse shocks in such times lead to severe dry-up of liquidity and deep discounting of asset prices. Specifically, the drying of liquidity triggers a series of small 'burst' in the highly leveraged MBIs which quickly spread to all the financial and non-financial firms (banks, hedge funds among others) in the complex network within the financial system to form a contagion.

[14]See Paul McCulley, PIMCO Investment Outlook, Summer 2007

Opinions and empirical evidence are converging to the reality that leverage of financial intermediaries is an imperative financial variable which can assist in envisaging stress in financial markets and understanding business and financial cycles.Since financial assets and liabilities of MBIs (BBIs) are (not) marked to market, we expect them to be more (less) synchronized or exhibit higher (lower) correlation with financial and economic activities.

> *Ho1: Volatility of equity of BBIs (MBIs) is higher (lower) since financial assets and liabilities are not (are) marked to market. There assets (and equity)of MBIs (BBIs) have exhibit higher (lower) correlation with financial conditions and economic activities*

D. The Threshold effects

Peek and Rosengren (1995) find that the health of the banking sector, the nature and the size of banks' response to changes in monetary policy depend on the liquidity of the bank.Glick and Plaut (1988) argue that monetary policy makers should pay more attention to off-balance sheet liquidity when choosing targets and operating procedures. This is because they are marked to market but have received less attention. The channel through which monetary policy operates becomes more complex when bothon and off-balance sheet liquidity co-exists. By focusing on banks to transmit on-balance sheet liquidity to the economy, the Fedignores the uncontrollable market-based liquidity provided by non-bank financial institutions. Moreover, since the money channel of monetary policy works through bank liabilities while the credit channel works through the assets, the responses of financial intermediaries to a shift in monetary policy should differ depending on the characteristics of assets/liabilities

In a similar line of study, Berger and Bouwman (2010) investigate how monetary policy affects banks' on- and off-balance sheet liquidity creation during normal and financial crises times. They find that during normal times, a contractionary monetary policy leads to a significant reduction in on-balance sheet liquidity creation by small banks, while the impact is insignificant on liquidity creation ability of large and medium-sized banks, which account for 90% of aggregate bank liquidity. However, the effect of monetary policy on on-and off-balance sheetliquidity creation by all banks is weaker during financial crises than during normal times. Consistent with findings by Kahn (2010) and Owsley (2011), they also find high liquidity relative to trendas a harbinger to financial crises and financial imbalance (Persistence increase in the price of assets without support of sound fundamentals) in housing prices, stock markets prices, and commodity prices among other assets. This leads to the second hypothesis

Ho2: There exists a threshold above (below) which monetary policy stance affects liquidity of MBIs and BBIs differently.

E. Changing structure of financial intermediaries and monetary policy

Silber (1977) early identified the need to focus on market-based financial intermediaries in the definition of market liquidity. He argued that the sole focus on banks as providers of liquidity ignored marketplace as a source of liquidity. This marketplace liquidity arose from trading of financial assets in financial market. For example: Saving and Loans institutions that concentrate on mortgages and create savings deposits might generate no more liquidity than Government National Mortgage Association (Ginnie mae) mortgage-backed securities that are traded actively in a secondary market. This trading facet to liquidity is ignored by monetary policy. He suggested that marketability of securities (market-based liquidity), maturity of the securities and price volatility may be potential candidates for inclusion in monetary policy setting. This would capture the interaction between monetary mechanism, market liquidity and financial structure. This view is supported by Cagan (1979) and Brunnermeier and Pederson (2009) who explain that there is mutual interaction between liquidity of securities market and funding liquidity of financial intermediaries. The capital and margin requirements determine the ability of financial intermediaries to provide liquidity.

Walsh and Wilcox (1995) state that business cycles may be tied to bank liquidity and balance sheet condition especially if there is correlation between bank loans and output. However, financial deregulation[15] and innovations which led to the growth of the secondary markets for residential mortgages and new forms of credit acting as substitute for bank loans can reduce the special role banks play in providing firms and households with credit or liquidity. Such innovations, according to Modigliani and Papademos (1990) distort the definition of "money" and created a new set of assets with almost interchangeable distinctiveness of liquidity and risk. This has complicated the ability to select the appropriate monetary aggregate as a policy target.

Blinder (1999) raises the important question of the implications of high-tech finance for the conduct of monetary policy. Should contemporary central banks respond to the explosion of derivatives and all things financial exotica? Should they operate in derivative and other exotic markets instead of confining themselves to open market operations based on government securities only? How should the design of monetary policy adapt to these developments? It is imperative to know that since the inception of Federal fund rate futures trading on Chicago Mercantile Exchange (CME), the Fedhas covertly and consistently used Federal Fund futures interest (FFFR) rate as bellwether of market expectation of future monetary policy decisions. More importantly, most of these "new markets" contain a great deal of information, are exceptionally deep and liquid and often create opaque and enormous

[15] See for example, the replacement of Glass-Steagall or banking Act of 1933 with financial Services Modernization Act/Gramm-Leach-Bliley Act of 1999 which removed financial specialization and allowed insurance firms, commercial banks and investment banks to compete in financial services offerings

leverage (For example: the repos and reverse repos, Eurodollar, Futures, options and Credit default swap markets). The high-tech financial instruments have not only affected the monetary policy transmission channel but have also shortened monetary policy lags and provided a new dimension of the link between short and long-term interest rate.Brunnermeier and Pederson (2009) states that structure of financial institutions (defined here as BBIs and MBIs) determines the liquidity in the economy hence the same structure should be used to transmit liquidity during recessions. Moreover, liquidity highly affects real economic activity and we may be interested in uncovering which liquidity (BBIs or MBIs) has higher effects on real activity

Ho3: Liquidity of MBIs and BBIs respond differently to different monetary policy stance measures below or above the threshold.

F. *Type of BBIs and non-linear monetary policy stance response*

According to Bernanke and Gertler (1995), the effectiveness of the credit channel depends on the response of the bank to the monetary policy. For example: A contractionary monetary policy that squeezes bank reserves will reduce the supply of bank loans or liquidity in the economy. However, should the bank change the composition of its liabilities (Such as selling bonds, issuing CD's and interbank loans which are not subject to reserve requirements), monetary contraction will neither affect the supply of loans nor the real economy. Li and St-Amant (2010) use TVAR to empirically study how financial market conditions (financial stress) affect the transmission of monetary policy shocks in Canada. They find that contractionary and expansionary monetary shocks have asymmetric effects on output under different regimes defined by financial market conditions.

Favero, Giavazzi and Flabbi (1999) investigate the response of bank loans in France, Germany, Italy and Spain to monetary policy contraction of 1992. They find that different banks (country and size-wise) respond differently to liquidity squeeze to mitigate reduction in supply of loans. Frenandez et al (2010) investigate the impact of monetary policy on stock market liquidity in Euro zone. For all the seven measures of stock market liquidity, they find that expansionary monetary policy of the European Central Bank (ECB) leads to increased liquidity in the German, French and Italian stock markets.

> *Ho4: The liquidity of different categories of BBIs responds differently and asymmetrically to either of the two monetary policy stance measures. As such, each has a unique threshold and threshold value.*

III. Data and Econometric Methodology

The data to measure the monetary policy stance comes from different sources. The monthly output measure, coincidence of economic indicators (CEI), is from U.S department of commerce (Conference board) website. The Federal fund interest futures rate (FFFR) is from Chicago Mercantile Exchange. The monthly consumer price index (CPI) is from Federal Reserve Economic database (FRED). The monthly real national economic activity index (NEAI) and adjusted financial market stress or condition index (AFCI) are from Federal Reserve Bank of Chicago. The quarterly data for BBIs and MBIs comes from the Federal Reserve Bank (FRB) website (Flow of funds). Specifically, I gather data relating to financial assets and financial liabilities of BBIs which comprise commercial banking (CB: Item L.109), Savings institutions (SI: Item L.114), Credit unions (CU: item L.115). The MBIs comprise Government sponsored enterprises (GSEs: Item L.124), issuers of asset-backed securities (ABS: Item L.126), finance companies (FC: Item L.126) and Securities brokers and dealers (SBD: Item L.129). The quarterly data is converted into monthly data. All data spans the period January 1988 through October 2011.

G. *Defining liquidity*

The definition of liquidity for both MBIs and BBIs is adopted from Adrian and Shin (2008, 2010). They define liquidity of each category of financial intermediary (BBIs and MBIs). Market-based liquidity (LIQMBI) and Bank-based liquidity (LIQBBI) are proxied by leverage since changes in leverage indicate contraction and expansion of balance sheets of BBIs and MBIs.

$$LIQMBI \text{ or } \mathrm{LIQBBI} = \frac{\text{Financial Assets (excluding government securities)}}{\text{Equity (Financial assets - total liabilities)}} \tag{i}$$

This definition has been applied in empirical work by Reinhart and Rogoff (2009), Kahn (2010) and Owsley (2011). The data of interest is total financial assets and total financial liabilities.

H. Measures of Monetary stance

There are two commonly used measures of monetary policy stance namely (i) Interest rate deviation and (ii) Changes in monetary aggregate or money base. To derive the interest rate stance, we need an "optimal" FOMC target interest which is derived using the Taylor (1993) rule.

$$r_t^{FFR} = r_t^N + \beta_1(\pi_t - \pi_t^*) + \beta_2(y_t - y_t^*) + \varepsilon_t \tag{ii}$$

In equation (ii), r_t^{FFR} is the FOMC target rate proxied by Federal fund futures contract interest rate (FFFR) in month t.There is no consensus about what interest rate to use to determine deviations from Taylor rule. Example: Ellingsen and Soderstrom (1999) use the three-month Treasury bill, Poole and Rasche (2000), Sack (2004) and Goukasian and Whitney (2006) use the 1-month-out federal funds futures contract rate. Kuttner (2001) and Faust, Swanson and Wright (2002a) use the current-month federal funds futures contract rate; However, Cochrane and Piazzessi (2002) use the one-month Eurodollar deposit rate, and Rigobon and Sack (2002) use the three-month Eurodollar futures rate. A study by Gürkaynak, Sack and Swanson (2002) show that FFFR dominate FOMC target rate and other market-based measures of monetary policy expectations up to about five months out horizons. Blider (1999) also intimates that FOMC use FFFR from CME as an indicator of market's expectations about future monetary policy actions before setting the target rate. In light of the forgoing argument, I use the FFFR since it is market determined, is forward looking and is also used by FOMC to extract market-expectation information.

