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Three Essays on Pricing and the Price Discovery Process of Sovereign Credit Default Swaps

Zubair Ali Raja

THREE ESSAYS ON PRICING AND THE PRICE DISCOVERY PROCESS OF SOVEREIGN CREDIT DEFAULT SWAPS

A Dissertation

by

ZUBAIR ALI RAJA

Submitted to Texas A&M International University
in partial fulfillment of the requirements
for the degree of

DOCTOR OF PHILOSOPHY

AUGUST 2017

Major Subject: International Business Administration (Finance Concentration)

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Approved as to style and content by:

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DEDICATION

I dedicate this dissertation to my late paternal and maternal grandparents. May their souls rest in peace! Amen

- Bashir Ahmed Khan (paternal grandfather)
- Raja Muhammad Sadiq (maternal grandfather)
- Sardar Begum (paternal grandmother)
- Anwer Begum (maternal grandmother)

ABSTRACT

Three Essays on Pricing and the Price Discovery Process of Sovereign Credit Default Swaps (August 2017)
Zubair Ali Raja, B.Sc. Computer Science, University of Engineering and Technology, Lahore; M.B.A. in Finance, The University of Punjab, Lahore; M.B.A. in International Business, Texas A&M International University
Chair of Committee: Dr. George R. Clarke

In the first essay, author undertakes a comprehensive study of eight emerging sovereign entities in order to determine the nature of long-run dynamic interaction between two highly related financial markets on which same, respective, sovereign credit/ default risk is traded. Thus, eight pairs of individual sovereign credit risk prices are independently analyzed using daily time series data during the time period 2006-2016 to determine which market more quickly impounds new information in efficiently pricing the credit risk. These related markets are sovereign credit default swap (CDS) and bond markets. Country level analysis suggests that prices in both markets move in tandem with each other and the sovereign CDS market dominates the price discovery process during tranquil periods, contributing more than 70% to the overall price discovery process, a finding attributed to its greater relative liquidity. However, during the crisis, a common stochastic trend is missing between CDS and bond spreads, suggesting that during times of extreme distress, these markets price credit risk differently. These results have implications for emerging market investors and asset managers who engage in arbitrage between the two markets as well as financial stakeholders who monitor sovereign credit spreads to gauge the level of political and/or default risk in emerging markets.

The second and third essays are closely related as they attempt to establish the notion that socioeconomic variables are key predictors of sovereign CDS prices. Existing literature

focuses overwhelmingly on global financial and country specific macroeconomic variables as determinants of CDS spread. Using the data from 66 countries over the period of 2007-2015, significant support is reported for the hypothesis in the second essay that state fragility, a socioeconomic construct borrowed from foreign policy literature, positively affects the CDS pricing. This support is robust across different regression models with varying specifications. Two way fixed effect model reports that after controlling for global and country specific macroeconomic variables a 1% increase in state fragility, ceteris paribus, causes an increase in CDS premium by 1.60%. Using the data from 2015 for 52 countries, essay three reports that one percentage point increase in social capital of a country causes credit derivative prices to decrease by 1.19%.

ACKNOWLEDGMENTS

Without the encouragement of my parents, this milestone would not have possible to achieve. I am especially thankful to my father, Nisar Ahmed Raja, for his hard work and sacrifices he made for his family due to which I am also able to earn this doctorate. His hard work was equally complemented by the sheer resolve of my mother, Perveen Akhter, whose priorities were to incite high moral values and passion for education amongst her children. I am also thankful to my wife, Afia Zubair Raja, who has supported me throughout this program and also assumed my responsibilities to take care of my darlings, my sons Ibrahim Zubair Raja and Ismail Zubair Raja, along with taking care of my parents during my absence from Pakistan. I also acknowledge the emotional support and prayers of my brother (Zuhaib Ali Raja), sister (Arooj Raheel), cousins, few very special friends and my aunt, Naila Fayyaz, who are my true well-wishers.

I would also like to thank my advisor, Dr. George Clarke for his guidance and support during the dissertation process, as well as my committee members, Dr. Siddhart Shankar whose guidance in writing the dissertation and job search was invaluable, Dr. Ken Hung for sharing important bits of advices and Dr. Antonio Rodriquez for his continuous productive feedback. Finally, I would like to pay my gratitude to Dr. Jorge Brusa, Director of the Ph.D. Program, and Ms. Pamela Short, Executive Secretary for the Ph.D. Program, for their help regarding administrative and funding matters throughout this odyssey.

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LIST OF ABBREVIATIONS

- ADF, Augmented Dickey-Fuller Unit Root Test
- AIC, Akaike information criterion
- BIS, Bank of International Settlements
- BYS, Bond yield spread
- CDS, Credit Default Swaps
- CBOE, Chicago Board Options Exchange
- CME, Chicago Mercantile Exchange
- CTD, Cheapest to deliver option
- FSI, Fragile State Index
- GC, Granger causality
- GG (1995), Gonzalo and Granger (1995) measure of price discovery
- HAS-1, Hasbrouck(1995) lower limit
- HAS-2, Hasbrouck(1995) upper limit
- HAS-MID, Mean of HAS-1 and HAS-2
- HAS (1995), Hasbrouck (1995) measure of price discovery
- ISDA, International Swap and Derivative Association
- I(0), Stationary time series
- I(1), Time series with unit root
- i.i.d., Independent and identically distributed
- IMF, International Monetary Fund
- JBT, Jarque-Bera Test of normality
- LRSHP, Long-run relationship
- OTC, Over the counter
- PDP, Price discovery process
- PP, Phillips-Perron Test of unit root
- SBIC, Schwarz Bayesian information criterion
- SC, Social capital
- sCDS, Sovereign Credit Default Swaps
- VAR, Vector Auto Regression
- VECM, Vector Error Correction Model
- VIX, Ticker symbol of CBOE volatility index

1 GENERAL INTRODUCTION

1.1 Introduction

Credit default swaps (CDS, hereafter) act as insurance against the financial loss of bond holders in case any credit event is triggered. They protect the holders of specific bonds, also called underlying bonds or reference obligations, when the bond issuing entity, also referred to as the reference entity, defaults or is unable to meet its contractual obligations. Although the role of CDS was controversial during the financial crisis of 2007-2009 and later during the European debt crisis, it certainly has been a remarkable recent financial innovation which could potentially improve the overall efficiency of the financial system. CDSs are widely traded derivatives which provide a venue to hedge investors' credit exposure and to extend their investment opportunity set through its effective use in the investment portfolio. Its introduction has positive market efficiency and welfare effects, which are channeled through its dynamic interaction with underlying security (bond) market (Criado, Degabriel, Lewandowska, Lindén, & Ritter, 2010). It provides bond holders with the opportunity to transfer their credit risk to CDS market participants, who are willing to own the bond holder's default risk, in exchange for periodic quarterly or semi-annually premiums without changing their positions in the underlying bond. Thus, it reduces transaction costs and allows for risk distribution among a larger pool of market participants which is beneficial to both private investors and overall society.

In CDS and bond markets, highly related assets are traded based on the same underlying credit risk i.e., price of CDS, also referred to as CDS spread or CDS premium,

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This dissertation follows the model of *Journal of International Money and Finance.*

in CDS market and bond spread[1] in bond market. Indeed, CDS is a derivative that derives its value from the credit risk of the underlying bond. If the credit risk – proxied by distance to default— is higher for a company or sovereign entity then its bond spread will be higher as well, resulting in an increase in CDS spreads which the protection seller will charge to the investor.

The introduction of CDS helps improve the efficiency of the bond market as more participants can express their views about the credit risk of the underlying reference entity, thus moving the default risk price closer to its true intrinsic value. Its introduction may also benefit bond issuing entities to have access to low cost funding as bond prices might remain stable due to the avenue available to bondholders to buy protection against their credit risk exposure. However, a possible negative effect of CDS trading is the diversion of liquidity from bond to derivative market due to an excessive number of pessimistic investors and traders with naked positions[2]. This can lead to a higher required rate of return and liquidity premiums in cash market which make the debt more expensive. Speculative CDS trading during the European sovereign crisis has already been held responsible by critics for higher borrowing cost for sovereign entities[3]. Naked exposure in the CDS market gives rise to the possibility of arbitrage profits as highly related CDS and bond markets may end up pricing the underlying credit risk differently, which may provide the opportunity to earn riskless profits.

In this context, the first part of this dissertation aims to further the nascent literature on market efficiency and the price discovery process (PDP, hereafter) of credit risk in the

[1] Also called bond credit spread or simply credit spread
[2] Position in which protection buyer does not hold underlying bond but still invests in CDS for speculative reasons
[3] https://www.imf.org/External/Pubs/FT/GFSR/2013/01/pdf/c2.pdf

area of emerging sovereign CDS and bond markets. Most studies on this topic have been conducted on corporate CDS. Hull and White (2000), Blanco et al. (2005), Longstaff et al. (2005), Zhu (2006), and Forte and Pena (2009) for example, all study the dynamic interaction between credit and bond spread, and the price discovery process of credit risk in CDS and bond markets using data on investment grade corporate entities. These studies consistently report that the CDS market leads the bond market in efficient pricing of corporate credit risk. Conversely, in the case of sovereign CDS (sCDS, hereafter), findings of price discovery studies on default risk are mixed and ambiguous (Augustin, 2014). Chan-Lau and Kim (2004), Fontana and Scheicher (2010), and Hassan, Ngene, and Yu (2011b) [4], for example, find mixed results regarding the dominance of any particular market in pricing the default risk.

The sCDS market is different from corporate CDS in many ways. For example, in the corporate CDS market, credit prices are determined based on both public and private information. However, in the case of sCDS, typically, only publicly available information drives the credit spread. Likewise, in the case of corporations, measurement of credit risk relies on key variables such as industrial characteristics, management competency, asset to debt ratio etc. Conversely, for sovereign entities these measurement criteria are not applicable. Therefore, the sovereign CDS market is distinctive and results of the studies on dynamic interaction between their CDS and bond spreads differ from those of corporate studies.

In the studies conducted on the price discovery process of credit risk in sCDS, one concern is the length of data. Almost all studies use the Vector Error Correction Model

[4] Though out of seven countries they analyzed, the overall bond market leads CDS market in terms of price discovery of default risk

(VECM) –which is supposed to analyze the long-run dynamic interaction between two time series— with short time period data sets. Furthermore, although all credit markets including emerging sCDS markets have witnessed unprecedented re-pricing of default risk since the global financial crises (Fontana & Scheicher, 2010) and get matured; most of the recent research in the area is conducted on Eurozone sovereign entities only. This is because prior to the financial crisis, developed countries' bonds were mainly considered information insensitive and treated as safe assets. As a result limited amount of sCDS were written on their bonds and their CDS markets were illiquid. Once the vulnerability of developed countries was proven in the wake of the global crisis, sCDS trading on their bonds gained momentum and researchers began to study the relationship between credit risk prices in sCDS and cash markets of developed countries. Thus, recent research ignores the detailed analysis of the price discovery process of credit risk for emerging entities, which are unique compared to the developed ones due to their different macroeconomic conditions. Recent episodes such as China's financial meltdown in 2015, the impact of reduced oil prices on countries like Russia, and the executive order issued from the Puerto Rican governor's office to declare a moratorium on a portion of debt on 30th June 2016[5], re-emphasize the importance of understanding the nature of emerging sovereign credit risk. Because this risk is being traded in the sCDS and underlying cash markets, by studying the price discovery process of aforementioned risk, involving these two markets, stakeholders can timely assess which market efficiently prices credit risk for emerging countries.

The second and third essays of this dissertation attempt to establish the relationship between sCDS pricing and socioeconomic constructs which, to the best of my knowledge,

[5] As Puerto Rica was unable to meet its obligation to back the debt worth $2 billion due on 1st July 2016

have not yet been explored in the literature. Usually pricing of sCDS has been associated with country specific macroeconomic variables and global financial factors. However, the second essay proposes that a non-traditional construct, namely state fragility, borrowed from foreign policy literature is positively associated with the sovereign CDS spread. State fragility has been defined in different ways in the foreign policy literature, however its modern definition evolved in the context of the war on terror (Call, 2008). According to this recent definition fragile state concept is linked with terrorism, thus indicating that these states are not only subject to terrorism themselves but can also be a threat to world peace. Baliamoune-Lutz and McGillivray (2011) mention fragile states as those states which are not able to improve their economic growth and/ or able to reduce the poverty due to their ineffective policies and governance, and poor institutional performance. This results in an inability to absorb the inflow of funds effectively —generated either through aid or loan— and therefore results in added premiums required by the creditors as compensation to bear additional sovereign credit risk. Therefore, intuitively CDS spreads of fragile states should also be high.

In the third essay the impact of another construct, called social capital, is determined on sovereign CDS premium. According to Fukuyama (2001), it represents the "*instantiated informal norms*" that allows collaboration among different parties. Countries with high social capital have high levels of generalized trust. In such societies people try to abstain from devious behaviors to avoid internal and external guilt as society collectively punishes people with an intent of opportunistic behaviors. Positive impacts of social capital have been widely reported in political economy, management and accounting literature especially on country's economic and financial development. At the same time, sovereign CDS pricing literature reports the negative relationship between country's economic development and its CDS premium. Therefore, this compelled the author of this dissertation to hypothesize a negative association between social capital and sovereign CDS premium of the country.

1.2 Overview of Credit Default Swap

1.2.1 What are Credit Default Swaps?

A credit default swap (CDS) is a fixed-income derivative which derives its value from the credit risk of the specific underlying bond —identified by its maturity, coupon, CUSIP etc. in the CDS contract– against which it is traded. A CDS typically is a bilateral over-the-counter (OTC, hereafter) contract, though significant numbers of standardized CDS contracts have started trading on formal exchanges. The purpose of a CDS is to protect the investment of lenders against any default, in case a credit event is triggered. These credit events usually occur when the bond issuing authority, which can be any corporation or government, is not able to meet its debt related contractual obligations. CDS are typically issued and traded against unsecured senior debt. Thus CDS acts as insurance against the default of bond issuer, allowing lenders to hedge their credit exposure. However, like other derivatives, one can have a naked exposure in the CDS market with the sole purpose of investment without necessarily having any investment in the underlying bond. The specific bond mentioned in the CDS contract is also called the reference obligation and the issuing authority of the bond is termed as reference entity.

Like all insurance, the buyer of the CDS needs to pay a periodic premium, usually on a quarterly or semi-annual basis, to the underwriter for bearing the credit risk. In line with the classical risk-reward principle of finance the premium is positively correlated with the likelihood of the reference entity being unable to meet its debt related obligations. Moreover the higher the number of credit events listed in the CDS contract, the higher will be the CDS premium charged by the protection seller. It is the fixed amount paid periodically by the CDS buyer until the expiration of the contract. This premium is also called the CDS spread or CDS price and listed as basis points, in annual terms, in the CDS market. For example if the CDS spread on an underlying bond having a face value of $1000 is traded at, say, 200 basis points (2%) then it means that a quarterly payment of $5 is due by the CDS buyer thus summing up to the total of $20 for the whole year. The CDS buyer can also opt to protect only a part of his investment if he is willing to bear some portion of the overall credit exposure. For instance in this example if the protection buyer is willing to buy CDS of only $500 on the underlying bond of $1000 then instead of $5.00 he needs to pay only $2.50 each quarter as he is protected for only half of the face value of the reference bond. However, he needs to ensure that CDS of this denomination is available at the exchange or that some dealer offers it in the OTC market.

Exact details about what constitutes a credit event are mentioned in Article-IV of Credit Derivatives Definitions[6] issued by International Swap and Derivative Association (ISDA) in the year 2003[7]. Typical credit events which trigger corporate CDS payment include, but are not limited to, bankruptcy and restructuring. Because sovereign entities are different than corporate ones, therefore the credit events which trigger sCDS payment also include repudiation/ moratorium in addition to bankruptcy. ISDA defines these credit events as follow:

- **Bankruptcy**: When the reference entity of dissolved (other than merger or amalgamation), becomes insolvent, seeks judgment for insolvency under the

[6]https://globalmarkets.bnpparibas.com/gm/features/docs/dfdisclosures/2003_ISDA_Credit_Derivatives_Definitions.pdf
[7] Subsequently amended in February, 2014 and became effective from 22nd September 2014

bankruptcy law, pass resolution for winding-up or liquidation etc.

- **Failure to Pay:** When the reference entity (bond issuer) is unable to pay after the expiration of any applicable grace period.
- **Repudiation/ Moratorium:** When an official from a bond issuing corporate or government authority rejects or challenges the validity of the whole or a part of the debt contract, imposes a ban or prohibition with respect to the obligation, or simply restructures the obligation in terms of maturity or payment amount.
- **Restructuring**: When the reference entity a) reduces the interest rate, interest amount and principal amount; b) delays the payment of interest or principal and c) changes the currency of interest or principal payments except for payments in Euro by European Union Member State which has adopted the currency after becoming a member of the Union.

Once any of the above mentioned credit events is triggered, the CDS seller needs to pay protection to the buyer either through a physical or cash settlement[8]. Under physical settlement, the underlying bond will simply be handed over to the seller who will pay the full face value of the contract to the CDS buyer. In the case of cash settlement only the difference between the face value and the market value of the bond is paid to the bondholder. For example, upon the triggering of any credit event, the CDS seller needs to pay $40,000 to the buyer if the underlying bond with face value of $50,000 is being valued at only $10,000 by the market[9].

[8] Cash settlement can also lead to the issue of naked exposure where one does not necessarily have to own a bond before buying the protection. Such exposure lead to a controversy during European sovereign crisis as it has been credited with increased borrowing cost of debt of sovereign entities.
[9] Price of the bond of default entity is determined by an independent committee called Credit Derivatives Determination Committee (CDDS) which conduct polls among CDS market makers

A key difference between CDS spreads and coupon payment of underlying bond is that CDS spread is considered as a pure proxy of the reference entity's credit risk. On the other hand, credit risk is just a small portion of the overall risk[10] for which the bondholders are rewarded through coupon payments. Return for bearing the credit risk is embedded in the interest payment of the underlying bond. Thus, under no arbitrage, if the investor requires a credit risk premium of 2% on a bond which is paying a 4% return (excluding default premium) then price of the CDS traded on underlying bond should be 200 basis points and the total annual return on the bond should be 6% (4%+2%). Therefore, by its mechanics CDS and bonds are highly related as they measure the same default risk and one can earn arbitrage profits if they do not price default risk at the same level.

1.2.2 CDS Market and Subsequent Development of Sovereign CDS

CDSs were initially introduced in the mid-1990s by banks to transfer their risk on commercial loans and provide a cushion to regulatory requirements in maintaining their capital. CDS for corporate and municipal bonds started being sold in the late-1990s. In derivative markets, CDS takes third spot in terms of high volume after derivatives traded on interest rates and foreign exchange. According to Bank for International Settlements (BIS), the volume of this market reached the notional amount[11] of $58 trillion by the end of 2007. As of December 2014 this stands at $16 trillion[12] as trading of this instrument sharply declined after the collapse of Lehman Brothers in September, 2008. Initially the growth of

[10] Which includes interest rate and liquidity risk along with credit risk
[11] Notional amount is the total amount of the all outstanding contracts e.g., in the world of two parties 'A' and 'B' where party 'A' has sold a protection of US$ 2 Million on an underlying bond to party 'B' and 'B' has sold the protection on the same underlying asset of US$ 1 million to 'A', the notional amount of CDS would be US$ 3 million. On the other hand gross market value of CDS contracts is only US$ 1 million i.e., if both parties will not be able to meet their obligation then there is a net loss of US$ I million only instead of being US$ 3 million, as party 'A' will not be able to pay net amount of US$ 1 million to party 'B; if credit event triggers on the reference entity.
[12] http://www.bis.org/publ/otc_hy1504.pdf, page 5

the CDS market was not that impressive. However, since the introduction of a standardized master agreement by the ISDA in 1998, the credit default swap market has grown rapidly (J. Hull, Predescu, & White, 2004). The ISDA master agreement, which governs all credit default swap transactions brought liquidity to the market as it reduced the high cost of negotiation (in terms of time delays). This expansion was further fueled by the introduction of the credit derivatives definitions in 2003.

Within the CDS market various innovations have been introduced by the market makers resulting in the availability of different kinds of CDS products to investors and hedgers. Apart from single name CDS, multi-name CDS are also available which provides protection to buyers against multiple reference entities through a single transaction rather than buying single name CDS for each underlying reference entity individually, thus resulting in reduced transaction costs. For example if an investor owns five bonds and needs to transfer the credit exposure on each one of them then he can buy a multi-name CDS (single contract), if offered by any dealer, referencing the issuers of all those bonds. If any of the reference entity defaults in that basket the CDS seller is bound to settle the contract by paying the amount related to insolvent entity. Another important product offered in the CDS market is the CDS index, which works in the same fashion as the indexes in equity and bond markets. Typically an investment fund manager with a large portfolio can hedge his credit exposure by buying a CDS index or he can simply include the index in his investment portfolio with no actual exposure in underlying obligations included in the index. These indexes are formed based on different criteria which include credit worthiness of underlying entities, country and/or region of reference entity, industry etc.

In recent years, particularly after the financial crisis and the subsequent Eurozone crisis, the role of sovereign CDS (sCDS, hereafter) have been under the limelight. Although the notional amount of all CDS keeps on decreasing since 2007, the share of sCDS notional amount as percentage of total notional amount of all outstanding CDS remained stable and grew from below 5% to nearly 15%[13], reaching its peak of $3.2 trillion in 2013. Before the Lehman Brothers collapsed in fall 2008, trading in CDS were mainly concentrated referencing corporate entities and sovereign emerging markets. But since then the market has re-assessed the default risk of developed countries, resulting in increased trade of their sCDS (Fontana & Scheicher, 2010). According to global financial stability report of IMF, issued in April 2013, sCDS have been offered to trade in OTC market by reporting dealers, since 2001, after the demise of Brady bond future contracts. These contracts were traded on the Chicago Mercantile Exchange (CME) for three countries i.e., Argentina, Brazil and Mexico. Demand for a more flexible sovereign risk hedging instrument drives the genesis of sCDS[14]. Like its corporate counterpart sCDS is used for hedging, speculative and basis trading. sCDSs take a unique and enhanced role after the financial crises of 2007.

Prior to the financial crisis most CDS contracts referenced emerging countries as they were perceived to be the most risky reference entities among sovereign countries. However, after the crisis trading on sCDS referencing advanced economies got momentum as market participants realized that systemic risk associated with advanced countries have profound and deeper impact on global financial stability. After the Eurozone debt crisis, sCDS become more controversial and have been in the limelight owing to their perceived role in worsening it. Speculative trading of these instruments during the crisis led to higher credit spread prices which were not justifiable given underlying fundamentals of the economy resulting in higher

[13] http://stats.bis.org/statx/srs/table/d5.2
[14] https://www.imf.org/External/Pubs/FT/GFSR/2013/01/pdf/c2.pdf, page 59

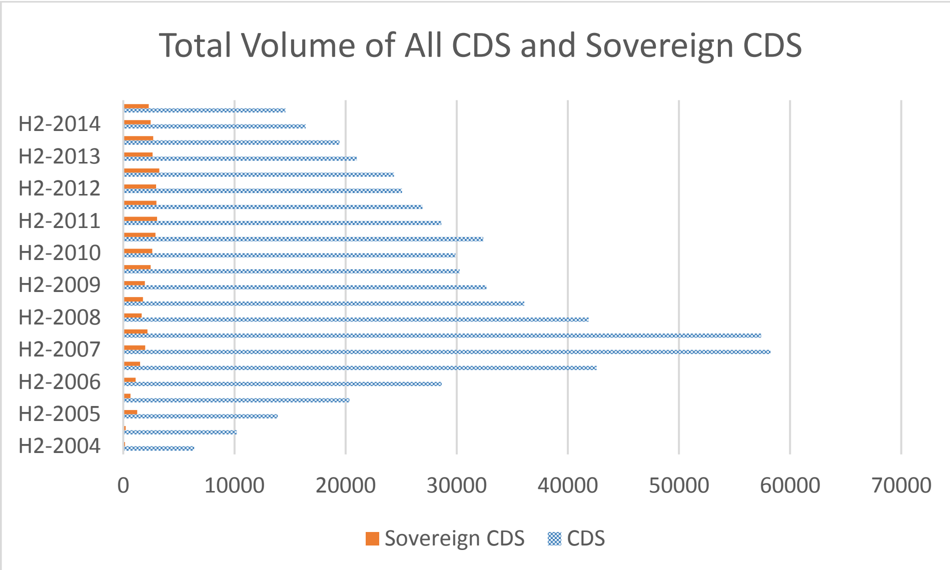
interest rate on the sovereign bonds[15] (theoretically sCDS spread and bond yields are positively correlated). This in turn, increased the borrowing cost of debt for sovereign entities by driving down the prices of their bonds. Overwhelming support of this notion led to the ban on speculative trading on sCDS in Europe in 2011. However, some experts challenge this logic and consider sCDS a vital market-based sovereign risk indicator. According to the 2013 IMF global financial stability report's findings, this ban will limit the rational price discovery process of credit risk as more participants bring informational efficiency in the market which is key to set efficient pricing of any asset.

The notional volume of sCDS increased since it was first reported by Bank for International Settlements (BIS) in the second half of 2004 until the first half of 2013, reaching its peak value of $ 3.2 trillion. Since the second half of 2013 there has been a downward trend in the volume of sCDS, though it is still stable relative to the total volume of all the CDS. This can be seen in figure 1.1 which shows that total volume of all CDS, since 2007, has sharply declined and that of sCDS is relatively stable. Figure 1.2 suggests that volume of sCDS, as percentage of total CDS, has reached its peak in the first half of 2015 where it accounts for approximately 15% of the total CDS notional volume. Reduction in the volume of sCDS from its peak value of $3 trillion in 2013 to $2 trillion in 2015 is greatly attributed to the ban on naked exposure by regulators in Europe.