π_t (π_t^*) is the actual inflation rate (target or tolerable inflation rate)in month t. The difference is the inflation deviation or gap. Inflation, π_t , is the rolling percentage change in consumer price index (CPI) over the last twelve months.[16]

$$\pi_t = \ln\left(\frac{CPI_t}{CPI_{t-12}}\right) * 100 \qquad \text{(iii)}$$

[16] The GDP deflator could be used as an alternative measure of inflation as originally used by Taylor (1993) but this inflation measure seems inconsistent after 1992. We could also employ core Personal Consumption Expenditure (PCE) index and PCE index to compute inflation rate as actually used by FOMC but Bernanke provides evidence showing that this measure consistently yield smaller deviations from Taylor rule. The CPI measure of inflation generates consistent results and is more reliable. Core CPI and core PCE exclude food and energy prices.

y_t (y_t^*) is the actual real output (potential real output)[17] in month t. The difference represents the output gap in month t.

There are three possible measures of output namely real industrial production, IP (Monthly frequency), real GDP (Quarterly frequency) and Coincident economic Indicators, CEI, (Monthly frequency). Most studies use IP which is a very narrow measure of aggregate economic activity. In this study, I use CEI since it is in monthly frequency (unlike GDP) and matches the frequency of other data variables used in this study. Moreover, CEI subsumes IP since it is an average of four variables namely employees on non-agricultural payrolls, real personal income less transfers, industrial production and real manufacturing and trade sales) CEI thus better reflects the aggregate level of economic activity.

ε_t is *iid* error term. This can be used to represent discretionary monetary policy of the central bank. It can be rationalized to mean that central banks make a partial adjustment to existing short term interest to set a new target interest rate. The parameters, β_1 and β_2, $\forall \in (0,1)$ are the weights which the central bank put on inflation and output. Equation (ii) stipulates that if either inflation or output or both deviate from target, the nominal federal fund rate should be adjusted to capture such deviations.

Clarida, Gali, and Gertler (1998, 2000) and Bernanke and Gertler (1999) argue that policy makers have incomplete information (uncertainty) at the time of setting monetary policy. Similarly, since the ex-post realized contemporaneous inflation deviation and output gaps are not known at the time of the decision, policy makers base their decision on lagged

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[17] The potential output (coincidence of Economic indicators, CEI), y^*, and tolerable or target inflation rate, π^*, are long run trend variables derived using Hodrick-Prescott filter with a smoothing parameter of 14400.

output and inflation gaps. Therefore, a forward-looking Taylor rule becomes more appropriate to explain both high and low inflation rates regimes and incorporate interest rate persistence by incorporating a smoothing parameter. Therefore, I construct a forward-looking "optimal" monetary policy estimation equation by modifying equation (ii) as follows.

$$r_t^{FFR} = r_t^N + \beta_1 (E[\pi_{12,t} \mid \Omega_t] - \pi^*) + \beta_2 (E[y_t \mid \Omega_t] - y_t^*) \qquad \text{(iv)}$$

r_t^N is the long run equilibrium nominal interest rate, $\pi_{12,t}$ is the average inflation between month t and month t+12[18] defined as

$$\pi_{12,t} = \ln\left(\frac{CPI_{t+12}}{CPI_t}\right) * 100 \qquad \text{(v)}$$

π^* is the long run target inflation rate, which according to empirical evidence by Taylor (1993) and Clarida et al (1999) is set at two percent. y_t (y_t^*) is the real (potential) output premised on flexible prices and wages. Ω_t is the information set available to monetary authority at time *t*. The variables used in estimation of parameters are excluded from this information set. The information set at time t, Ω_t, is used by policy makers to form rational expectations (denoted by E).

The nominal interest rate, r_t^N, can be decomposed into real rate, r_t^R and target inflation rate.

[18] I use observed inflation rate instead of expected. This may result in implied loss of observation if we had a small sample which is not the case here. Therefore, there is no difference whether observed or expected inflation rate is used.

$$r_t^N = r_t^R + \pi^* \tag{vi}$$

The Federal fund futures rate, r_t^{FFR}, can also be decomposed into real rate, rr_t^{FFR} and expected inflation rate in 12 months since the model is forward-looking

$$r_t^{FFR} = rr_t^{FFR} + \pi_{12,t} \text{ Hence } rr_t^{FFR} = r_t^{FFR} - E(\pi_{12,t} \mid \Omega_t) \tag{vii}$$

Equations (vi) and (vii) are plugged into equation (iv) to yield equation (viii) below

$$rr_t^{FFR} = \{\mathrm{r}_\mathrm{t}^\mathrm{R} + \pi^* + \beta_1(E[\pi_{12,t} \mid \Omega_\mathrm{t}] - \pi^*) + \beta_2(E[y_t \mid \Omega_\mathrm{t}] - y_t^*)\} - E(\pi_{12,t} \mid \Omega_t)$$
$$rr_t^{FFR} = \mathrm{r}_\mathrm{t}^\mathrm{R} + (\beta_1 - 1)(E[\pi_{12,t} \mid \Omega_\mathrm{t}] - \pi^*) + \beta_2(E[y_t \mid \Omega_\mathrm{t}] - y_t^*) \tag{viii}$$

We need to capture interest rate smoothing since the central bank partly adjusts the existing interest rate to set a new target interest rate.

$$r_t^{FFR} = \rho r_{t-1}^{FFR} + (1-\rho) r_t^N + \zeta_t \tag{ix}$$

The smoothing parameter is $\rho \in (0,1)$. A very high ρ signifies that the prior period interest rate significantly influence the actual rate hence the higher the smoothing effect. The term ζ_t is an exogenous random shock that is *i.i.d.* r_t^{FFR} is the right hand side of equation (iv). Therefore, if plug equation (ix) into equation (viii) to incorporate smoothing parameter, $\rho \in (0,1)$ we get a new equation.

$$rr_t^{FFR} = (1\text{-}\rho)\{\mathrm{r}_\mathrm{t}^\mathrm{R} + (\beta_1 - 1)(E[\pi_{12,t} \mid \Omega_\mathrm{t}] - \pi^*) + \beta_2(E[y_t \mid \Omega_\mathrm{t}] - y_t^*)\} + \rho r_{t-1}^{FFR} + \zeta_t \tag{x}$$

We can remove unobservable "expectation" variables from equation (x) and express the equation in terms of realized variables to yield the following equation

$$r_t^{FFR} = (1\text{-}\rho)[\mathrm{r}_\mathrm{t}^\mathrm{N} - \beta_1\pi^* + \beta_1\pi_{12,t} + \beta_2(y_t - y_t^*)] + \rho r_{t-1}^{FFR} + \vartheta_t$$
$$r_t^{FFR} = (1\text{-}\rho)\,\mathrm{r}_\mathrm{t}^\mathrm{N} + \beta_1(1\text{-}\rho)(\pi_{12,t} - \pi^*) + \beta_2(1\text{-}\rho)(y_t - y_t^*)] + \rho r_{t-1}^{FFR} + \vartheta_t \tag{xi}$$

We know that information set, Ω_t contains all the variables the FOMC has at the time target interest rate is chosen. However, since $E_t\left[\vartheta_t|\Omega_t\right]=0$, we have orthogonality conditions. Therefore, the parameters ρ β_1, and β_1 , $\forall \in (0,1)$ in equation (xi) can be estimated using Generalized Method of Moments (GMM). The joint estimation of the parameters permits measurement of expectation errors in setting target interest rates. The errors can be used to assess deviations from expectation model.

To implement GMM, we need a set of instruments to replicate information set, Ω_t. The instruments consists of twelve lags of log difference of commodity price index (to take care of price puzzle and assist in forecasting inflation), twelve lags of inflation measures (π_{t-1} to π_{t-12}), four lags of output measure ($y_{t-1}, y_{t-2}, y_{t-3}$ and y_{t-4}) and one lag of policy rate, r_{t-1}^{FFR} . If we define $Z_t \in \Omega_t$ as a set of instrumental variables defined above and let Z_t to be orthogonal to the error term in equation (x), that is, $E\left[Z_t\zeta_t\right]=0$, then, the equation (xi) becomes

$$E\{[r_t^{FFR} - (1-\rho)\,\mathrm{r_t^N} + \beta_1(1-\rho)(\pi_{12,t} - \pi^*) + \beta_2(1-\rho)(y_t - y_t^*)] + \rho r_{t-1}^{FFR}]\}Z_t = 0 \qquad \text{(xii)}$$

We equate the equation to zero since we are using rational expectation model which assumes there are no systematic errors in forecasting the target rate.

In equation (xi), we substituted unobservable variables with realized variables. Therefore, GMM is implemented by correcting for autocorrelation and heteroscedasticity of unknown form with a lag truncation parameter of 12 since Taylor rule use $\pi_{12,t}$. We have also selected Bartlett weights to ensure positive definiteness on the variance-covariance matrix to be estimated. According to Baum, Schaffer, and Stillman (2003), GMM is a more efficient estimator in the presence of heteroscedasticity. Moreover, the approach adopted in this estimation generates more accurate estimates and is consistent with the Fed's monetary policy goal of stabilizing inflation or commodity prices.

The estimated parameters of equation (xii) and observable variables are then fitted to estimate the "optimal" or "equilibrium" interest rate in month t ($\hat{r}_t^{FFR}$) according to the systematic Taylor rule.The deviation of the actual target policy rate, r_t^{FR} (proxied by FFFR) from the estimated benchmark rate, $\hat{r}_t^{FFR}$, defines the interest rate-based monetary stance.