The sCDS market has its own unique attributes compared to the overall CDS market. Though the majority of CDS contracts in the market are single names i.e., 55% of notional value outstanding belongs to single name but these numbers are at extreme in the case of sCDS where 95% belongs to single name contracts. This can be witnessed in figure 1.3 and

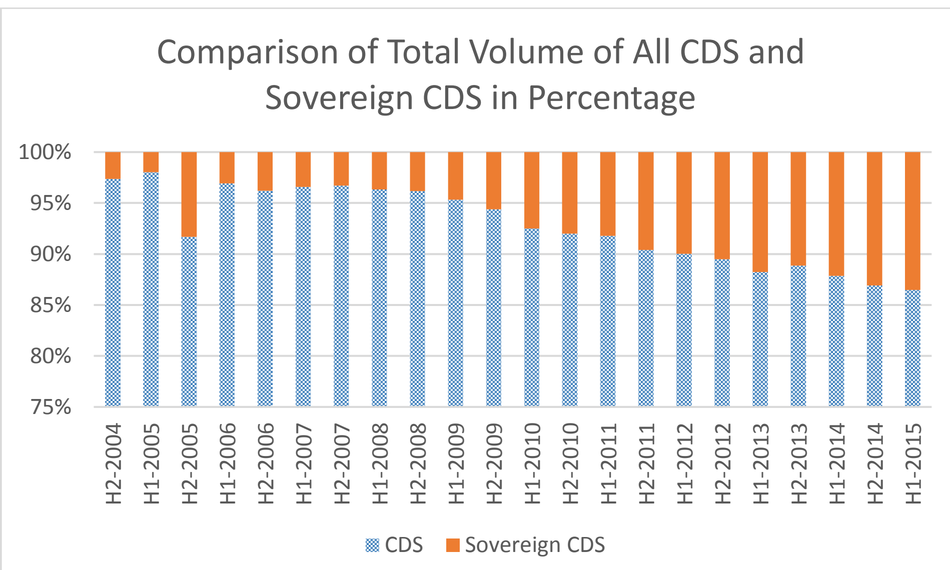
[15] This point of view against speculative trading mostly holds among governments and politicians.

Figure 1.1: Total volume of all CDS and sovereign CDS over the years



Source: Bank for International Settlements (BIS) website; years on y-axis and US$ in billions on x-axis

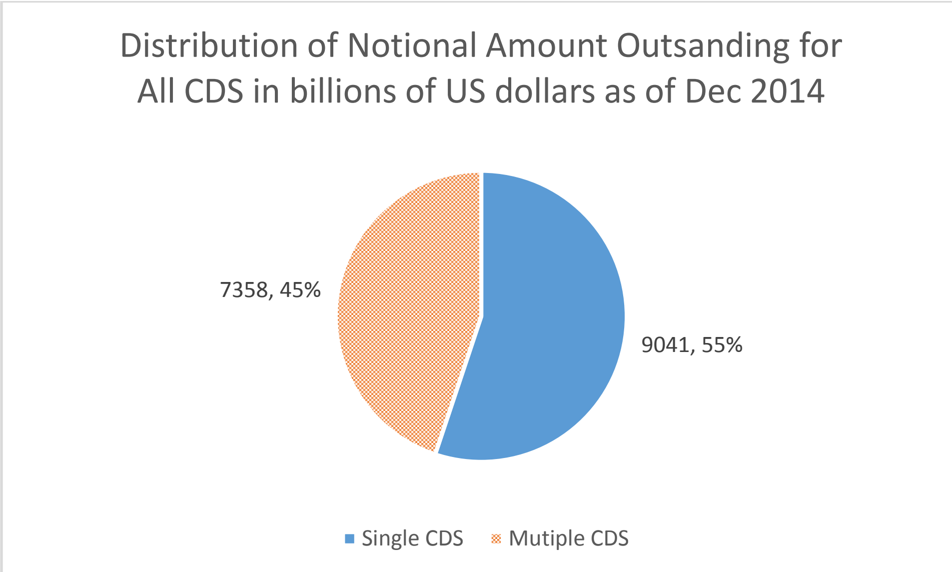
Figure 1.2: Volume of sovereign CDS as %age of total outstanding CDS over the years



Source: Bank for International Settlements (BIS) website; years on x-axis and volume of sovereign CDS as percentage of total CDS on y-axis.

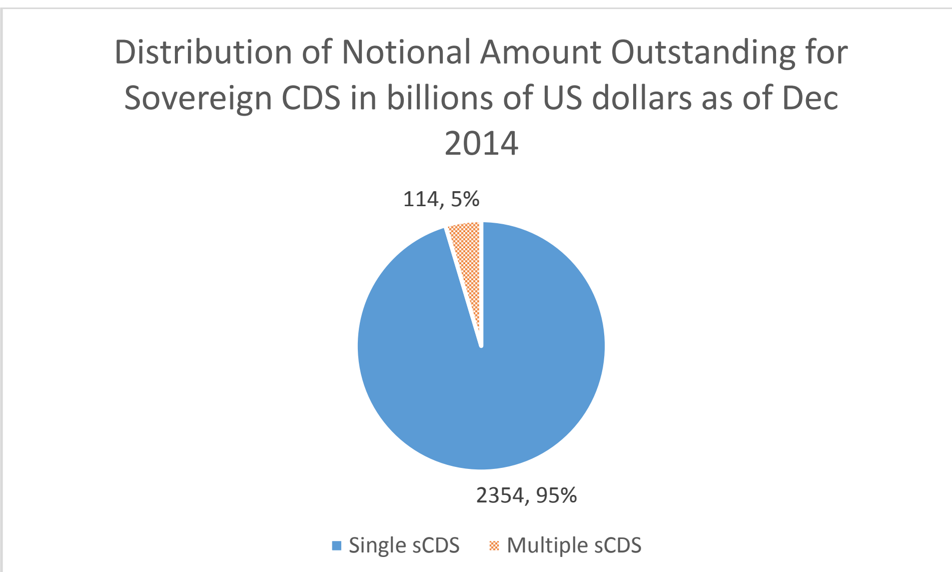
figure 1.4. It also supports the rationality to analyze single name sCDS time series data, rather than index data, to gain further insight of this market. Overall CDS market is concentrated as high volume of notional amount is traded among few reporting dealers.

Figure 1.3: Distribution of CDS between single and multiple CDS as of Dec. 2014



Source: Bank for International Settlements (BIS) website.

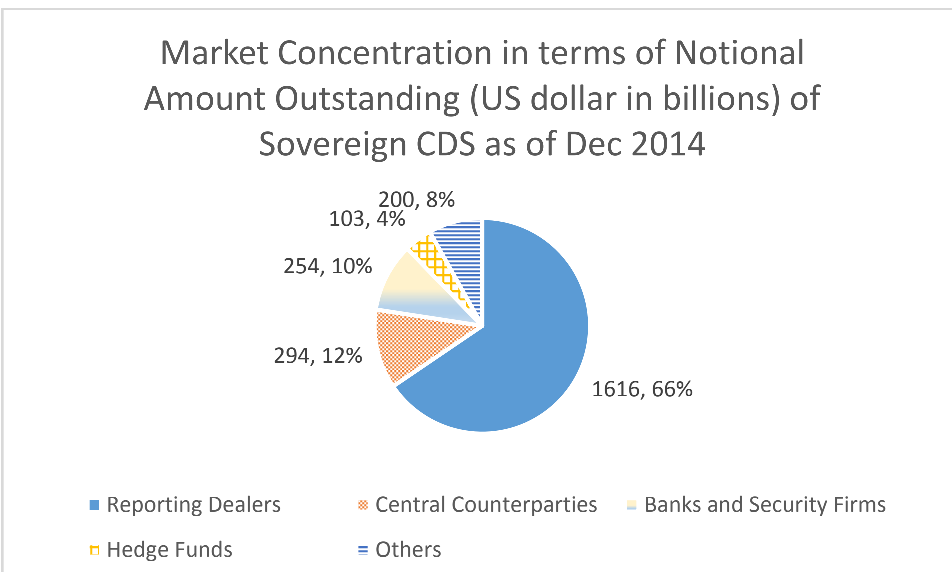
Figure 1.4: Percentage of single and multiple name sovereign CDS as of Dec. 2014



Source: Bank for International Settlements (BIS) website.

According to figure 1.6 major volume i.e. 47% of total notional amount outstanding is bought and sold by reporting dealers. This figure also shows the rising contribution of central counterparties which mitigate counterparty risk and serve as exchange where more standardized contracts are traded. The role of these counterparties was enhanced after the financial crisis in 2007. In the case of sCDS, same first spot is held by reporting dealers but sCDS market seems far more concentrated compared to the overall CDS market as 66% (see figure 1.5) of sCDS total notional volume is held by the handful of reporting dealers. These dealers are big banks which are globally systemically important financial institutions. The prime reason for their domination in sell and buy sides of sCDS market is related to their huge exposure in sovereign debt. According to Fitch Ratings[16] top 10 U.S. and European financial institutes act as counterparties of 80% of all sCDS trade. Hedge funds are the net buyers of the sCDS after financial crisis, whereas they used to be the net seller early.

Figure 1.5: Market concentration for sovereign CDS as of December 2014



Source: Bank for International Settlements (BIS) website.

In short, compared to the overall corporate CDS market, the sCDS market has its own peculiarities. Another important difference between the sCDS market and the corporate CDS

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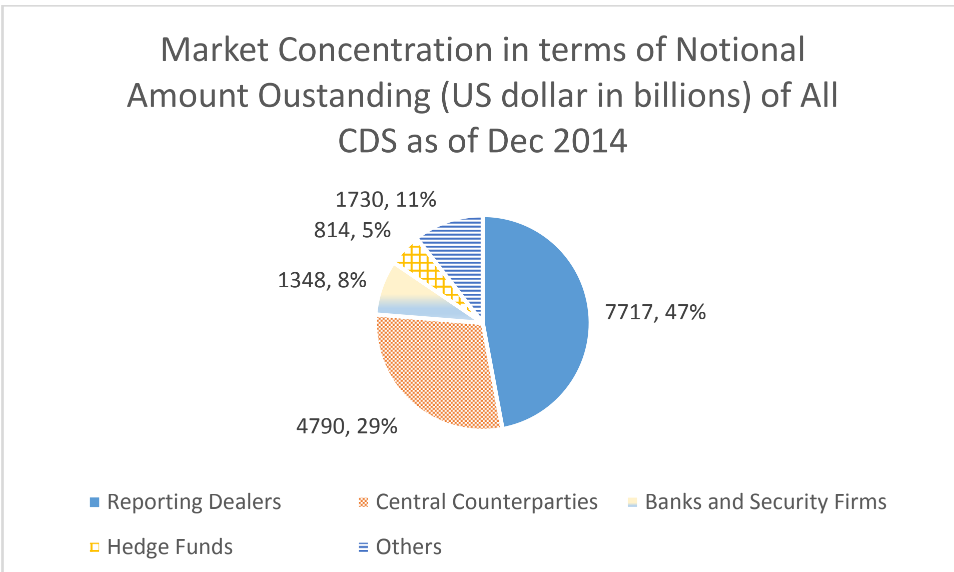
[16] Published in 2011.

market is that volume of underlying sovereign bonds is much higher compared to the volume of sCDS offered for trade (approx. $19.6 trillion outstanding in sovereign bonds vs. only $2.4 trillion notional amount of sCDS by the end of December, 2014[17]). The situation is totally different in the case of corporate CDS market as notional amount of CDS referencing corporate entities is much higher than the total amount of outstanding bonds issued by the firms.

Figure 1.6: Market concentration for all CDS as of December 2014



Source: Bank for International Settlements (BIS) website

1.3 The Relationship between CDS Prices and Bond Credit Spread

The price of a CDS is considered to be a measure of the default risk[18] of the entity, on whose bonds the CDS is being traded (Chan-Lau & Kim, 2004). It should be equal to the amount of the underlying bond's yield spread, of par-floating rate note, over and above the interest rate of floating risk-free security of the same tenure (Duffie, 1999). Here, the intuition is fairly simple. By holding a risky bond whose annual return is, say, '*Y*' and then

[17] http://www.bis.org/statistics/c2.pdf
[18] I will interchangeably use terms, default risk and credit risk throughout this draft.

buying a CDS protection on the bond for an annual premium of, say, '*C*' an investor will end up earning a net annual return of '*Y-C*'. These two transactions are equivalent to holding a risk-free treasury bond of the same maturity with an annual risk-free return of '*RF*', that is '*RF=Y-C*'. Therefore, if company XYZ has issued a five-year bond and a CDS is written on this bond in order that debt holders can hedge their credit exposure then theoretically CDS spread, which is simply a measure of credit risk of XYZ, should be given as follows:

$$CDS_{xyz,5} = BYTM_{xyz,5} - RF_5$$

Where

$CDS_{xyz,5}$ *is the price of credit default swap traded on the bond with 5-year maturity issued by 'XYZ' company*[19]

$BYTM_{xyz,5}$ *is the total yield-to-maturity of the 5 year bond issued by the 'XYZ'*

RF_5 *is the interest rate of risk-free treasury bond of the same maturity, i.e., 5-years, and*

$(BYTM_{xyz,5} - RF_5)$, *this difference is called bond spread (usually denoted by* $BS_{xyz,5}$*) which is the measure of credit spread extracted from bond market*

Details of aforementioned theoretical relation are discussed in depth in Duffie (1999). Theoretically under no market frictions, the difference between the CDS spread and bond spread, called CDS-bond basis $(CDS_{xyz,i} - BS_{xyz,i})$, should be equal to zero. However, the no-friction assumptions which Duffie makes do not hold in reality[20]. As a result, violation of these assumptions results in non-zero basis for both corporate and sovereign entities, an occurrence which is consistently documented in the empirical literature (Fontana and Scheicher (2010), Arce et al (2013), Augustin (2014), among others).