Federal fund interest rate monetary stance/deviation, FFDEV= $r_t^{FR} - \hat{r}_t^{FFR}$ (xiii)

A positive (negative) monetary stance $r_t^{FR} > \hat{r}_t^{FFR}$ ($r_t^{FR} < \hat{r}_t^{FFR}$) is indicative of tight or contractionary (expansionary) monetary policy. The simple Taylor (1993) rule in equation (ii) and subsequent modifications have worked remarkably well. Taylor (2008) argues that a policy that steadily responds to economic conditions based on a simple rule such as Taylor rule have a number of benefits. First, it leads to near elimination of uncertainty about the process of setting monetary policy rates now and in future. Second, it depicts how policy makers should react to changing economic conditions. Third, it enables policy makers convey a cogent and data-dependent decisions to the public. Fourth, it helps to align short term actions with long term goals such as long run inflation objective. Lastly, the public can comfortably hold the policy makers accountable to for their decisions and actions. Deviations from the simple variant Taylor rules (equation (ii) without expectation adjustment) have been used by Hubrich, and Tetlow (2011), Khan (2010), Fernandez et al

(2010) Goukasian and Whitney (2006), Sack (2004) and Rigobon and Sack (2002) among others to define monetary stance. It is worth noting the large and persistent deviations with long-term inflation and economic effects, which may exacerbate liquidity or financial imbalance, are relevant in this study. Small and ephemeral deviations in response to contingent economic and financial conditions are appropriate and desirable

The monetary aggregate approach is based on the growth of money base (M2 money). Money base is simply the total currency (coins and bank notes) in circulation in the economy plus the reserves financial institutions maintain with the central bank. Any monetary authority or central bank has control over money base by either changing the reserve requirements of BBIs or open market operation (OMO). The change in money base or monetary aggregateis primarily implemented through the sale and purchase of Treasury bills by the government. A higher or positive (negative) growth rate in money baseis an indicator of liquidity trap (excess liquidity) in the economy and is used during contractionary (expansionary) economic conditions to increase (reduce) liquidity in financial markets and real economy (Li and St-Amant, 2010). I define BMG_t as growth rate in money base in month t, then,

$$BMG_t = \frac{BMG_t - BMG_{t-6}}{BMG_{t-6}} * 100 \qquad \text{(xiv)}$$

BMG_t is defined as the rolling six month growth rate in money base.

I. Why threshold vector autoregressive (TVAR) modeling?

I postulate that financial market liquidity, monetary policy and other macroeconomic variables are mutually reinforcing. Therefore, we have endogenous relationship among the variables. The simultaneity relationship suggests that on one hand, market liquidity is a function of the monetary policy and macro variables. Conversely, central bank monetary , quantitative easing actions and macro variables (economic activity and financial market conditions) may be a function of financial market liquidity. To take care of this explicit simultaneity problem, I utilize threshold vector autoregressive (TVAR).

In econometric modeling, conventional (Symmetric) VAR explicitly allow for endogeneity or simultaneity among time series data to evaluate dynamic interactions. Cook (2006), Meen (2008) and Feng and Wongwachara (2009), apply TVAR and find asymmetric behavior of UK house prices depending on economic upswings and downswings. They conclude that econometric models such as conventional VARwhich surmise linear and symmetry asset price behavior across different economic regimes are not only mis-specified but also yield biased results. This evidence motivates me to use TVAR to incorporate regime switch.

Ehlers (2009) points out that the beauty and novelty of the TVAR model is that it permits easy and endogenous selection of the regime depending on the shocks in the system and other variables. The model provides an easy way to capture potential nonlinearities, conditional dynamics in responses to structural shocks and existence of multiple equilibria. The impulse response functions are non-linear since the effects of the shocks are permitted to vary not only with the sign and the size of the shock, but also with the initial conditions. It thus becomes possible to evaluate the effects of a specific variable under different regimes. Moreover, the variable by which different regimes are defined is potentially an endogenous variable included in the VAR. It thus becomes probable that regime switches may occur after the shock to each variable.

Tong (1978) developed the insightful TVAR (a multivariate version of threshold autoregressive model, TAR) to take care of endogenous conditional behavior of series with two uniquely different dynamics. TVAR works best when all the endogenous variables in the model are subject to similar regime switching behavior. Given two regimes, 1 and 2, the endogenous LIQMBI and LIQBBI under two monetary policy stances can be modeled as follows:

$$y_{1t} = \begin{cases} c_1 + \lambda_1(L)y_t + \varepsilon_{1,t} \text{ if } \mathrm{q_t} \leq \gamma_{BMG} \\ c_2 + \lambda_2(L)y_t + \varepsilon_{2,t} \text{ if } \mathrm{q_t} > \gamma_{BMG}. \end{cases} \text{ and } y_{1t} = \begin{cases} c_1 + \lambda_1(L)y_t + \varepsilon_{1,t} \text{ if } \mathrm{q_t} \leq \gamma_{FFDEV} \\ c_2 + \lambda_2(L)y_t + \varepsilon_{2,t} \text{ if } \mathrm{q_t} > \gamma_{FFDEV} \end{cases} \quad \text{(xva)}$$

$$y_{2t} = \begin{cases} c_1 + \lambda_1(L)y_t + \varepsilon_{1,t} \text{ if } \mathrm{q_t} \leq \gamma_{BMG} \\ c_2 + \lambda_2(L)y_t + \varepsilon_{2,t} \text{ if } \mathrm{q_t} > \gamma_{BMG}. \end{cases} \text{ and } y_{2t} = \begin{cases} c_1 + \lambda_1(L)y_t + \varepsilon_{1,t} \text{ if } \mathrm{q_t} \leq \gamma_{FFDEV} \\ c_2 + \lambda_2(L)y_t + \varepsilon_{2,t} \text{ if } \mathrm{q_t} > \gamma_{FFDEV} \end{cases} \quad \text{(xvb)}$$

In equations (xva) and xvb), L is a lag indicator. y_{1t} and y_{2t} are LIQMBI and LIQBBI respectively. y_t is a vector of contemporaneous variables consisting of base money growth-based monetary stance (BMG) and interest rate rule based monetary policy stance (FFDEV), lagged LIQMBI, national economic activity index (NEAI) and adjusted Financial stress index (AFCI)[19]. LIQBBI is evaluated used two monetary policy stances, BMG and FFDEV. $c_i$is *nx1* vector of intercepts. $\varepsilon_{it} \sim iid[0, \Sigma_i]$ because I allow for heteroskedasticity. $\lambda_i(L) = \lambda_{i1}L + \lambda_{i2}L^2 + \lambda_{i3}L^3 + \ldots\ldots.. + \lambda_{ip}L^p$ is a lag polynomial with *nxn* matrix, λ_{ij}, $\mathrm{j} = 1,2,3\ldots\ldots.\mathrm{p}$. $q_t$is regime indicator while γ is the value of threshold.

[19] Financial stress index (AFCI) combines eleven variables indicating credit and liquidity spreads in U.S financial markets.[19] These measures explain actual and expected behavior of financial assets prices. The real economic activity index (NEAI) provides a broad range of measure of economic activity by combining a series of 85 macroeconomic data. Both indices are more useful than individual indicators, (for example real GDP as economic activity indicator and TED spread for financial market indicator) since they capture market wide conditions. They are available on monthly basis unlike real GDP which is available on quarterly basis. Still, other real economic activity indicators such as nonfarm payrolls are available on monthly basis but they capture only one aspect of the economy (labor market in this case). See Hakkio and Keeton (2009) and Davig and Hakkio (2010) for details.

Equations (xva) and (xvb) can be combined and written in reduced form as follows:

$$
\begin{aligned}
y_{1t} &= c_{11} + \lambda_{11}(L)y_t + \varepsilon_{11,t}\ \mathrm{I_t}(\mathrm{q_t} \leq \gamma_{BMG}) + c_{12} + \lambda_{12}(L)y_t + \varepsilon_{12,t}\ \mathrm{I_t}(\mathrm{q_t} > \gamma_{BMG}) \\
y_{1t} &= c_{21} + \lambda_{21}(L)y_t + \varepsilon_{21,t}\ \mathrm{I_t}(\mathrm{q_t} \leq \gamma_{FFDEV}) + c_{22} + \lambda_{22}(L)y_t + \varepsilon_{22,t}\ \mathrm{I_t}(\mathrm{q_t} > \gamma_{FFDEV}) \\
y_{2t} &= c_{31} + \lambda_{31}(L)y_t + \varepsilon_{31,t}\ \mathrm{I_t}(\mathrm{q_t} \leq \gamma_{BMG}) + c_{32} + \lambda_{32}(L)y_t + \varepsilon_{32,t}\ \mathrm{I_t}(\mathrm{q_t} > \gamma_{BMG}) \\
y_{2t} &= c_{41} + \lambda_{41}(L)y_t + \varepsilon_{41,t}\ \mathrm{I_t}(\mathrm{q_t} \leq \gamma_{FFDEV}) + c_{42} + \lambda_{42}(L)y_t + \varepsilon_{42,t}\ \mathrm{I_t}(\mathrm{q_t} > \gamma_{FFDEV}) \qquad \text{(xvi)}
\end{aligned}
$$

Here, $I_t(\bullet)$ is the indicator function where I_t=*1* if $q_t \leq \gamma_i$ (Below threshold or regime 1) and I_t=0 if $q_t > \gamma$ (above threshold or regime 2). The variance-covariance matrix of the residuals in equation ((xvi) differ under each regime such that

$$
\begin{cases}
\left[\varepsilon_{ij,t}(\varepsilon_{ij,t})'\right] = \Omega_1 & \forall t{:}I_t(q_t \leq \gamma) \\
\left[\varepsilon_{ij,t}(\varepsilon_{ij,t})'\right] = \Omega_2 & \forall t{:}I_t(q_t > \gamma)
\end{cases}
$$

J. Does threshold effect exist?

After specifying the TVAR model and its basic mechanics, the next big question is whether threshold effects exist to justify the use of the model. In our case, the threshold variable is monetary policy stance (BMG or FFDEV). Testing for existence of threshold effects is ideally comparable to testing the null hypothesis of linear VAR against the alternative hypothesis of TVAR (two thresholds VAR) using equation (xvi). Specifically, testing for existence of threshold effects are equivalent to the null hypothesis to test if coefficients are equal under the two regimes.