[19] Five year CDS is used here for explanation purpose as it's spread is commonly used in the empirical literature on CDS.

[20] First, both risky and risk-free bonds are par-floating rate instruments. Second, there should be no transaction cost and effects of tax must be negligible. Third, in case of credit event payment of CDS spread should stop. Fourth, once credit event occurs, protection buyer should be paid on next coupon date.

This non-zero basis suggests the presence of arbitrage opportunity in a frictionless market. Theoretically; if the CDS-bond basis is negative —CDS spread is lower than the underlying bond's credit spread— investors can take a long position in the risky bond and purchase the maturity matched CDS to hedge their credit risk. In doing so, they can earn riskless profits and over time, as more investors adopt this trading strategy, the arbitrage opportunity will disappear, with the CDS-bond basis returning to zero. Conversely, when CDS basis is positive, investors can sell the underlying risky bond, taking short position in risky asset and write (sell) CDS on the shorted bond to earn riskless excess profit. Once again, as more investors put on this trade, the resulting price movements from the buying and selling will return the basis to zero. However, as mentioned above empirical literature on CDS and bond markets document a consistent non-zero basis, suggesting the presence of a number of factors which prevent arbitrageurs from monetizing the basis spread.

2 ESSAY 1: PRICE DISCOVERY OF CREDIT RISK IN EMERGING SOVEREIGN CREDIT DEFAULT SWAP AND BOND MARKET

2.1 Introduction

Due to the increasing exposure of investors to the sovereign debt market, sovereign credit risk has become an increasingly important area to study. The price of sovereign credit risk is determined in two markets i.e., bond market and credit default swap (CDS[21], hereafter) market. CDS are a flexible financial hedging instrument used to protect bondholders' investment in an underlying bond, called the reference obligation. Therefore, if a bondholder is concerned that the bond issuer, or reference entity may default, he can either take a short position in the bond or buy CDS protection on the bond. In the case of a default, the CDS seller is bound to compensate the bondholder for the value against which he has bought CDS protection. Because the CDS acts as a type of insurance on the underlying bond, the value of the premium is derived from the underlying credit risk of the protected bond. The higher the default risk of the bond, the higher is the annual premium (also called CDS price or CDS spread) the purchaser must pay the seller. Thus, bond and CDS prices should be related since conceptually, it is the same credit risk that is traded on them. When an asset is traded in a single market, its price is solely determined in that market, however if it is traded in two different markets as is in the case with sovereign CDS and bonds, then the price discovery process may either be split between two markets or one market may dominate the other in which case it would be considered more efficient in pricing credit risk.

[21] 'sCDS' for sovereign credit default swaps

Against that backdrop, this essay studies which market, the emerging sovereign CDS or bond, is more efficient in impounding new information by measuring their relative contributions towards the price discovery process (PDP, hereafter) related to sovereign credit risk. In doing so, it examines how these two markets dynamically interact with each other in the long-run. Though this topic has been researched in the price discovery literature, unlike with the corporate sector where the CDS market's domination over the bond market has been firmly documented, results in the sovereign sector have been mixed. While some studies have documented the bond market's domination, others have reported the CDS market's domination while still others suggest a two-way dynamic interactive effect between these markets. However, in recent times most of the focus in this area has been on Eurozone developed countries due to the ongoing euro crisis, resulting in the need to update and reexamine emerging sovereign entities. This need is underscored all the more by recent events such as China's financial meltdown in the year 2015, the impact of reduced oil prices on emerging countries like Russia, Venezuela etc., and the executive order issued by the Puerto Rican governor's office declaring a moratorium on a portion of debt on 30th June 2016[22]. Because the credit risk associated with such events is traded in both the sovereign CDS and underlying cash bond markets, thorough investigation of the price discovery process related to this risk is essential in understanding how these markets operate and which one may be more efficient in pricing in the risk.

As such, this paper contributes to the extant literature in four ways by i) adjudicating the ongoing debate regarding market efficiency in pricing of sovereign credit risk, ii)

[22] Puerto Rica was unable to meet its obligation to back the debt worth $2 billion due on 1st July 2016

analyzing data over a much longer time period than has been done before[23], thus enabling a more fulsome study of the long-run dynamic interaction between two these markets, iii) examining the persistence of the result by parsing the data into pre-crisis, post-crisis and crisis period subsamples, and iv) operationalizing two price discovery measures for the first time in the literature to test the robustness of the initial findings[24].

Before the financial crisis it was generally understood that economic outlooks of emerging markets should be more scrutinized than developed countries as emerging markets might be more susceptible to domestic and global financial shocks. Therefore, pre-crisis sovereign CDS (sCDS, hereafter) were mainly traded on emerging market bonds, with the pricing on developed market bonds based on interest rate and liquidity risk only (Fontana & Scheicher, 2010). However, after the crisis, sCDS trading on developed country bonds increased substantially, thus providing a fertile area to study for the researchers. This resulted in a plethora of studies examining the pricing of credit risk in the Eurozone area. However, given that almost all credit markets witnessed a significant shift in the pricing of default risk after the crisis, an updated study of the dynamic interaction between sCDS and bond credit spreads is necessary, as called for by Li and Huang (2011)[25].

Moreover, the model employed in informational efficiency studies between the CDS and bond markets, the Vector Error-Correction Model (VECM), which up until this point has been used to examine relatively short periods of time, is best suited for longer-period time series data. This is because the main element of the VECM is the co-efficient of error

[23] Data spans from 2nd January 2006 to 21st April 2016 in this paper. On the other hand; most studies have analyzed only three to four years of data.
[24] Usually studies in the area of sovereign credit risk price discovery only report Gonzalo and Granger (1995) measure of price discovery. However, in studies pertaining to corporate CDS few have reported both Gonzalo and Granger (1995) and Hasbrouck (1995).
[25] Their study covers the period from 01 Jan 2004 – 31 Jul 2008

correction terms, which determines in the "*long-run*" which market impounds information more efficiently. Therefore, by definition, a fulsome study of the dynamic interaction of emerging market sCDS and bond spread designed to settle the question of which market is more efficient requires long periods of quality data.

To the best of my knowledge, the most recent such comparative study of these markets was conducted by Coudert and Gex (2013), whose data only covered the time period from 02 January 2007 to 18 March 2010. As a result, it does not capture the recent changes in the dynamics of price discovery as outlined by Fontana and Scheicher (2010). Moreover, the authors only reported results for the overall sample using panel analysis and did not include country-level findings. However, country-level results are a critical component of emerging country price discovery studies since single name CDS comprise 95% of the outstanding notional amount of sCDS and as such, provide the level of details regarding market interaction most practical for credit investors. Finally, while there are two traditional price discovery measures[26] that can be employed in CDS-bond efficiency examinations, namely the Gonzalo and Granger (1995) and Hasbrouck (1995)[27] measures, extant studies typically only employ one, the GG-1995. However, given that the two measures sometimes produce conflicting findings, both should be utilized in any study of informational efficiency, with one serving as a robustness check for the other.

In this study, I find that long-run interaction between these two markets only occurs during periods of relative calm, as no such interaction is observed during the crisis period. Moreover, my results indicate that when the interaction is present, the CDS market is more efficient in the pricing of sovereign credit risk as per the GG-1995, its median contribution

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[26] Which will be discussed in detail in the methodology section
[27] GG-1995 and HAS-1995, hereafter

toward price discovery is more than 70%[28]. Furthermore, in all periods in which an interactive effect is observed, there is no two-way effect, indicating that while the bond market adjusts to information impounded in the CDS market, the opposite does not occur. The only exception to this finding is Mexico, where the bond market is observed to lead the CDS market during periods of tranquility. As reasons for the generally greater price efficiency of the sCDS market, I cite the higher relative liquidity of the market and associated greater level of information impounded.

2.2 Literature Review

Price discovery studies have their roots in the theoretical papers of Duffie (1999) and J. C. Hull and White (2000)[29] who suggest that the CDS price should be equivalent to the credit spread of a floating-rate note traded at par over a risk-free interest rate. Therefore the CDS-bond "basis" – the difference between the CDS price and yield spread of the underlying bond— should be equal to zero. If not, there would be an arbitrage opportunity to earn riskless profit. Using price differences in CDS premium and yield spread, basis traders can implement an investment strategy to earn arbitrage profits. If the CDS price is narrower than the underlying bond credit spread, i.e. "basis" is negative, then traders can go long the credit and buy CDS protection to have a profitable default-free position (Fontana & Scheicher, 2010). This way they can pocket risk-less profit as bond will provide them net positive cash flow even after paying for default-protection (CDS) on them. On the other hand if "basis" is positive then they can gain arbitrage profit by shorting the underlying bond and selling protection on that bond. Extant literature, in the area of sovereign entities, presents consistent

[28] These results are also supported by the HAS (1995) measure although the relative contribution is somewhat lower at 63%

[29] They develop the pricing model of CDS premium and also apply their model to evaluate the CDS traded on Ashland Inc. at the close of trading day on 13th July 2000.

empirical evidence of non-zero basis. These studies include, but are not limited to Ammer and Cai (2011)[30], Levy (2009), Fontana and Scheicher (2010), M. Adler and Song (2010) and Arce, Mayordomo, and Peña (2013), among others. This deviation from the parity relationship results due to market frictions namely counterparty risk, difference in liquidity, cheapest-to-deliver option (CTD)[31] and investor propensity to flight-to-quality during period of stress.

Empirically observed violations of arbitrage relationship led to subsequent research to investigate which market incorporates the information faster to efficiently price the default risk of the underlying entity. The market which is quicker to incorporate the price of credit risk is referred as "lead" market and is considered to contribute more towards the price discovery process of default risk. The one, which follows the lead market in pricing the risk, is called the "lag" market. Although there is deviation from the strict arbitrage relationship in the short run, studies in both (corporate and sovereign CDS) find that CDS and bond credit spreads move in tandem in the long run (Blanco, Brennan, and Marsh (2005), Zhu (2006), Baba and Inada (2009), Forte and Pena (2009), Norden and Weber (2009), Varga (2009), Ammer and Cai (2011) and Coudert and Gex (2013)). This suggests that innovation in one market can spill over to the other market and results in the co-movement of these spreads (in other words they are co-integrated).

Most studies on the topic of dynamic interaction between CDS and bond spread have been conducted on corporate CDS where researchers almost unanimously reached a

[30] This paper is written in 2007 but published in 2011.
[31] CTD option gives the privilege to the protection buyer to deliver the lowest valued bond of an entity, in case of credit event (default) pertaining to that entity, even if that CDS protection was not bought for that specific bond. Thus, CTD option provides protection against all bonds of par maturity issued by the entity in case of default event.

consensus that the CDS market leads bond market in efficient pricing of credit risk (Li & Huang, 2011). For example Blanco et al. (2005), Longstaff, Mithal, and Neis (2005), Zhu (2006), Forte and Pena (2009), among others; all study the aforementioned relationship and the price discovery process of credit risk in CDS and bond markets using data on investment grade entities. They find that CDS leads the bond market in terms of efficient pricing of default risk. On the other hand, in the case of sovereign sCDS, findings of price discovery studies on default risk are mixed (Augustin, 2014). For example Chan-Lau and Kim (2004), Fontana and Scheicher (2010), and Hassan et al. (2011b)[32] report mixed and conflicting findings regarding the dominance of any particular market in pricing the default risk. The sCDS market is different than corporate CDS market. For example, in the corporate CDS market, the credit prices are determined based on both public and private information but in the case of sCDS, only publicly available information drives credit risk determination. Likewise, in the case of corporations, measurement of credit risk relies on key variables such as industrial characteristics, management competency, asset to debt ratio etc. For sovereign entities, these measurement criteria are not applicable to compute their default risk. Therefore, the sovereign CDS market is distinctive and results of the studies on their dynamic interaction between CDS and bond spread differ from those of corporate studies.