Ho: $\lambda_{11} = \lambda_{i2}$ *(horizontally: No threshold effects)*

The resulting residual sum of squares (RSS) from equations (xvi) is derived as follows

$$RSS(\hat{\gamma}) = \varepsilon_{ij,t}(\gamma)'\varepsilon_{ij,t}(\gamma) \qquad \text{(xvii)}$$

The variance of RSS= $\sigma^2 = \dfrac{1}{T}\varepsilon_{ij,t}{}'\varepsilon_{ij,t} = \dfrac{1}{T}RSS(\hat{\gamma})$ (xviii)

If we define RSS_0 and RRS_1 as residual sum of squares under null and alternative hypothesis, we can compute the F statistic.

$$F_1 = \frac{RSS_0 - RSS_1(\hat{\gamma})}{\hat{\sigma}^2} \qquad \text{(xix)}$$

K. How do we estimated the threshold values, γ,?

The threshold parameter, γ, is not known a prior and a complete grid search has to be endogenously carried out to identify all possible values of γ. This requires a non-standard inference procedure. Suppose the optimal threshold value is γ* which falls within a range of $\bar{\gamma}$ and $\underline{\gamma}$, then γ* is chosen to minimize residual sum of squares (RSS). The minimization process simultaneously captures both the threshold parameter, γ*, and lag order, *p,* such that

$$(\gamma^*, \hat{p}) = \arg\min_{\gamma \in Y, p \in P} \mathrm{RSS}(\underline{\gamma}.........\bar{\gamma}, p) \qquad \text{(xx)}$$

The lag order, *p,* is determined using the Swartz Bayesian Information criterion (SIC)[20]. We now develop the hypothesis to test for existence of threshold value; γ. Since γ* is unknown a prior, the conventional t-tests have non-normal distribution. Hansen (1996, 2000) developed a bootstrap procedure to simulate possible asymptotic distribution using likelihood ratio (LR). Define $RSS_0(\gamma_0)$ and $RSS_1(\gamma_1)$ as the residual sum of squares sans (true RSS) and with threshold effects

Ho: $\gamma_0 = \gamma_1$

[20] I use SIC as opposed to the popular Akaike Information Criterion (AIC) since according to Canova (2007) AIC is not only inconsistent in lag selection but it also known to overestimates the true lag order with positive probability. SIC on the other hand affords a larger penalty to the number of Parameters to be estimated in the model and hence yield more consistent and parsimonious.

$$LR_1(\gamma) = \frac{RSS_0(\gamma_0) - RSS_1(\gamma_1)}{\hat{\sigma}^2} \tag{xxi}$$

The $LR_1(\gamma)$ statistic is compared with non-normally distributed critical values derived by Hansen (2000). It is possible to form asymptotic confidence interval of γ* from the asymptotic distribution of $LR_1(\gamma)$. Specifically, the critical values, c, at a given significance level,

c(α)=-2ln(1-√1-α). Therefore, if $LR\ (\gamma) \leq c(\alpha)$, we fail to reject the null of Ho: $\gamma_0 = \gamma_1$. Note that $1\text{-}\alpha$ is the confidence level indicating non-rejection region.

L. *Impulse Response Functions*

Koop, Pesaran and Potter (1996) formulate the non-linear Impulse Response Function (NLIRF) of TVAR. The sign and magnitude of the shock depends on the initial conditions and vary with time. The shocks will generate varying Impulse responses (non-linear). There are no restrictive symmetry conditions. Given k horizons or forward periods from period *t* (*t+k* horizons ahead) and information set, Ω_{t-1} available at period *t-1,* (proxied by y_{t-1}), the set-up of the model is as follows:

$$NLIRF_y(k, \varepsilon_t, \Omega_{t-1}) = E(Y_{t+k} \mid \varepsilon_t, \Omega_{t-1}) - E(Y_{t+k} \mid \Omega_{t-1}) \tag{xxii}$$

The sign of the shock may also influence regime change if the shock exceeds the threshold value. For example: If we are currently using expansionary monetary policy, a large positive shock may trigger a shift in initial regime to contractionary monetary policy should such a shock exceed the threshold. This is not impossible given the aggressive interest rate cuts pursued by the Fed within a short period of time. If a shock causes a reallocation of regimes, then it has a moving average representation of structural disturbanceand Wold decomposition of such a disturbance is non-extant.

IV.Empirical Results and Discussion

M. Forward-Looking Taylor Rule estimation

The results of GMM estimation of the "optimal" or benchmark short-term interest rate are presented in table 1. The identity matrix estimation weights is based on two stage least squares method (2SLS) with GMM standard errors. The data was pre-whitened. As expected, all the coefficients are positive. Panel A estimate is based on the optimal inflation rate fixed at 2% according to a variant simple Taylor rule. The difference between computed inflation rate (% change in CPI) and 2% constitute the inflation gap in this case. In panel B I do a robustness check by estimating the optimal inflation rate through smoothing of interest rate using Hodrick-Prescott filter. This estimates the long-term inflation rate after eliminating spikes in interest rate. The difference between computed inflation rate (% change in CPI) and smoothed inflation constitute the deviation of Fed fund rate from optimal short-term rate (FFDEV). From panel A, the smoothing parameter, ρ, is very high at 0.986 implying that the target short-term interest rate depend on the past short-term rate. The annual real interest rate is estimated at 2.76% (0.23*12) and is usually fixed at between 2% and 2.5% annually. Coefficients for inflation and output gaps are 0.649 (fixed at 0.50 in simple Taylor rule) and 0.844 (fixed at 0.5 or 1.0) respectively. Similar derivations of these coefficients byJovanovic and Zimmermann, (2010) yielded ρ=0.973, $\beta 1$=3.713, $\beta 3$=0.457 and average real interest rate, rr* of 2.46%. The difference in their results and mine could be due to different sample periods, minor difference in model specification and the measure of output gap (they use industrial production while I use coincidence of economic indicator index). The J-statistic in panel A and B is insignificant hence the model is correctly identified and the instruments are valid. I fail to reject the null hypothesis that instruments are orthogonal to overall error term. The R-square (0.99) is very high. This is consistent with specification of equation (xii) where the regressors and instruments should fully explain the the Federal Fund rate (unexplained residuals equal zero). The results in panel A and B confirm the forward-looking Taylor rule.

Table 1: GMM Estimation

The table shows estimation results for GMM. The estimation is based on equation. Panel A results are based on fixed optimal annual inflation rate of 2%. Panel B is based on smoothed inflation rate using Hodrick-Prescott. Both estimations are based on equation (ix). *, ** and *** implies 1%, 5% and 10% significance level.

Convergence achieved after 3 iterations

Parameter	**Panel A**	**Panel B**
	Coefficients	Coefficients
ρ	0.986*	0.985*
B1	0.649***	0.786***
B2	0.844***	0.330***
rN	0.234*	0.0539*
Determinant residual covariance	0.0548	0.0532
J-statistic	285*0.111635	285*0.106289
R-squared	0.990111	0.990211
Adjusted R-squared	0.989996	0.990097
S.E. of regression	0.235964	0.232486
Durbin-Watson stat	1.334161	1.365839

N. Descriptive statistics and Correlation analysis

As postulated in hypothesis 1, table 2 shows that the equity of BBIs (EQBBI) exhibit higher fluctuation (standard deviation) relative to equity of MBI (EQMBI) because the BBI assets and liabilities are not marked to market. However, the equity of Finance companies (EQFC) exhibit the highest volatility certainly because of their heavy short-term financing (use of commercial paper) and long term lending (Assets) hence only one side of the balance respond to changes in market interest rate. The undervaluation of BBIs assets and liabilities during economic boom and overvaluation of the same during economic recession partly explains why volatility of LIQBBI is high (38.443) relative to volatility of LIQMBI (paltry 0.508). Careful consideration is required in interpreting the liquidity results. Liquidity is proxied by financial leverage (total financial assets/equity). A higher liquidity indicates declining equity (Increasing leverage or expansion of balance sheet). A negative liquidity such as LIQSI implies that financial assets are less than liabilities (negative equity). Liquidity is thus given reverse interpretation. Irrespective of high volatility of equity and LIQBBI, LIQCB and LIQCU have lower financial risk because of higher equity levels and better capitalization as required by the Fed. LIQBBI is 0.993 compared to LIQMBI's 1.069, an indicator of higher balance sheet expansion of MBIs relative to BBIs'. In panel C, financial market conditions, as shown by adjusted financial condition index (AFCI), fluctuate less than economic activity as shown by National Economic condition index (NEAI). This could be due to the fact that policy makers first intervene in financial markets to smooth fluctuations and expect the interventionary policy to permeate to real economy. Financial markets are thus the first 'contact points'of positive interventionary policy while real economy is the secondary 'contact point' which slowly imbibes the positive effects of interventionary policies. All variables exhibit excess Kurtosis (Greater or less than 3), positive or negative skew distribution and non-normal distribution as evidenced by statistically significant Jarque-Bera which rejects the null hypothesis of normal distribution of the time series data.

Table 3 provides correlation analysis of different variables. The results in table two (panel A) reveal that as financial conditions deteriorate (AFCI increases), equity of bank-based institutions (EQBBI) increases (Positive correlation of 0.264).

Table 2: Descriptive Statistics

In table, panel is summary statistic of bank-based institutions (BBIs). Panel B details summary statistics of market-based institutions (MBIs) while panel C provide descriptive statistics of economic variables used in this study. EQBBI, EQCB, EQCU and EQSI is the equity of bank-based institutions, commercial banks, credit unions and saving institutions respectively. LIQBBI, LIQCB, LIQCU and LIQSI is the liquidity of the same institutions. EQMBI, EQABS, EQFC, EQGSE and EQSBD is the equity of Market-Based Institutions, Asset-Backed Securities firms, Finance Companies, Government Sponsored Enterprises and Securities Brokers and Dealers. LIQMBI, LIQABS, LIQFC, LIQGSE and LIQSBD is liquidity of the same institutions. These variables have been deflated by their own mean. AFCI is the adjusted Financial condition Index (Indicator), NEAI is the national Economic Condition Index, FFFR is the Federal Fund Futures interest Rate, BMG is base money growth (Monetary aggregate). FFDEV is the Federal Fund rate deviation from the optimal short-term interest rate as derived from forward looking Taylor rule. *, ** and *** indicate significant at 1%, 5% and 10% respectively.CV is coefficient of variation. Data is monthly from 01/1988-10/2011. Jarque-Bera (JB) tests the null of normal distribution.

	Descriptive statistics for bank-based institutions (BBI)							
Panel A	Mean	Range	Std. Dev.	CV	Skew	Kurtosis	JB	Obs
EQBBI	0.998	3.885	0.977	0.979	0.478	2.065	*21	285
EQCB	0.998	8.466	1.776	1.78	0.804	3.014	*31	285
EQCU	0.997	1.663	0.529	0.531	0.066	1.571	*24	285
EQSI	0.998	2.077	0.531	0.532	-0.179	2.061	*12	285
LIQBBI	0.993	791.97	38.443	38.705	5.351	106.039	*127436	285
LIQCB	0.965	486.17	27.442	28.44	-4.537	81.472	*74101	285
LIQCU	1	0.772	0.212	0.212	1.222	3.174	*71	285
LIQSI	-1.005	481.08	26.286	-26.15	-14.233	225.282	*596355	285
Panel B	Descriptive statistics for Market-based institutions (MBI)							
EQMBI	1.027	2.972	0.681	0.663	1.045	3.208	*48	285
EQABS	1.096	3.395	0.749	0.683	0.968	3.04	*41	285
EQFC	0.606	19.884	4.41	7.276	0.517	2.843	**12	285
EQGSE	1.077	4.096	0.784	0.728	0.951	3.099	*39	285
EQSBD	1.046	1.9	0.53	0.507	0.41	1.705	*26	285
LIQMBI	1.069	3.394	0.508	0.475	1.647	9.079	*520	285
LIQABS	1	12.006	1.165	1.165	-1.877	22.225	*4173	285
LIQFC	1.099	115.887	10.326	9.394	8.666	79.336	*66637	285
LIQGSE	0.999	17.922	1.481	1.483	1.21	25.26	*5453	285
LIQSBD	1.069	2.068	0.375	0.351	0.793	4.359	*47	285
Panel C	Descriptive statistics for Economic fundamentals							
AFCI	-0.115	5.564	0.718	-6.239	1.563	7.933	*391	285

NEAI	-0.159	6.007	0.84	-5.282	-1.769	8.185	*452	285
BMG	0.756	34.401	2.426	3.207	6.289	60.312	*39449	285
FFFR	4.251	9.748	2.441	0.574	0.021	2.358	***5	285
FFDEV	-0.008	3.594	0.725	-92.492	0.442	2.651	**10	285

This can be attributed to regulatory pressure to increase the buffer capital or a cautionary approach due to financing uncertainty associated with financial stress in the economy. The low correlation between BMG and LIQBBI, LIQCB, LIQCU and LIQSI could be attributed to a number of reasons. One, the increase in monetary aggregate or money base may be considered as a substitute of changes in reserve requirements (Mankiw, 2011). Therefore, BMG may have insignificant effect on LIQBBI. Two, these institutions maintain their assets and liabilities at book values, hence the balance sheet variables don't respond to changes in monetary policy. Three, the institutions are regulated by the Fed through other mechanisms such as reserve requirements. Four, the change in liquidity is a lagging indicator of monetary policy. The use of monthly frequency means that we may not immediately capture the effects of monetary policy on liquidity of banking institutions. These explanations could also justify the relatively low correlation between Adjusted financial condition index, AFCI (or national Economic Activity Index, NEAI) and LIQBBI, LIQCB, LIQCU and LIQSI. The negative correlation between FFFR and EQBBI, LIQBBI, LIQCB, and LIQSI implies that conventionally, as short term interest rate increases, leverage or liquidity declines as these institutions cannot secure financing or the cost of borrowing is very high.

The negative correlation (-0.272) between AFCI and NEAI implies that as financial conditions deteriorate (AFCI increases), economic activity declines. The positive (negative) correlation of 0.371 (-0.38) between AFCI (NEAI) and BMG confirms the idea that as financial conditions (Economic activities) deteriorates, the Fed will increase the money base.

Panel B indicates that as postulated in hypothesis one, the total assets of MBIs (BBIs), TAMBI (TABBI) exhibit ten times higher (lower) correlation (0.38 vs 0.038) with LIQMBI (LIQBBI).Moreover, LIQMBIs, LIQABS, LIQGSE and LIQSBD are more synchronized with AFCI and NEAI due to relatively high correlations. Specifically, as NEAI declines, leverage/liquidity increases. TAMBI is also highly correlated with LIQABS and LIQSBD.

Table 3: Correlation Analysis

Panel A provides correlation among economic variables, economic variables and liquidity of BBIs and economic variables and equity of BBIs (EQBBI). Panel B provides correlation between economic variables and liquidity of MBIs on one hand and correlation between economic variables and equity of MBIs (EQMBI). All variables are defined in table 1.

Panel A — Correlations for BBI variables and Economic fundamentals

	EQBBI	LIQBBI	LIQCB	LIQCU	LIQSI	AFCI	NEAI	FFDEV	FFFR
EQBBI	1.000								
LIQBBI	0.048	1.000							
LIQCB	0.191	0.001	1.000						
LIQCU	-0.569	-0.250	-0.252	1.000					
LIQSI	0.074	0.014	0.018	-0.110	1.000				
AFCI	0.264	0.002	0.148	-0.149	0.087	1.000			
NEAI	-0.351	0.043	-0.070	-0.034	0.038	-0.272	1.000		
FFDEV	-0.017	0.044	0.037	-0.099	-0.112	-0.085	0.204	1.000	
FFFR	-0.596	-0.151	-0.065	0.439	-0.117	0.031	0.263	0.642	1.000
BMG	0.150	0.008	-0.012	-0.006	-0.011	0.371	-0.388	-0.270	-0.184
TABBI	0.934	0.038	0.194	-0.467	0.058	0.152	-0.334	-0.003	-0.683

Panel B — Correlations for MBI variables and Economic fundamentals

	EQMBI	LIQMBI	LIQABS	LIQFC	LIQGSE	LIQSBD	TAMBI
EQMBI	1.000						
LIQMBI	-0.241	1.000					
LIQABS	0.614	0.248	1.000				
LIQFC	0.100	-0.023	0.025	1.000			
LIQGSE	0.047	0.507	0.241	-0.037	1.000		
LIQSBD	0.214	0.623	0.481	0.044	0.047	1.000	
AFCI	-0.035	0.524	0.273	-0.067	0.304	0.345	0.168
NEAI	-0.067	-0.345	-0.381	0.056	-0.460	-0.204	-0.286
FFDEV	0.110	-0.108	-0.016	-0.024	-0.312	0.065	0.009
FFFR	-0.424	-0.228	-0.491	-0.060	-0.475	-0.246	-0.125
BMG	-0.099	0.426	0.167	-0.014	0.647	0.066	0.191
TAMBI	0.798	0.381	0.776	0.087	0.139	0.670	1.000

This is because through "repos" and "reverse repos", the value of assets (reverse repos) decline at a faster rate than value of liabilities (repos). This is consistent with the arguments by Adrian and Shin (2008) that the expansion and contraction of balance sheet of market-based institutions can help explain economic swings and assist in predicting potential financial crisis. The negative relation with FFDEV also implies that pursuing contractionary monetary policy results in reduction in liquidity. As BMG increases, LIQMBI increases (correlation 0.426) but this can be largely explained by the high positive correlation between LIQGSE and BMG. Excess liquidity in the market allows firms to take more risk and expand their balance sheets.

Overall, I fail to reject hypothesis 1 because the volatility of equity and liquidity of BBIs (LIQBBI) is higher than that of MBIs. Again, as postulated in hypothesis 1 LIQBBI is less synchronized with financial conditions (AFCI) and real economic activities (NEAI). Moreover, liquidity of MBIs (LIQMBI) at aggregate and individual levels is positively related to total assets, financial conditions and economic conditions.

O. Does threshold exists?

In order to establish whether threshold exists, I first establish if the data is stationary since this is a pre-requisite for threshold vector Autoregressive (TVAR) model. I use both the augmented Dickey-Fuller (ADF) and Kwiatkowski-Phillips-Schmidt-Shin (KPSS) tests. ADF tests the null of unit root in time series data while KPSS tests the null of stationary time series data. Both tests include intercept only and intercept and trend carried out at levels and first difference (using intercept only). All series are covariance stationary in levels except LIQMBI (under ADF intercept and trend KPSS both intercept and intercept and trend) which becomes stationary after at first difference. The results are presented in table 4. Using ADF t-test statistic, we reject the null of unit root behavior and for KPSS, we use the LM statistic and fail to reject null of stationarity in the data.

Table 4: Unit root test

In this table, ADF is Augmented Dickey Fuller (ADF) test. KPSS is the Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test statistic. Both tests include intercept only. The unit root lags are selected using Swartz Information Criterion (SIC). The critical values for ADF and KPSS are shown at the bottom of the results. ADF tests the null of Unit root (non-stationary) while KPSS tests the null of Stationary time series data

	Unit root testing					
	ADF			**KPSS**		
	Level (Intercept)	Level (Intercept and trend)	1st Diff (Intercept)	Level (Intercept)	Level (Intercept and trend)	1st Diff (Intercept)
Variable	t-Statistic	t-Statistic	t-Statistic	LM-Statistic	LM-Statistic	LM-statistic
LIQBBI	-9.576	-9.773	-18.840	0.337	0.247	0.103
LIQCB	-5.991	-11.029	-15.784	0.595	0.146	0.075
LIQCU	-3.210	-0.798	-4.427	1.206	0.468	0.837
LIQSI	-15.384	-15.457	-13.394	0.187	0.053	0.118
LIQMBI	-2.635	-2.695	-9.010	0.777	0.234	0.060
AFCI	-3.724	-3.779	-15.658	0.129	0.083	0.154
NEAI	-3.164	-3.235	-18.712	0.317	0.102	0.071
FFDEV	-4.760	-4.770	-7.104	0.031	0.031	0.042
BMG	-6.103	-10.665	-16.649	0.324	0.107	0.066
Critical Values						
1% level	-3.454	-3.991	-3.454	0.739	0.216	0.739
5% level	-2.872	-3.426	-2.872	0.463	0.146	0.463
10% level	-2.572	-3.136	-2.572	0.347	0.119	0.347

In table 5, I employ the Hansen (2000) threshold test. In multivariate framework, the test has two null hypotheses for existence of threshold.