In general, the first major study of the efficient pricing of credit risk involved corporate entities and was conducted by Blanco et al. (2005). Using data from 2nd Jan 2001 to 20th June 2002, they test the no-arbitrage relation between CDS spread and bond spread for 33 North American and European high-investment grade firms. They find that CDS market contributes, on an average, 80% towards price discovery of credit risk. Thus their main

[32] Though out of seven countries they analyzed, bond market leads CDS market in terms of price discovery of default risk

finding suggests that CDS market indisputably lead bond market in determining the default premium. Forte and Pena (2009) also find that CDS market leads bond market as price discovery of credit risk mainly takes place in CDS market. Using the dataset for 17 non-financial European and North American firms from 12 September 2001 to 25 June 2003 they also find that equity market is most superior, in efficiently pricing the credit risk, followed by the CDS market. Furthermore, their study highlights the existence of time variation in market information share of all the capital markets and raises the importance of sub-sample analysis. From 1st Jan 1999 to 31st Dec 2002, Zhu (2006) analyzed 55 corporate entities' CDS and bond spread and finds that CDS moves ahead of bond spread. In short extant literature in the area involving corporate entities unanimously report the superior informational characteristics of the CDS spread compared to the bond spread in pricing the default risk of the entity.

Regarding studies involving sovereigns, Li (2009) investigates the hedging capability of sovereign CDS, using data from 1999 to 2002, over the credit risk of underlying traded government bonds. He finds the lack of contribution of CDS market in pricing the credit risk and confirms the lag of one week in price adjustment of credit risk in CDS market in response to bond market. Thus, he concludes that the sovereign CDS market is not informational efficient in measuring credit risk. This finding about total domination of bond market in measuring the credit risk is not surprising at all as the CDS market was nascent back in 1999, thus investors might still have staunchly followed the bond market to proxy for default premium.

Ammer and Cai (2011)[33] tested the efficient pricing of credit risk in sovereign CDS

[33] Study was conducted in 2007 but published in 2011.

and bond market for nine emerging countries from 26th February 2001 to 31st March 2005 and report relatively mixed results about the dominance of any particular market. However, among seven countries where authors confirm the long-run relationship between two time series, they conclude that the CDS spread only marginally leads the bond spread (page#382). This contribution of CDS series is significantly smaller than what Blanco et al. (2005) have reported in their study of corporate entities i.e., 58% vs.80% contribution, on average. Their study is unique as before this publication research in the area was primarily focused on investment grade corporate entities and this was the first article written on efficient credit risk pricing of emerging sovereign entities (page 370). They also analyzed the impact of cheapest-to-deliver (CTD)[34] option, incorporated in CDS contract, on the spread of derivatives and found that as the sovereign entity becomes riskier, sCDS spread increased more than one-to-one in relation to bond spread. Therefore, when credit risk increases or distance to default decreases, then it would be more likely that CDS would be in-the-money and protection buyer will exercise the CTD option of CDS (similar to put option on the underlying asset). This indeed results in steeper slope of CD-BS relationship where CDS spread increases more than the increase in credit spread of underlying bond. This may result in positive CDS basis[35] for sovereign entities with low rating and high yield offerings in their study. They attribute the price leadership to the liquidity factor of the market.

Li and Huang (2011) examine the price discovery process of credit risk of sovereign emerging entities between January 2004 and July 2008 and find that CDS market have shown tremendous improvement –though bond market is still marginally ahead in efficiently pricing

[34] Details given in the footnote# 13 earlier.
[35] CDS basis is the difference between the CDS premium and bond spread which suggests the price of the credit risk of the bond.

the default risk— in contributing towards the price discovery process of the risk compared to what previous studies had reported. They attribute it to the increase in the development of CDS trading on sovereign debt in the aftermath of the financial crisis and availability of better quality CDS data in recent years. Li and Huang (2011) also suggest further investigation towards exploring the interaction between sCDS and bond market in order to update the literature on informational efficiency of these markets towards credit risk pricing down the lane (page 223).

Within the context of the financial crisis, Coudert and Gex (2013) analyze sCDS and bond spread of 18 sovereign (including eight emerging countries) and 17 financial entities in panel regression. They find that in case of financial institutions and high-yield sovereigns, CDS market leads bond market in efficient pricing of default risk. However, the opposite is true for low-yield sovereigns. The authors attribute their findings to the liquidity of relative markets and assert that the more liquid market leads the other market in terms of efficient pricing of risk. They further find that the role of the CDS market as a leader in price discovery amplifies during financial crisis as more participants express their thoughts in an efficient way about true price of default risk in CDS market during turmoil. The main drawback of their paper, along with short time-period, is that they did not provide country level results about price leadership between two spreads. Country level results are more useful as 95% of sCDS market is comprised of single name CDS. Therefore, hedge funds managers, reporting dealers, regulators and other stakeholders may be more interested in country level findings.

Using weekly frequency data for emerging countries from January 2004 to October 2009, Hassan et al. (2011b) find mixed results and do not conclude that any particular market dominates the other market in efficient pricing of the credit risk. Likewise, Aktug, Nayar, and Vasconcellos (2013) report mixed results and find that in some cases the CDS market lead but in others, bond market leads. The main issue with their study could be an "asynchronous data bias" as they have used daily data for CDS spreads and monthly data to construct bond spreads. This is acknowledged by the authors (page 253, footnote#2) and they suggest future studies could be conducted using daily data for both series (page 258). In short, studies in the area on emerging markets have mainly reported mixed results, though with the development and maturity of sCDS market the role of CDS market in pricing the sovereign credit risk has improved substantially.

Apart from the studies on emerging countries, recent research has focused on studying the relationship in developed countries. Developed sovereign entities are different from their emerging counterparts due to differences in macroeconomic conditions. The importance of the sCDS market in developed countries increased after the financial crisis as prior beliefs about the sovereign credit risk of these countries were optimistic. In fact underlying sovereign bonds of developed countries were considered as risk-free assets and therefore the sCDS market was not very developed for these sovereign entities. Results of developed countries are also not definitive as few studies recognize the dominance of the CDS market, but few others find bond market leads CDS market. Varga (2009), and Delis and Mylonidis (2011) reported CDS market being the lead market but Coudert and Gex (2013) and Arce, Mayordomo, and Peña (2011) find the dominance of bond market in price discovery process of sovereign credit risk. In sum, unlike studies on corporate entities where CDS spread leads bond spread, studies on sovereign entities report mixed results. However, after the crisis emphasis was given to advanced sovereign countries and not much research was conducted on emerging sovereign entities.

2.3 Hypothesis Development

Based on the theoretical framework which proposes that CDS and bond credit spread move in tandem with each other in the long-run and share a common stochastic trend with non-zero bond basis (Blanco et al. (2005), Zhu (2006), Baba and Inada (2009), Varga (2009), Carboni (2011), Hassan, Ngene, and Yu (2011a), Aktug et al. (2013), Coudert and Gex (2013), among others), I propose the following:

H1: *sCDS spread and bond spread will be co-integrated in the long run with non-zero CDS-bond basis*

Unlike corporate CDS, where existing literature consistently repot the superior informational content of CDS spread over bond spread in pricing credit risk, studies in sovereign CDS report mixed findings. Though recent studies report the improved role of sCDS in efficient pricing of default risk, e.g. Li and Huang (2011) etc., but its domination in setting the credit risk's price has not yet been firmly established owing to conflicting results reported in extant literature.

To participate in the CDS market, investors do not immediately need to outlay cash, therefore more participants should express their thoughts with relative ease without much barrier. This should actually result in quick impounding of information in sCDS prices which suggests that it must be more efficient in pricing the risk. However due to widely reported mixed results in this area of research and following Ammer and Cai (2011), Li and Huang (2011), Hassan et al. (2011a) and among others, I do not specifically propose any single hypothesis. Hence, I propose the following hypotheses:

H2 (a): *sCDS market will lead bond market in efficient pricing of credit risk and will contribute more to the price discovery process of default risk between two markets.*

H2 (b): *Bond market will lead sCDS market in efficient pricing of credit risk and will contribute more to the price discovery process of default risk between two markets.*

H2 (c): *There could be an equal magnitude of feedback between two markets while efficiently setting the price of credit risk.*

2.4 Data and Methodology

I have performed the empirical analysis on eight emerging countries i.e., Brazil, Colombia, Mexico, Panama, Peru, Russia, Turkey and Venezuela. Selection of these countries is contingent on the availability of sCDS and underlying bond yield data with 5-years to maturity[36]. Data for these countries is collected and processed from January 2006 to April 2016 from Bloomberg except for Panama and Peru. In the case of Panama I have not been able to interpolate the bond yield spread data beyond 4th October 2010 and data for Peru starts from 13th December 2006. Being synthetic, CDS contracts are available virtually in unlimited quantities but this is not the case with bonds as they are issued only in limited numbers. Therefore, following Blanco et al. (2005), Forte and Pena (2009), Levy (2009), among others; I acquire the 5-year yield data by linear interpolation of the yields of two sovereign bonds. One of which should have a maturity between three to five years and the other's maturity should fall within five to seven years, for each trading day from 02nd January 2006 to 21st April 2016.

[36] I use CDS and bond yield data with 5-year maturity because CDS with 5 years maturity is the most liquid instrument traded in the CDS market. This has also been widely used by the extant literature in this area.

While selecting the bonds to create yield-to-maturity data of 5-year maturity bonds for each trading day, all CUSIPs of the bonds maturing between 01st January 2009 and 21st April 2023 are collected for aforementioned eight emerging countries from the Bloomberg. While collecting the CUSIPs I have ensured the following criteria:

1) Bonds must not have any specific conditions, like they must not be a) callable, b) puttable, or c) convertibles. Therefore, only bullet bonds are considered to interpolate the yield data.
2) Bonds must not be a) securitized, b) structured, or c) subordinated.
3) Bonds must be issued in US Dollar and have fixed rate coupons, and
4) The issue must not be a private placement.

The time span of data analyzed for eight countries is given in table 2.1.

Finally 5-year swap rate is subtracted from the yield-to-maturity of 5-year bond for each trading day for every country to construct a time series of bond credit spread. Swap rate is used as proxy for risk-free rate as many studies argue that instead of treasury rates they are actually considered as risk-free rate by market participants. These studies include but are not limited to Blanco et al. (2005), Forte and Pena (2009), Fontana and Scheicher (2010), Ammer and Cai (2011), among others. Daily time series of CDS and bond spreads with 5-year maturity are plotted for every country and shown in the figure 2.1.

Table 2.1: Time span of CDS and bond spread data used for each country in first essay

Countries	Data span
Brazil	02nd January 2006 to 21st April 2016
Colombia	02nd January 2006 to 21st April 2016
Mexico	02nd January 2006 to 21st April 2016
Panama	02nd January 2006 to 04th October 2010
Peru	13th December 2006 to 21st April 2016
Russia	02nd January 2006 to 21st April 2016
Turkey	02nd January 2006 to 21st April 2016
Venezuela	02nd January 2006 to 21st April 2016

The extant literature (Baba & Inada, 2009; Blanco et al., 2005; Coudert & Gex, 2013; Forte & Pena, 2009; Zhu, 2006) among others, generally use reduced form vector autoregressive (VAR) model with error correction term [also called vector error correction model (VECM)] to measure the long-run dynamic interaction between these two related markets. VECM is based on the statistical concept of a co-integration between two non-stationary time series. Irrespective of the fact that two time series are individually non-stationary *I(1)* but if, in the long-run, any specific linear combination between them is stationary *I(0)* then these time series are considered co-integrated and, therefore, one can empirically employ VECM to analyze the dynamic relation between them. Because of the theoretical relationship between *CDS* and *BS* time series[37] —as CDS-basis needs to be zero under strict arbitrage relation or given market frictions at least they should move in tandem with each other with non-zero basis— VECM seems to be an appropriate choice to study the lead-lag role between these non-stationary series over longer period of time.

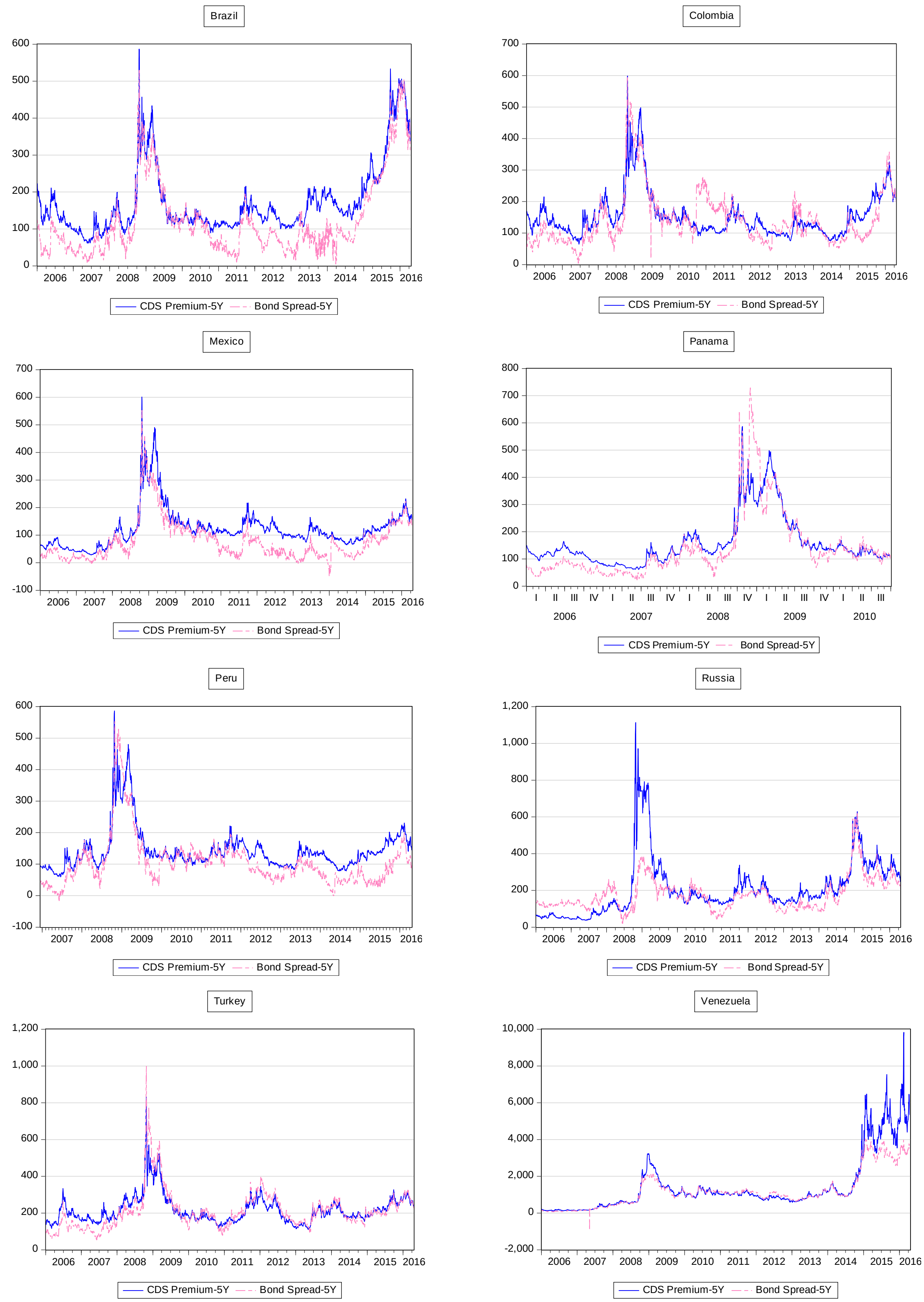
The theoretical relationship between two markets will be given by the following regression equation:

$$CDS_{i,t} = \alpha_0 + \alpha_1 BS_{i,t} + \varepsilon_{i,t} \qquad (1)$$

Where '$CDS_{i,t}$' and '$BS_{i,t}$' are the CDS and bond spread of country '*i*' at time 't', respectively. Theoretically, given both time series are *I(1)*, a long-run relationship (LRSHP) should hold between them or in other words there exist unique 'α_0' and 'α_1' such that $\varepsilon_{i,t} = CDS_{i,t} - \alpha_0 - \alpha_1 BS_{i,t}$ is *I(0)*. In this way I consider CDS and bond credit spread co-integrated. Ideally, in this case,'α_0' should be theoretically zero and 'α_1' should be equal to one if a parity relation holds between two time series as both represent the same credit risk for

[37] Aforementioned studies mostly report these time series as *I(1)*.

Figure 2.1: Daily time series of CDS and bond spreads for eight countries



Sovereign CDS premiums and bond spread. This figure plots the time series of 5-year USD denominated sovereign CDS prices and bond spreads (calculated after deducting the 5-year risk-free swap from yield to maturity of 5-year bonds). Data is from 2nd Jan 2006 to 21st Apr 2016 except for Panama (Peru) where data ends (starts) on 4th Oct 2010 (13th Dec 2016).

sovereign entity '*i*' in two different markets. In simple words, if there is one unit movement in '$BS_{i,t}$' in either direction then there should be a movement of equal magnitude in an identical direction in '$CDS_{i,t}$' under strict arbitrage relation. Therefore, under parity relation both series should be co-integrated with a co-integration vector [1, $\alpha_{1=}$ -1, $\alpha_{0=}$ 0].

However, due to market frictions this theoretical relation does not hold and a researcher may find a co-integrated relationship between '$CDS_{i,t}$' and '$BS_{i,t}$' with '$\alpha_{0\neq}$ 0' and/or '$\alpha_{1\neq}$ 1'. Whenever, there will be any deviation from this long-term relationship of *CDS* and *BS* series then either one series or both subsequently adjust in up-coming periods, in order to restore the equilibrium relationship. This brings us to an interesting research question of which market, on average, reveals the true price of the credit risk more efficiently by quickly impounding new information. The market which will significantly adjust in subsequent periods, after the deviation from the LRSHP is triggered, will be considered as less efficient as it adjusts to the publicly available information in the other market. The other market will be considered as the lead market as it is efficiently pricing the credit risk and responsible for the actual deviation from equilibrium relationship. This dynamic interaction of the LRSHP of CDS and BS can be empirically modeled through VECM, a restricted vector autoregressive (VAR) with error correction term, and given by the following set of system equations:

$$\Delta CDS_{i,t} = \lambda_1 (\varepsilon_{i,t-1}) + \sum^{k}_{j=1} \beta_j \Delta CDS_{t-j} + \sum^{k}_{j=1} \delta_j \Delta BS_{t-j} + u_{1i,t}$$

$$\Delta BS_{i,t} = \lambda_2 (\varepsilon_{i,t-1}) + \sum^{k}_{j=1} \beta_j \Delta CDS_{t-j} + \sum^{k}_{j=1} \delta_j \Delta BS_{t-j} + u_{2i,t} \quad (2)$$

The VECM model in the system of equations consists of two parts. First an 'error correction term' which represents the deviation from the LRSHP in the previous trading day and second, the lagged first order differences (Δ) of *CDS* and *BS* series. In system of equations (2), $u_{1i,t}$ and $u_{2i,t}$ are i.i.d. residuals and $\varepsilon_{i,t-1} = CDS_{i,t-1} - \alpha_1 BS_{i,t-1} - \alpha_0$ is an error correction term and treated as deviation, between *CDS* and *BS*, from the LRSHP. Here the co-integration co-efficients of the two series are embedded in the error correction term and normalized into a vector $[1, \alpha_1, \alpha_0]$. First restriction of $[1, \alpha_1 = -1, \alpha_0 \neq 0]$ is imposed on the co-integration vector to check whether spreads in both markets move by the same magnitude. If null of $\alpha_1 = -1$ is not rejected then VECM is applied with the same imposed restriction otherwise VECM is applied by using the vector $[1, \alpha_1 \neq -1, \alpha_0 \neq 0]$.

In the case of disequilibrium from long-run relationship, I am interested in determining the magnitudes and signs of 'λ_1' and 'λ_2' which are error correction coefficients and would help me to examine which market is the leader in efficiently pricing the credit risk. 'λ_1' and 'λ_2' can be considered as speed of adjustment of CDS and BS series, respectively, which bring respective markets back to equilibrium in current period (t) after deviation from the LRSHP is observed in the previous trading day (t-1). If $|\alpha_1| >= 1$ **(**$|\alpha_1| < 1$**)**, it means that the level of *CDS* is higher (lower) than the level necessary to keep the system in equilibrium in period 't-1' and to bring the pair of series back to equilibrium, in current period 't', CDS spread should decrease (increase) and/or BS should increase (decrease). That is, 'λ_1' < 0 ('λ_1' > 0) and 'λ_2' > 0 ('λ_2' < 0). If only one of the lambda has the correct sign and is statistically significant, it suggests that only one market is efficiently contributing towards the price discovery process of the sovereign credit risk and the series which adjusts significantly does not lead the process. Thus, if $\lambda_1(\lambda_2)$ is statistically significant then bond (CDS) market will lead the price discovery process of credit risk and *CDS* (cash) market will adjust to remove pricing error observed in the previous trading day. Both markets will contribute towards the efficient pricing of credit risk if both lambdas are significantly different than zero.

If co-integration does not exist between the two time series then I have only used the second part, listed in the system of equations (2), and totally omit the error correction term. Such models, are called VAR models. VAR models are designed to capture the joint dynamics among multiple time series. They are the system of multiple linear equations where each endogenous variable is a function of lagged values of all endogenous variables in the system including its own lags. Therefore, in order to determine whether VAR or VECM should be used one needs to go through two steps. In the first step, determine whether both series are non-stationary. In the second step (if the answer to the first step is affirmative) determine if both series are co-integrated?

Due to the low power of the Augmented Dickey Fuller test in rejecting the unit root, I have also used the Phillips-Perron test to test the presence of unit root of each series for every country. Once non-stationarity is established for each pair of series for eight countries I have conducted the Johansen co-integration test to determine the linear combination between them; which should be *I(0)* if both series hold LRSHP, and therefore are co-integrated. Once both conditions are satisfied I have conducted VECM to determine the nature of dynamic interaction between both series. Else, I have adopted VAR to capture the joint dynamics between CDS and BYS series. In case of VAR, Granger Causality test is conducted. In this case, the null hypothesis is the joint test that all the lagged variables of CDS do not Granger-cause BS and are given as under:

$$\beta_1 = \beta_2 = \beta_3 = \beta_4 \dots \dots \dots \dots = \beta_k = 0$$

Likewise the joint test that all the lagged variables of BS does not Granger-cause CDS is given as follows:

$$\delta_1 = \delta_2 = \delta_3 = \delta_4 \dots \dots \dots \dots = \delta_k = 0$$

Like any econometric model, VECM needs to be properly specified i.e., the number of lags need to be determined before using these models. Two widely used information criteria in choosing lags are Akaike Information Criteria (AIC) and Schwarz Information Criteria (SIC). While choosing for appropriate lags through aforementioned criteria I have also controlled for serial correlation of error terms in the system of equations (Fung, Sierra, Yau, and Zhang (2008); Wooldridge (2010)). However, there is no universal approach in selecting the information criteria for choosing the appropriate number of lags. Forte and Pena (2009) and Ammer and Cai (2011) along with others have used SIC. On the other hand, Blanco et al. (2005), Carboni (2011) and Avino and Cotter (2014) have used AIC. I would use SIC to select the optimal number of lags as it suggests parsimonious model and penalize for having additional lags if they unnecessarily reduce degree of freedom without contributing much in determining the unbiased coefficients of error correction terms in Vector Error Correction Model.

Finally, I have used two traditional methods of price discovery; both of which rely on VECM. These two popular common factor models are Gonzalo and Granger (1995) and Hasbrouck (1995)[38]. HAS (1995) assumes that price volatility reflects new information, and therefore the market which contributes more to the variance of innovation of common trend is also deemed to contribute most to the price discovery ((Blanco et al., 2005). On the other hand, GG (1995) suggests that market which adjusts least to the price movements in the other

[38] Hereafter GG (1995) and HAS (1995), respectively.

market is deemed to be more efficient and leads the price discovery process. Most of the price discovery studies involving corporate CDS and cash markets report the results of both methods ((Blanco et al., 2005; Forte & Pena, 2009), but sovereign studies usually report results of GG (1995) only ((Ammer & Cai, 2011; Coudert & Gex, 2013)). I have reported the results of both methods which would be an additional contribution of this study to this strand of literature involving sovereign entities. Using equation (2), according to GG (1995), the contribution of the CDS market towards the price discovery process of default risk is given as follows:

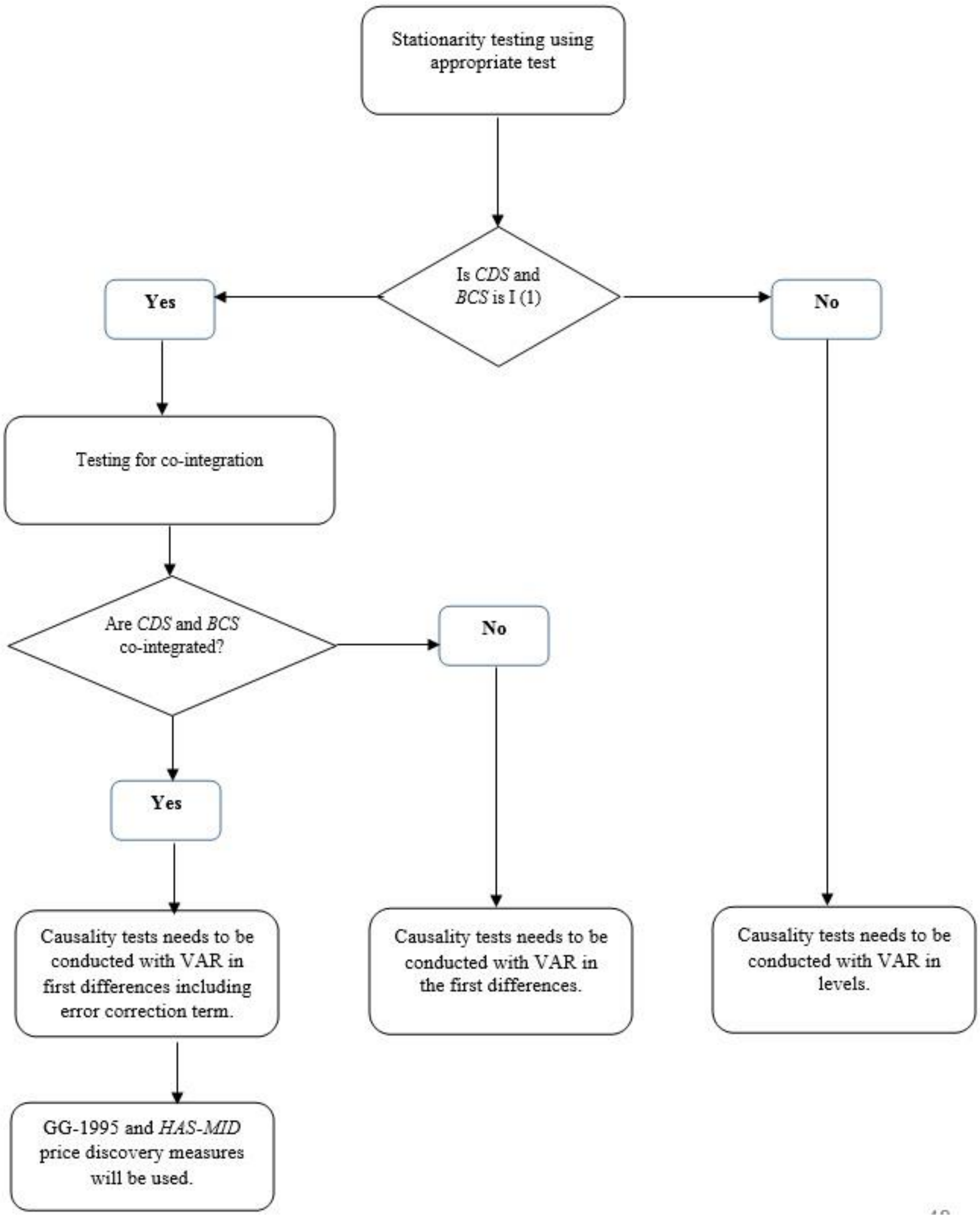
$$GG_{cds} = {}^{\lambda_2}\!/_{(\lambda_2 - \lambda_1)}$$