Ho1: There is one regime (linearity and Ha1: There are two regimes (one threshold).

Ho2: There is one regime (linearity) and Ha2: There are three regimes (Two thresholds). The critical values are generated through bootstrap distribution of the threshold variable. To eliminate extreme observations, I employ a 10% trim of the observations and then employ grid search for the threshold on the remaining 80% of the observations. The threshold is searched when the data is in levels (Threshold Autoregression, TAR). For robustness check, grid search is performed when the data is in first difference (Momentum autoregression, MTAR).

The results are provided in table 5. Panel A tests for statistical threshold whereby the threshold variables (FFDEV and BMG) are tested for existence of threshold using their own lags. Using TAR and MTAR modeling, I reject the null of one regime (linearity). Therefore, there exists one threshold (2 regimes). MTAR further renders support to existence of two thresholds (three regimes).

This supports the arguments of Taylor (2008) that there is an "optimal" short-term rate below (above) which there is a financial imbalance. Therefore, when the Fed rate is below the "optimal" short term interest rate, we have a negative FFDEV and the Fed is pursuing an expansionary monetary policy. Persistently low Fed rate leads to availability of "cheap" money, excess liquidity in the market, increasing asset prices (bubbles) and eventual burst. A positive FFDEV means the Fed rate is above the optimal short-term rate and the Fed is pursuing a contractionary monetary policy. The money base growth (Monetary Aggregate) also has three regimes. Therefore, there exists a growth rate in supply of M2 money above (below) which there is excess liquidity in both BBIs and MBIs.

Panel B tests for existence of threshold given LIQBBI and LIQMBI. Using FFDEV as the threshold variable, we find that there exists two and three regimes below (above) which the FFDEV will affect LIQBBI and LIQMBI differently. We find the same evidence when we use monetary aggregate (BMG) as the monetary stance instrument for LIQMBI. For BMG and LIQBBI, we fail to reject linearity against two regimes under TAR (p-values 0.148 and

0.332 for 2 and 3 regimes respectively). The existence of 3 regimes under MTAR is particularly interesting since it indicates that under both FFDEV and BMG, LIQMBI exhibit more momentum in either positive FFDEV (contractionary policy) or negative FFDEV (expansionary policy) and BMG (Strong rejection of linearity under TAR and MTAR compared to LIQBBI). In this case, the structure of financial intermediaries (MBIs and BBIs) does significantly matter.

To test whether there is a link between monetary policy stance, LIQMBI and LIQBBI, we test for existence of threshold under different financial conditions (proxied by AFCI) and economic activities (proxied by NEAI). Under both TAR and MTAR, we find existence of two and three regimes implying thatAFCI and NEAI will behave differently and independently as either FFDEV or BMG shift from one regime to another. For example: if FFDEV is negative (contractionary policy), liquidity will dry-up and both financial and economic activities will flag. There are three main implications of these results: One LIQBBI and LIQMBI shift back and forth depending on the value of threshold variable (FFDEV

Table 5: Testing for existence of threshold (linear vs Threshold model)

This table provides summary results of tests of one regime (Linear) versus threshold (2 regimes and three regimes). All variables are defined in table 1. L(*i*) indicates lag order determined through SIC. TAR is threshold autoregression (Threshold tests at levels and MTAR is momentum threshold autoregression (Threshold tests at first difference). The P-values (Shown) and critical values (Not shown) are established through 500 bootstrap replications. The TAR and MTAR columns indicate the computed values. The null hypotheses are 1. There is one regime (linear) as opposed to 2 regimes (one threshold) and 2. There is one regime (linear) as opposed to 3 regimes (two thresholds).

Panel A	**Statistical Threshold**				
Threshold variable	(L4) FFDEV	TAR	p-Value	MTAR	P-Value
	Ho: Linear (1 regime) vs 2 regimes	64.220	0.035	70.963	0.020
	Ho: Linear (1 regime) vs 3 regimes	98.955	0.115	123.905	0.012
Threshold variable	(L7) BMG				
	Ho: Linear (1 regime) vs 2 regimes	328.191	0.000	47.966	0.000
	Ho: Linear (1 regime) vs 3 regimes	366.875	0.000	946.868	0.000

Panel B	**Fundamental Threshold; Liquidity of BBIs, MBIs and Monetary stances**				
Threshold variable,	(L4)FFDEV and LIQBBI				
	Ho: Linear (1 regime) vs 2 regimes	252.467	0.008	231.207	0.008
	Ho: Linear (1 regime) vs 3 regimes	317.778	0.004	276.200	0.012
Threshold variable	(L4)FFDEV and LIQMBI				
	Ho: Linear (1 regime) vs 2 regimes	167.888	0.000	169.549	0.000
	Ho: Linear (1 regime) vs 3 regimes	205.496	0.000	259.277	0.000
Threshold variable	(L2) BMG and LIQBBI				
	Ho: Linear (1 regime) vs 2 regimes	39.223	0.148	53.627	0.096
	Ho: Linear (1 regime) vs 3 regimes	54.585	0.332	86.702	0.108
Threshold variable	(L4)BMG and LIQMBI				
	Ho: Linear (1 regime) vs 2 regimes	188.257	0.000	207.251	0.000
	Ho: Linear (1 regime) vs 3 regimes	239.252	0.000	341.284	0.000
Panel C	**Fundamental Threshold; Macro conditions and Monetary stances**				
Threshold variable	(L2)FFDEV and NEAI				
	Ho: Linear (1 regime) vs 2 regimes	63.668	0.000	32.443	0.048
	Ho: Linear (1 regime) vs 3 regimes	82.339	0.000	68.450	0.000
Threshold variable	(L1)FFDEV and AFCI				
	Ho: Linear (1 regime) vs 2 regimes	55.278	0.000	87.508	0.000
	Ho: Linear (1 regime) vs 3 regimes	78.694	0.000	129.807	0.000
Threshold variable	(L2) BMG and NEAI				
	Ho: Linear (1 regime) vs 2 regimes	50.317	0.000	59.732	0.000
	Ho: Linear (1 regime) vs 3 regimes	60.699	0.028	159.425	0.000
Threshold variable	(L2) BMG and AFCI				
	Ho: Linear (1 regime) vs 2 regimes	81.839	0.000	139.783	0.000
	Ho: Linear (1 regime) vs 3 regimes	124.060	0.000	235.283	0.000
Panel D	**Financial and Economic conditions and liquidity**				
Threshold variable	(L4) AFCI and LIQBBI				
	Ho: Linear (1 regime) vs 2 regimes	125.570	0.016	429.840	0.000
	Ho: Linear (1 regime) vs 3 regimes	197.790	0.010	285.780	0.000
Threshold variable	(L4) AFCI and LIQMBI				
	Ho: Linear (1 regime) vs 2 regimes	121.511	0.000	111.424	0.000
	Ho: Linear (1 regime) vs 3 regimes	181.774	0.000	183.352	0.000
Threshold variable	(L4) NEAI and LIQBBI				
	Ho: Linear (1 regime) vs 2 regimes	153.082	0.020	51.579	0.197
	Ho: Linear (1 regime) vs 3 regimes	184.791	0.037	247.870	0.017
Threshold variable	(L4) NEAI and LIQMBI				
	Ho: Linear (1 regime) vs 2 regimes	73.429	0.000	64.318	0.000
	Ho: Linear (1 regime) vs 3 regimes	106.404	0.003	105.030	0.000

or BMG). Two, the existence of thresholds affords flexibility and ability to capture changes in LIQBBI and LIQMBI regimes that occur regularly over time as FFDEV and BMG change. Three, MBIs and BBIs frequently readjust their liquidity expectations shortly after fresh information regarding monetary policy becomes available to them. The news will also shift financial conditions and economic activities into a new regime.

Panel D investigates if LIQBBI and LIQMBI respond to shift in regimes of financial conditions (AFCI) and economic activities (NEAI). I find existence of two and three financial conditions and economic activities regimes, a shift to which BBIs and MBIs will also respond and adjust their liquidity (balance sheet expansion or contraction) accordingly.

P. Is there a threshold monetary stance for each bank-based institution?

To assess validity of the fourth hypothesis, I test whether the liquidity of each of the financial institution that constitute BBIs (commercial banks, credit unions and saving institutions with liquidity denoted as LIQCB, LIQCU and LIQSI respectively) switch regimes in response to changes in monetary policy. The rational for this assessment is that BBIs are primarily used as conduits of monetary policy transmission by the Fed. Panel A of table 6 shows that not only does one threshold (2 regimes) exists but also that increased uncertainty in monetary policy forces BBIs to switch regimes even three times (2 threshold) under TAR. The existence of two or three regimes under MTAR provides further evidence that there is momentum or overreaction in a given regime relative to the other. For example: There is little or no monetary policy intervention during expansionary period but aggressive actions are taken by policy makers and the BBIs themselves under contractionary monetary policy. This is a partial justification for existence of multiple regimes using MTAR modeling if threshold is extant. Panel A assesses existence of threshold using interest rate monetary stance (FFDEV) while panel B provides summary results of the same under monetary aggregate monetary stance (BMG).

Q. Estimation of threshold values

Now that we know thresholds monetary stance exists using the results of table 6, what is the value of these thresholds? This is what table 7 provides.

Table 6: Testing for existence of monetary stance threshold for each BBI

This table provides summary results of tests of one regime (Linear) versus threshold (2 regimes and three regimes). All variables are defined in table 1. L(*i*) indicates lag order determined through SIC. TAR is threshold autoregression (Threshold tests at levels and MTAR is momentum threshold autoregression (Threshold tests at first difference). The P-values (Shown) and critical values (Not shown) are established through 500 bootstrap replications. The TAR and MTAR columns indicate the computed values. The null hypotheses are 1. There is one regime (linear) as opposed to 2 regimes (one threshold) and 2. There is one regime (linear) as opposed to 3 regimes (two thresholds). Panel A tests existence of threshold using FFDEV as threshold variable while panel B uses BMG as threshold variable.

Panel A	**Bank based Institutions liquidity and FFDEV**				
Threshold variable	(L2)FFDEV and LIQCB	TAR	p-value	MTAR	P-value
	Ho: Linear (1 regime) vs 2 regimes	150.902	0.008	88.250	0.040
	Ho: Linear (1 regime) vs 3 regimes	175.952	0.044	142.615	0.052
Threshold variable	(L4)FFDEV and LIQCU				
	Ho: Linear (1 regime) vs 2 regimes	94.785	0.104	110.552	0.024
	Ho: Linear (1 regime) vs 3 regimes	173.188	0.152	233.222	0.008
Threshold variable	(L4)FFDEV and LIQSI				
	Ho: Linear (1 regime) vs 2 regimes	699.627	0.000	690.972	0.000
	Ho: Linear (1 regime) vs 3 regimes	711.650	0.000	757.992	0.000
Panel B	**Bank based Institutions liquidity and monetary Aggregate (BMG)**				
Threshold variable	(L7)BMG and LIQMB	TAR	p-Value	MTAR	P-Value
	Ho: Linear (1 regime) vs 2 regimes	100.392	0.016	101.780	0.016
	Ho: Linear (1 regime) vs 3 regimes	110.728	0.044	157.823	0.028
Threshold variable	(L3)BMG and LIQCU				
	Ho: Linear (1 regime) vs 2 regimes	244.354	0.000	285.524	0.000
	Ho: Linear (1 regime) vs 3 regimes	423.276	0.000	530.168	0.000
Threshold variable	(L3)BMG and LIQSI				
	Ho: Linear (1 regime) vs 2 regimes	121.873	0.012	334.255	0.004
	Ho: Linear (1 regime) vs 3 regimes	200.624	0.020	350.667	0.004

This identification of threshold values is important because it indicates the point at which policy makers need to intervene in the market and financial intermediaries need to adjust their liquidity or balance sheets. The table shows FFDEV, BMG, AFCI and NAEI threshold values for two and three regimes. The forgoing discussion is premised on threshold values under two regimes since two regimes have a more pragmatic economic interpretation. In panel A, we can deduce that if a deviation from benchmark or optimal short-term interest rate of 1.0273% will persuade BBIs to change their leverage or liquidity (LIQBBI). Since this deviation is positive, it captures contractionary monetary policy. This is consistent with investor's behavior where liquidity disappears rapidly during economic recession or when the Fed is pursuing contractionary monetary policy.

Panel A also indicates that LIQBBI shifts to a new regime whenever adjusted financial condition index (AFCI) hits 0.1289 (financial stress condition starts to pick up). However, MBIs need to change their LIQMBI at a higher financial stress condition (0.6697). A positive AFCI indicates that financial markets are more uncertain and there is economic downturn. These results are consistent with monetary threshold values of FFDEV and BMG. LIQBBI (LIQMBI) will shift to a new regime when national economic activity index (NAEI) breaches the barrier of 0.6380 (-0.8691). In short, MBIs adjust their liquidity only when economic activities contract or declines (enter negative zone)unlike BBIs.

MBIs will shift their liquidity (LIQMBI) to a new regime when interested rate deviation is 1.3292%. The BMG threshold values are 1.1419% and 0.0446% for LIQBBI and LIQMBI to switch regimes. Again, this represent a positive growth in money base which, consistent with FFDEV, represent a contractionary economic condition during which the Fed tries to increase liquidity into the economy or financial markets when faced with liquidity trap.The fact the FFDEV and BMG threshold values (1.3292% and 1.1419% respectively) for LIQMBI are higher than those of LIQBBI (1.0273 and 0.0446 respectively) has important implications. One possible explanation is that a prolonged monetary policy stance has higher implications for the liquidity of MBIs. This is because their assets and liabilities largely constitute marketable securities which have to be liquidated. They also take long and short positions in the market contingent on prevailing liquidity in the market and market interest. The second possible explanation is reaction time. Banks are more conservative hence react faster to changes in monetary policy changes. This could be due to regulations by the Fed or the need to avoid runs if a bank is highly leveraged and fails to meet its liquidity obligations.

It is noteworthy that MBIs are not regulated by Fed and have no obligation to take less risk even under contractionary monetary policy. The third possible rational is that MBIs are unable to rewind their 'repos' and 'reverse repos' positions quickly hence their threshold is higher (longer reaction time). The fourth and last possible explanation is risk-taking behavior. Some MBIs such as FCs are characterized by high leverage and negative equity capital. By this very nature, MBIs continue with business as usual even as monetary policy stance signals the need to change liquidity regime.

In panel A (bank-based institutions), all BBIs have different FFDEV threshold values. However, the BMG threshold values (1.1005, 1.2015 and 1.0922 for LIQCB, LIQCU and LIQSI respectively) all seem to coalesce around 1.1% money base growth rate below or above which there are different liquidity regimes. Therefore, as conduits of transmitting monetary policy, these institutions have synchronized reaction to changes in monetary aggregate (BMG). The negative FFDEV for LIQCB implies that commercial banks change their leverage during economic boom which is punctuated by expansionary monetary policy. This is consistent with the threshold value of NEAI of LIQBBI (0.6380) which indicates increased economic activities which is spurred by expansionary monetary policy. The credit unions, which are member owned and are ideally non-profit making, shift their leverage or liquidity during contractionary monetary policy (FFDEV=1.0273%). This is the same for saving institutions which mostly engage in mortgage financing. The results in panel A (two regimes) provides evidence that BBIs have different FFDEV thresholds values above or below which they will change their liquidity.

Panel B provides threshold values of FFDEV, BMG, AFCI and NEAI for three regimes. The results imply that the more the regimes, the higher the uncertainty and time variation of monetary policy tools, financial conditions (AFCI) and degree of economic activities (NEAI).

Table 7: Estimation of Threshold values

Table 7 shows the threshold values of FFDEV, BMG, AFCI and NEAI. A single threshold implies existence of two regimes. Two thresholds mean that three regimes exists. L is the number of lags.. Panel A shows the single threshold value (TH1) of FFDEV, BMG, AFCI and NEAI that separates two regimes. Panel B showstwo threshold values (TH1 and TH2) of FFDEV, BMG, AFCI and NEAI which separate three regimes.

Panel A	Threshold variable			
	FFDEV	BMG	AFCI	NEAI
1 Threshold (2 regimes)	TH1	TH1	TH1	TH1
FFDEV	0.9877			
BMG		1.1915		
LIQBBI	1.0273	0.0446	0.1289	0.6380
LIQMBI	1.3292	1.1419	0.6697	-0.8691
Bank-based institutions				
LIQCB	-0.7022	1.1005		
LIQCU	1.0273	1.2015		
LIQSI	0.8395	1.0922		

Panel B	Thresholds variable							
2 thresholds (3 Regimes)	FFDEV	FFDEV	BMG	BMG	AFCI	AFCI	NEAI	NEAI
	TH1	TH2	TH1	TH2	TH1	TH2	TH1	TH2
FFDEV	0.2273	1.0195						

BMG			-0.2291	1.2015				
LIQBBI	0.4436	1.0273	0.0819	0.2241	0.1118	0.3982	0.2136	0.6380
LIQMBI	-0.5689	1.0273	0.0756	1.1548	-0.1933	0.6697	-0.7141	0.1589
Bank-based institutions								
LIQCB	-0.7022	-0.0499	0.4253	1.1005				
LIQCU	1.0273	-0.0133	0.0756	1.2015				
LIQSI	0.5611	0.9726	0.6403	1.0596				

R. Regime Specific Impulse Response of liquidity to monetary stance

Figure 1 and 2 shows the impulse response of LIQBBI to one standard deviation shock of LIQBBI and FFDEV in regimes 1 and 2. As expected, contractionary monetary policy (regime 1) has immediate impact on LIQBBI. The graph shows leverage or liquidity suddenly decline after just one month. However, the buildup of leverage in regime two is slow and seems to dissipate after 10 periods (Months). Therefore, there is differential reaction in the two regimes which further warrants the need for threshold modeling. Figure two is consistent with findings in table 7 where BMG threshold values vacillates around 1.1%. BBI don't seem to respond differently to BMG shocks since they are conduits of monetary transmissions. However, one standard deviation shock to LIQBBI has huge and immediate impact on the LIQBBI.

Figure 3 and figure 4 show that MBIs react to FFDEV and BMG differently in both regimes. Perhaps, because of their risk-taking nature, LIQMBIs react more to negative FFDEV (which indicates expansionary monetary policy) than to contractionary monetary policy. This is certainly because they have locked-in repos and reverse repos agreements which they are unable to unwind quickly in regime 1. Unlike BBIs,, one standard deviation shock of LIQMBI has a positive impact on LIQMBI.