On the other hand, the average of lower bound and upper bound of the Hasbrouck measure is used for determining the efficiency of a particular market in pricing the credit risk. For CDS market contribution, Hasbrouck lower and upper bounds are given as under:

$$HAS_{lower,cds} = \frac{\lambda_2^2\left(\sigma_1^2 - {}^{\sigma_{12}^2}\!/_{\sigma_2^2}\right)}{\lambda_2^2\sigma_1^2 - 2\lambda_1\lambda_2\sigma_{12} + \lambda_1^2\sigma_2^2} \qquad HAS_{upper,cds} = \frac{\left(\lambda_2\sigma_1 - {}^{\lambda_1\sigma_{12}}\!/_{\sigma_1}\right)^2}{\lambda_2^2\sigma_1^2 - 2\lambda_1\lambda_2\sigma_{12} + \lambda_1^2\sigma_2^2}$$

The variance-covariance matrix of $u_{1i,t}$ and $u_{2,t}$ is represented by σ_1^2, σ_2^2 and σ_{12}. Due to its construction, the informational share of the first variable used in the VECM system is exaggerated (for details see Hasbrouck (1995)). Therefore, following the advice of Baillie, Booth, Tse, and Zabotina (2002) I will report the average of these two bounds (*HAS-MID*). The value of *GG-1995* and *HAS-MID* will be bounded between 0 and 1. If the value of these two measures will be more than 0.5 then it would suggest that a more than 50% contribution towards credit risk pricing is done by sCDS market e.g. if the values of these two measures are 0.69 then it shows that a 69% contribution comes from sCDS market to the PDP of sovereign credit risk.

Figure 2.2: Sequence of steps applied to use VAR or VECM methodology in first essay



Source: Author

The summary of aforementioned steps is summarized in figure 2.2 which is mentioned pictorially on the previous page that how author proceed to decide when to use VAR or VECM.

2.5 Results

Descriptive statistics

Eight emerging countries have been selected for the purpose of analysis in this paper. These sovereign entities include Brazil, Colombia, Mexico, Panama, Peru, Russia, Turkey and Venezuela[39]. CDS and bond yield spread (yield-to-maturity) data has gathered using the procedure mentioned under the data and methodology section. This data covers the time-span from January 2nd, 2006 to April 21st, 2016 except for Panama and Peru. For Panama I have not been able to construct the bond yield series beyond 4th Oct 2010 and for Peru data starts from 13th Dec 2006[40]. After subtracting the par maturity swap rate from bond yield data I ended up getting bond credit spread (BS) which is the proxy of sovereign credit spread from bond market. Table 2.2 presents the descriptive statistics for CDS and BS series for all eight countries in an alphabetic order. First descriptive statistics are mentioned for CDS series for a country followed by the BS series statistics. By looking at skewness and kurtosis measures for both series of each country it can be clearly noticed that underlying stochastic data generating process is not co-variance stationary. Thus, as we go through the time period data seems to come through different underlying probability distribution functions. This evidence supports the case of having non-stationary data series which can formally put to test using unit root testing tools. Descriptive statistics show that Venezuela's credit risk is the highest

[39] Their selection is based on the availability of the data.
[40] Thus data for all other countries is from 2nd January 2006 to 21st April 2016 except for Panama and Peru. For Panama it is from 2nd January 2006 to 4th October 2010 and for Peru it is from 13th December 2006 to 21st April 2016.

and most volatile among the countries analyzed. Controversial policies of President Nicholas Maduro make the case for such high credit risk of Venezuela as CDS prices have crossed the mark of 9,500 basis points in 2015. On an average CDS buyer needs to pay 14.44% (1,444 basis points) to protect the value of Venezuelan bond which is very high compared to other countries in our analysis. For other countries this percentage ranges from a mere 1.23% (for Mexico) to 2.16% (for Turkey).

Unit root testing

After suspecting non-stationarity in the credit risk series (CDS and BS) of every country I have formally conducted the unit root test for each one of them. I have used Augmented Dickey-Fuller (ADF) test whose null hypothesis suggests that there is a unit root and series is not stationary. If the null is rejected at 5% level of significance then I can conclude that a particular series is stationary. While using ADF, SIC is used to determine the optimal lag selection. Due to the low power of this test I have complemented the findings of the ADF test with that of the Phillpis-Perron (PP) unit root test. One advantage of PP test over ADF is that one does not need to give lags to test the unit root. Result of unit root testing is presented in table 2.3.

Results of ADF and PP tests show that both CDS and BS series are non-stationary for each country as null hypothesis of the unit root of these tests have not been rejected at 5% level of significance. In the case of CDS-bond basis series, tests suggest the presence of stationarity across the board except for Venezuela. This refers to the fact, that apart from Venezuela, given I would establish a co-integration relationship between CDS and BS series for all countries, I may employ VECM model to determine which market is efficient and dominates the process of sovereign credit risk price discovery (PDP) in the long-term.

Table 2.2: Descriptive statistics of daily CDS and bond spreads data

Descriptive Statistics for CDS and Bond Spread Series (Jan 2006-Apr 2016)*								
	Mean	Median	Max.	Min.	Std. Dev.	Skewness	Kurtosis	Obs
				Brazil				
BRCDS	173.26	138.92	586.86	61.50	94.58	1.86	5.92	2689
BRBS	123.80	89.60	529.50	4.91	103.30	1.67	5.27	2689
				Colombia				
CLCDS	153.25	134.91	598.66	64.70	70.14	2.31	9.62	2689
CLBS	143.73	120.75	593.72	3.90	85.27	1.86	7.20	2689
				Mexico				
MXCDS	122.95	111.38	601.21	28.17	71.58	2.33	10.54	2689
MXBS	78.53	54.50	552.30	-48.55	74.11	2.04	8.47	2689
				Panama				
PNCDS	158.61	129.67	586.86	61.33	91.21	1.93	6.34	1241
PNBS	140.83	106.77	728.67	22.80	119.29	2.23	8.23	1241
				Peru				
PECDS	143.11	128.68	586.28	59.66	66.10	2.69	11.87	2442
PEBS	106.12	92.11	552.35	-16.10	79.95	2.49	11.17	2442
				Russia				
RSCDS	210.32	169.66	1113.38	36.88	154.95	2.01	8.13	2689
RSBS	176.82	161.45	628.30	19.69	86.42	1.59	6.89	2689
				Turkey				
TKCDS	216.49	196.62	831.31	110.95	76.24	2.25	11.74	2689
TKBS	210.59	193.20	1000.70	54.55	102.43	2.18	10.95	2689
				Venezuela				
VNCDS	1444.56	988.86	9834.90	117.63	1502.33	1.97	6.32	2689
VNBS	1212.72	1029.75	4055.40	-948.83	956.19	1.26	3.91	2689

*All data is from 2nd January 2006 to 21st April 2016, except in the case of Panama and Peru. In the case of Panama data ends on 4 October 2010 and for Peru data starts from 13 December 2006.

Co-integration tests

Once it has been established that both credit risk series exhibit unit root, I have formally tested for the presence of co-integration relationship between them using the Johansen test for co-integration. Co-integration suggests that though individual series are non-stationary any linear combination between them must be stationary. Simply put, these series move in tandem with each other and the distance between them exhibits stationarity.

Table 2.3: Unit root test results of daily CDS, bond, and basis spreads (full sample)

Unit Root Test for CDS, BS and CDS-bond Basis (Jan 2006 - Apr 2016)						
	CDS Spread		Bond Spread		CDS basis	
Country	ADF	PP	ADF	PP	ADF	PP
Brazil	I(1)	I(1)	I(1)	I(1)	I(0)	I(0)
Colombia	I(1)	I(1)	I(1)	I(1)	I(0)	I(0)
Mexico	I(1)	I(1)	I(1)	I(1)	I(0)	I(0)
Panama	I(1)	I(1)	I(1)	I(1)	I(0)	I(0)
Peru	I(1)	I(1)	I(1)	I(1)	I(0)	I(0)
Russia	I(0)	I(1)	I(1)	I(1)	I(0)	I(0)
Turkey	I(1)	I(1)	I(1)	I(1)	I(0)	I(0)
Venezuela	I(1)	I(1)	I(1)	I(1)	**I(1)**	**I(1)**

Results of Augmented Dickey Fuller (ADF) and Phillips-Perron (PP) are given in this table for CDS, BS and CDS-bond basis series. CDS-bond basis is the difference between CDS and BS and this series needs to be stationary if I intend to use VECM model on CDS and BS series to find which market is more efficient in incorporating new information. Data is from 2nd Jan 2006 to 21st Apr 2016 for all series, except for Panama where date ends on 4th Oct 2010 and Peru where it starts from 13th Dec 2006. Results suggest that both ADF and PP tests are unable to reject the null hypothesis of unit root for both credit risk series for each country at 5% level of statistical significance. Therefore, suggesting that both series are non-stationary for each country. In the case CDS-bond basis both tests have rejected the null of unit root for all countries except in the case of Venezuela where tests suggest the presence of stationarity (mentioned in bold).

The maximum of one co-integration rank (co-integration relationship) can exist between two series. Results of Johansen test for co-integration is given in table 2.4; second column of the table mentions the trace statistics of aforementioned test with corresponding p-values. Here, null hypothesis is that co-integration rank is zero i.e. there does not exist any relationship between two series. Clearly this null is rejected for all countries except for Venezuela, mentioned in bold, where trace statistics is 8.07 with a p-value of 0.46. This suggests that apart from Venezuela a common trend exists between both credit risk series for all the countries thus referring to the fact that both markets are following the same fundamentals and pricing the credit risk similarly.

Table 2.4: Co-integration test on CDS and bond spreads (full sample)

	Co-integration Test on CDS and BS Series (Jan 2006 to Apr 2016)	
	Null hypothesis	
	Zero co-integration vector (P-value)	Co-integration vector is [1,-1,c] (P-value)
Brazil	26.25 (0.00)	1.51 (0.22)
Colombia	23.98 (0.00)	0.44 (0.51)
Mexico	31.36 (0.00)	0.07 (0.79)
Panama*	20.73 (0.00)	4.46 (0.03) α1= 1.07***
Peru**	44.01 (0.00)	0.72 (0.40)
Russia	23.80 (0.00)	3.13 (0.08) α1= 1.49***
Turkey	33.16 (0.00)	2.23 (0.14)
Venezuela	8.07 (0.46)	N/A

* Data is from Jan 06 to Oct 10

** Data is from Dec 06 to Apr 16

Second column shows the results of trace statistics and their p-value (in brackets) of Johansen tests of co-integration which is applied on CDS spread and bond spread of each country. SIC has used for lags selection. Results show that only in the case Venezuela I am not able to reject the null hypothesis of no co-integration. In the third column restriction of [1,-1, c] is applied on co-integration vector with non-zero constant. Results show that only in the case of Panama and Russia null hypothesis of [1, α1= -1] is not rejected where slope parameter is greater than unity and significant at 1% level. For Panama and Russia table mentions the empirical value of α1 is 1.07 and 1.49, respectively. **N/A** indicates that restriction cannot be applied in the absence of a co-integrating vector.