Figure 1: LIQBBI and FFDEV regime-specific shock

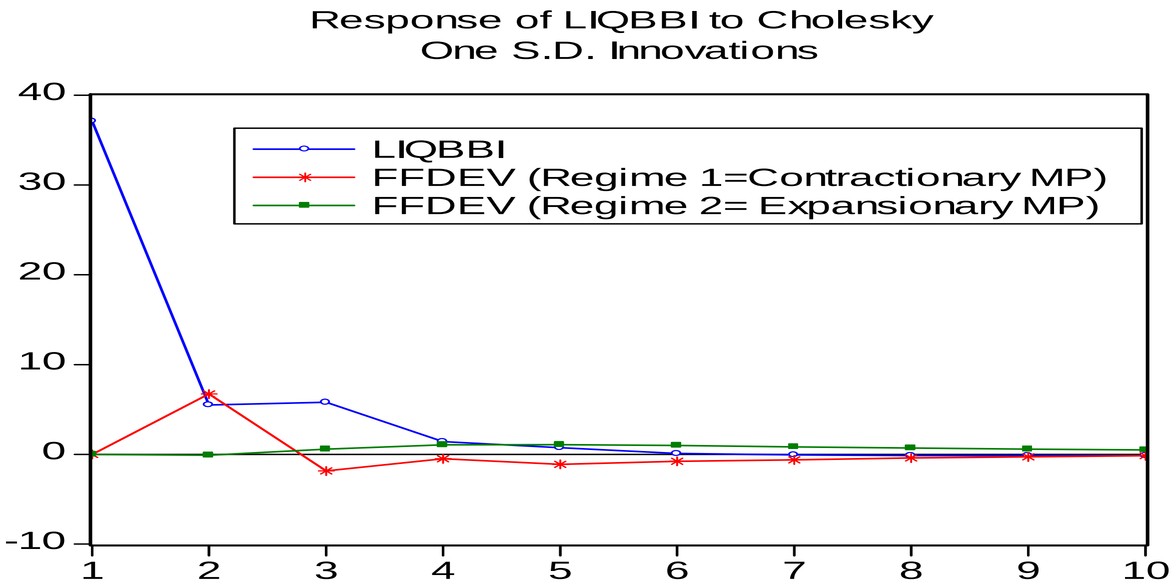
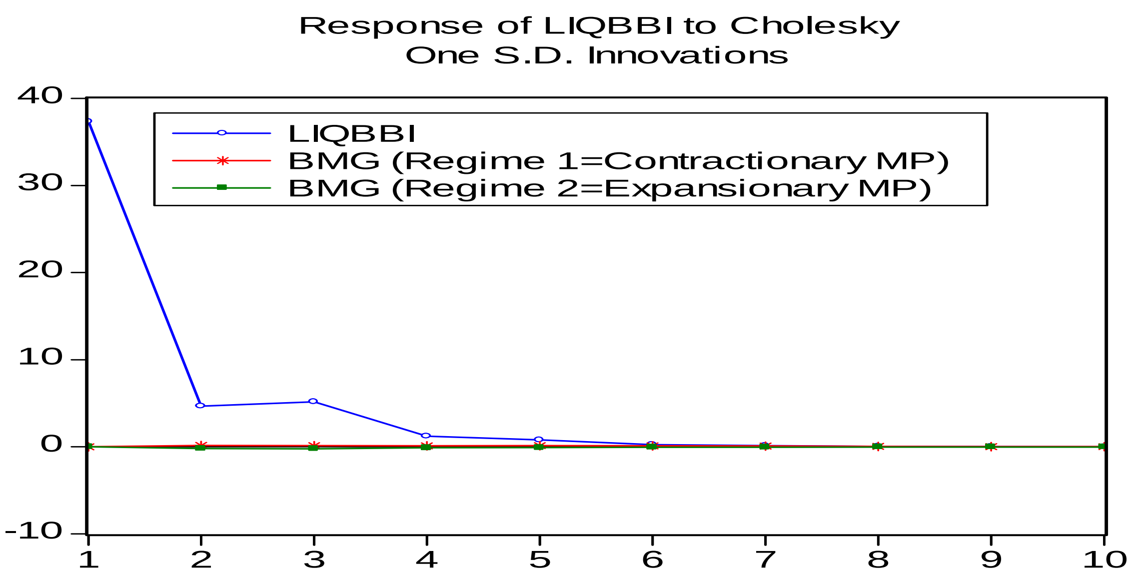


Figure 2: LIQBBI and BMG regime-specific shock



This could be attributed to the positive relationship between assets and leverage (liquidity) of MBIs. However, according to figure 4, MBIs react more to decrease in money base growth (BMG) than increase in base money. This is because the high cost of financing leads to contraction of the liabilities side of their balance sheets.

Figure 3: LIQMBI and FFDEV regime-specific shock

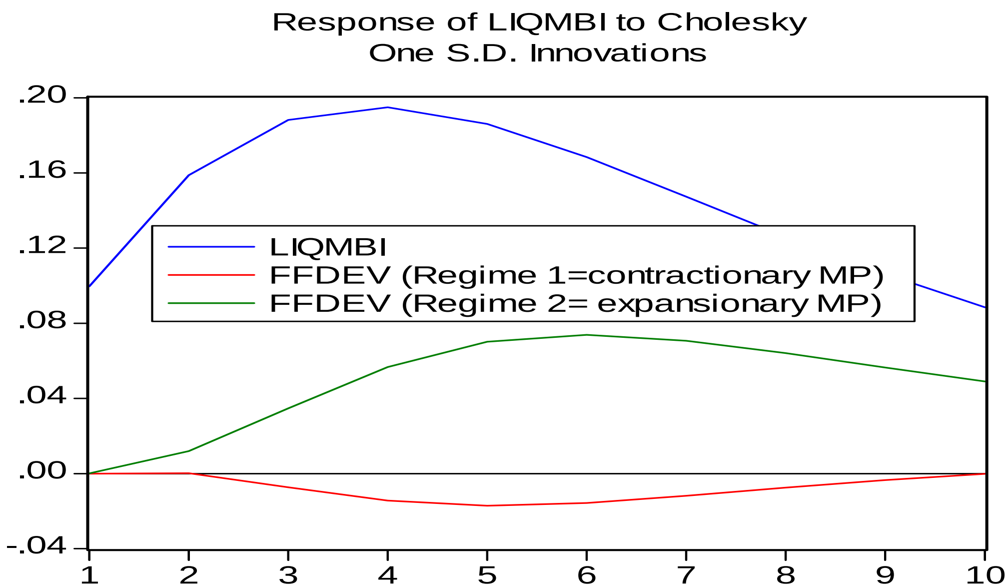
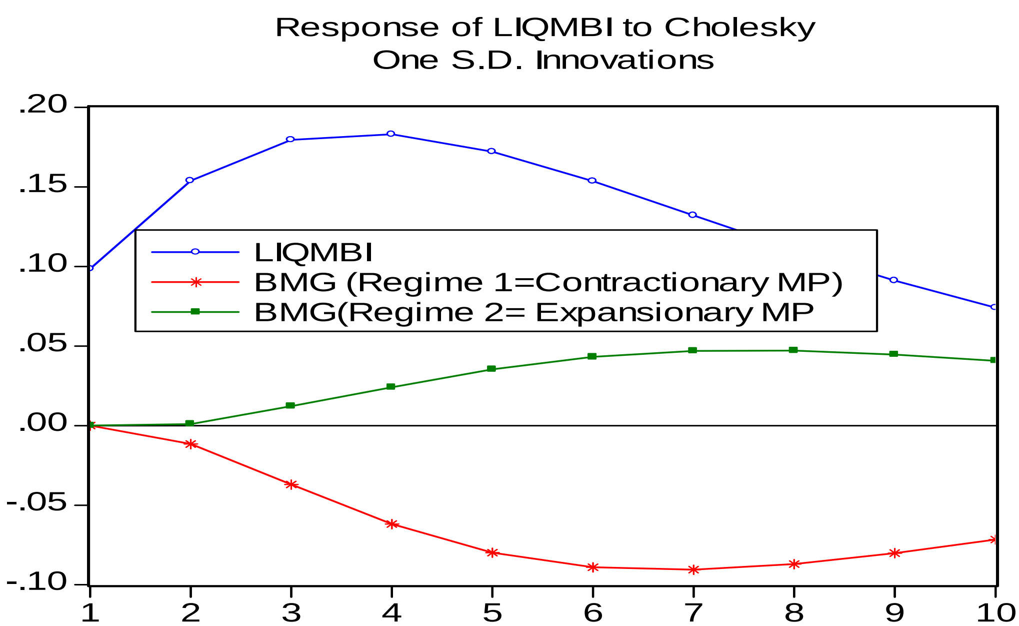


Figure 4: LIQMBI and BMG regime-specific shock



V. Summary and Conclusion

This study set out to investigate whether monetary policy stance have different effect on liquidity of BBIs and MBIs. I find evidence that supports hypothesis one since result indicates that liquidity and equity of BBIs are more volatile due to misevaluation of assets and liabilities. The higher correlation between LIQMBI and AFCI on one hand and between LIQMBI and NEAI on the other, indicate that MBIs are more synchronized with financial and economic conditions relative to BBIs. This supports arguments by Adrian and Shin (2008) that LIQMBI is a good indicator of economic and financial conditions. Therefore, MBIs ought to be included as conduits of monetary policy transmission. Using GMM, TVAR and impulse response functions, I provide evidence that the structure of financial intermediaries matter in design and pursuit of a particular monetary policy. First, I find existence of both one and two thresholds (two and three regimes respectively) which define different liquidity regimes of both BBIs and MBIs. The identification of existence of these regimes is an indicator of uncertainty in monetary policy as postulated by Mankiw and Miron (1986). It is also a mechanism of allowing monetary policy stance to be time-varying since different regimes occur at different times. The threshold values of MBIs are higher than those of BBIs which have important implications for policy makers in design of monetary policy. BBIs do not respond to changes in base money growth while the reaction to FFDEV is rapid and magnified, perhaps due to conservative nature of BBIs or the need to meet regulatory capital and liquidity of overreaction to monetary policy changes. MBIs differently react to both FFDEV and BMG monetary stances. They experience higher expansion of liquidity or leverage under FFDEV during expansionary regime than in contractionary regime. MBIs liquidity (LIQMBI) respond more to BMG than BBIs. This is because BMG is implemented through sale and purchase of Treasury bills. MBIs use Treasury bills (and other tradable securities) as collateral while borrowing (repos) and accept the same as collateral while lending (reverse repos).It is safe to conclude that monetary aggregate policy should be implemented through MBIs instead of BBIs while interest rate targeting by Fed should be aimed at BBIs. This is because BBIs and MBIs react asymmetrically to monetary policy shocks as they expect diverse scenario. It is thus credible to evaluate differently the response of LIQBBI and LIQMBI to contractionary and expansionary monetary policies.

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