Next step after establishing a co-integration relationship is to test the theoretical values of co-integration vector by applying restriction on it. Under parity relation both series should be co-integrated with a co-integration vector [1, α_1= -1, α_0= 0]. Meaning that values of both of these series must be equal to each other as we move along the timeline. However, this is a stringent restriction and I have applied a modified restriction with non-zero constant as my proxy for risk-free rate is imperfect. Thus, I have applied a restriction of [1,-1] on the co-integration vectors of all countries except Venezuela where I have already found no co-integration relation. This restriction means that whenever there is a unit increase in bond spread then there is a corresponding increase in CDS price by the same magnitude. Results of this restriction are mentioned in the third column of table 2.4 with respective p-values. Here null hypothesis suggests that there exists a co-integration vector [1,-1]. Results show that except for Panama and Russia this restriction is applicable on all other countries. In the case of Panama and Russia co-integration vector is reported as [1,-1.07] and [1,-1.49], respectively. It appears that participants in the CDS market consider Panama and Russia's sovereign bonds very risky and increase in their credit risk in the bond market triggers acute response in their CDS prices. Ammer and Cai (2011) claim that due to cheapest to deliver (CTD) option embedded in CDS contracts we may have such co-integration vector as increase in BS by one unit will likely to trigger an increase of credit risk price by more than one unit in the CDS market. My findings on vector restriction are different than that of Ammer and Cai (2011) as they found absence of [1,-1] restriction for all 7 countries included in their sample with mean vector value of [1,-1.30] for all countries. Also, unlike them my finding suggests that series are co-integrated for Russia since 2006[41]. However, in the case of Venezuela both studies suggest the absence of co-integration.

Price discovery measures using VECM

To determine which market is more efficient in pricing the credit risk of emerging sovereign entities I have employed VECM on paired series where co-integration relation has been established. SIC is employed as an optimal lag selection criteria. In equation two, first part is an error correction term and '$\varepsilon_{i,t-1}$' represents the deviation from the long-term relationship between CDS and BS series. In order to move back to the parity relationship either CDS or BS or both needed to adjust in time 't' by removing the discrepancy which is encountered in period 't-1'. The signs and statistical significance of 'λ_1' and 'λ_2' actually determine which market is the price leader and which market is the follower. If '$|\alpha_1|>1$' then

[41] Ammer and Cai (2011) data ends on 31st March 2005

lambda-1 should be less than zero and/or lambda-2 should be greater than zero i.e., '$\lambda_1 < 0$' and/or '$\lambda_2 > 0$'. In other words if CDS series is above its co-integration level in period 't-1' then in time 't' either CDS series moves back towards BS series or BS moves up towards CDS series or both should move towards each other to remove the discrepancy. If lambdas will have wrong sign then series will not converge and co-integration relation will not be observed. In case of '$|\alpha_1| < 1$' one should have opposite values of lambdas to remove the discrepancy to reinstate long-run relation in the following period i.e. '$\lambda_1 > 0$' and/or '$\lambda_2 < 0$'. Results in table 2.5 show that both series converge for all countries in order to rectify the deviation from long run relationship as, given $|\alpha_1| > 1$, λ_1 is negative and λ_2 is positive for all countries. However, there is an interesting trend which can be observed that is for most countries λ_1 is not significant and λ_2 is statistically significant at 1% level. This suggests that mostly its bond spread series which adjust to restore the co-integration relation and thus, follows the CDS market to price sovereign credit risk. CDS market seems to dominate the bonds market in efficient pricing of credit risk as it is bond market which adjusts to publicly available information. Only exceptions are Mexico and Turkey where it appears that bond market is the price leader as CDS spread adjusts at 1% level of significance to the publicly available information in its respective bond market. Also, in the case of Turkey there is a two way interaction between both series as both converge significantly to remove the discrepancy in the following period.

To exactly quantify the level of contribution each market made to the price discovery process of sovereign credit risk over the period of January 2006 to April 2016, I have used Gonzalo and Granger (1995) and Hasbrouck (1995) methods. Their results are given in table

2.5, column six for GG (1995) and column nine for Hasbrouck (1995). GG measure mentions the contribution of CDS market in discovering the credit risk of a country.

Table 2.5: CDS & bond market contribution to PDP of sovereign credit risk (full sample)

Contribution of CDS and Bond Markets to Price Dicovery Process from Jan 06 - Apr 16*								
						Hasbrouck		
	λ_1	t-Statistic	λ_2	t-Statistic	GG (CDS)	Lower	Upper	Mid (CDS)
Brazil	-0.007	-1.49	**0.021**	**3.51**	74.60%	0.44	0.92	68.10%
Colombia	-0.003	-0.97	**0.015**	**3.12**	82.78%	0.57	0.94	75.73%
Mexico	**-0.019**	**-3.81**	0.005	0.95	21.65%	0.04	0.40	22.10%
Panama	-0.004	-0.54	**0.030**	**2.54**	89.08%	0.58	0.97	77.81%
Peru	-0.007	-1.61	**0.019**	**3.96**	73.86%	0.65	0.89	76.94%
Russia	-0.004	-1.62	**0.007**	**3.62**	62.13%	0.51	0.90	70.20%
Turkey	**-0.012**	**-2.01**	**0.037**	**5.03**	75.05%	0.51	0.92	71.25%
Mean					68.45%	0.47	0.85	66.02%
Median					74.60%	0.51	0.92	71.25%
Mean excluding Mexico					76.25%	0.54	0.92	73.34%
Median excluding Mexico					74.83%	0.54	0.92	73.49%

*Data for all countries starts from 2nd January 2006 to 21st April 2016 except for Panama and Peru. For Panama it ends on 4th October 2010 and for Peru it starts from 13th December 2006. This table reports two widely used price discovery measures i.e., Gonzalo and Granger (1995) and Hasbrouck (1995) along with upper and lower bound of the Hasbrouck. These measures represent the contribution of CDS market in pricing the sovereign credit risk in long-run and are calculated based on λ1 and λ2 obtained from following equation and restriction of α1 equals unity is imposed except in the case of Panama and Russia:

$$\Delta CDS_{i,t} = \boldsymbol{\lambda_1} \left(CDS_{i,t-1} - \alpha_0 - \boldsymbol{\alpha_1} BS_{i,t-1}\right) + \sum\nolimits^{k}_{j=1} \beta_j \Delta CDS_{t-j} + \sum\nolimits^{k}_{j=1} \delta_j \Delta BS_{t-j} + u_{1i,t}$$

$$\Delta BS_{i,t} = \boldsymbol{\lambda_2} \left(CDS_{i,t-1} - \alpha_0 - \boldsymbol{\alpha_1} BS_{i,t-1}\right)) + \sum\nolimits^{k}_{j=1} \beta_j \Delta CDS_{t-j} + \sum\nolimits^{k}_{j=1} \delta_j \Delta BS_{t-j} + u_{2i,t}$$

$$GG\,(CDS) = \lambda_2 \big/ (\lambda_2 - \lambda_1)$$

$$HAS_{lower,cds} = \frac{\lambda_2^2 \left(\sigma_1^2 - \sigma_{12}^2 \big/ \sigma_2^2\right)}{\lambda_2^2\sigma_1^2 - 2\lambda_1\lambda_2\sigma_{12} + \lambda_1^2\sigma_2^2} \qquad HAS_{upper,cds} = \frac{\left(\lambda_2\sigma_1 - \lambda_1\sigma_{12} \big/ \sigma_1\right)^2}{\lambda_2^2\sigma_1^2 - 2\lambda_1\lambda_2\sigma_{12} + \lambda_1^2\sigma_2^2}$$

Finally $HAS_{mid,cds}$ (last column in table-5) is simply the average of $HAS_{lower,cds}$ and $HAS_{upper,cds}$.

Highest contribution of CDS market in discovering credit risk is measured for Panama where GG measure suggests 89.08% of the contribution is made by the derivative market. On the other hand, though not statistically significant, only 21.65% contribution is made in the case of Mexico by the derivative market. It means that among the countries in our analysis CDS market is most efficient for Panama and most inefficient for Mexico. There is one way interaction found between two markets for all countries except for Turkey where both markets (as both lambdas of Turkey are significant) actively interact with each other in pricing the credit risk. Hasbrouck measure supports the finding of GG measure and result indicates that during the period of 2nd January 2006 to 21st April 2016 mean (median) contribution towards price discovery of sovereign credit risk by derivative market is 68.45% (74.60%) and 66.02% (71.25%) according to GG and Hasbrouck measures, respectively. Further if we exclude Mexico, where cash market dominates the discovery process, then mean contribution of derivative market increases to 76.25% according to GG measure and 73.34% according to Hasbrouck measure. Therefore, during the whole period CDS market is more efficient in incorporating the new information and bond market adjusts itself to the publicly available information in CDS market. This finding is in-line with the intuition that market participants in derivative market can express their sentiments about the sovereign credit risk more efficiently compared to cash market as they actually do not need to outlay cash to express their opinion about sovereign credit risk.

Sovereign credit risk price discovery measures in pre-crisis, crisis and post-crisis era

In their study of analyzing credit risk price discovery process among European stock, bond and CDS markets, Forte and Pena (2009) find time varying contribution to price discovery by different markets. Therefore, in order to determine whether the dominance of derivative market changes over time I have conducted detailed subsample analysis. I have divided the time period in pre-crisis (period-1), crisis (period-2) and post-crisis (period-3) time periods. Period-1 starts from 2nd Jan 2006 and ends on 12th Sept 2008 when Lehman Brothers files for bankruptcy[42]. For crisis period (period-2) my data spans from 15th Sept 2008 to 31st Dec 2009[43]. Finally period-3 starts from 1st Jan 2010 and ends on 21st Apr 2010[44]. In order to use VECM to find which market efficiently prices credit risk during each of these periods I have repeated the process which has performed earlier over the whole time period for each country.

First unit tests have been conducted for CDS, BS and basis series and their results are given in table 2.6 for all three periods. Apart from Russia, CDS and BS series for every country have been found to be non-stationary during the pre-crisis period. During the same period CDS-bond basis appears to be stationary except for Russia. Because Russia's result for period-1 is different than other countries, they are mentioned in bold in the table. Thus, given formal co-integration test suggest that pair of credit risk series are co-integrated in period-1, we can apply VECM on the CDS and BS series for each country (except Russia) to determine which market contributes more efficiently to credit risk pricing.

For period-3 (post-crisis) table 2.6 suggest the same finding as both credit risk series are I(1) and basis series is I(0) for every country including Russia. Therefore once co-integration will be established between CDS and BS, VECM can be applied to each pair of credit risk series for all countries during period-3. However, during period-2 unit root tests' findings on credit and basis series are quite different than other two periods. Here, either test has rejected null of unit root for any of the credit risk series or unable to reject the null of unit

[42] For Peru pre-crisis period start from 13th Dec 2006 and ends on 12th Sept 2008.
[43] 13th and 14th Sept 2008 were Saturday and Sunday, respectively.
[44] For Panama post-crisis period starts from 1st Jan 2010 and ends on 4th Oct 2010.

root for basis series. For example in the case of Brazil, on one hand both ADF and PP tests have rejected the unit root presence for CDS and BS series but on the other hand also unable to reject it for the CDS-bond basis series.

Table 2.6: Unit root test results of daily CDS, bond, and basis spreads (sub-samples)

Order of Integration of CDS and BS Series during pre-Crisis, Crisis and post-Crisis Periods								
			CDS spread		BS		CDS-Bond Basis	
Country	Period	% of total observations	ADF	PP	ADF	PP	ADF	PP
Brazil	Period-1	26.22%	I(1)	I(1)	I(1)	I(1)	I(0)	I(0)
crisis	Period-2	12.61%	I(0)	I(0)	I(0)	I(0)	I(1)	I(1)
	Period-3	61.18%	I(1)	I(1)	I(1)	I(1)	I(0)	I(0)
Colombia	Period-1	26.22%	I(1)	I(1)	I(1)	I(1)	I(0)	I(0)
	Period-2	12.61%	I(1)	I(1)	I(0)	I(0)	I(0)	I(0)
	Period-3	61.18%	I(1)	I(1)	I(1)	I(0)*	I(0)	I(0)
Mexico	Period-1	26.22%	I(1)	I(1)	I(1)	I(1)	I(0)	I(0)
	Period-2	12.61%	I(1)	I(0)	I(0)	I(0)	I(1)	I(1)
	Period-3	61.18%	I(1)	I(1)	I(1)	I(1)	I(0)	I(0)
Panama	Period-1	56.81%	I(1)	I(1)	I(1)	I(1)	I(0)	I(0)
	Period-2	27.32%	I(0)	I(0)	I(0)	I(0)	I(0)	I(0)
	Period-3	15.87%	I(1)	I(1)	I(1)	I(1)	I(0)	I(0)
Peru	Period-1	18.76%	I(1)	I(1)	I(1)	I(1)	I(0)	I(0)
	Period-2	13.88%	I(1)	I(0)*	I(1)	I(1)	I(1)	I(1)
	Period-3	67.36%	I(1)	I(1)	I(1)	I(1)	I(0)	I(0)
Russia	**Period-1**	**26.22%**	**I(1)**	**I(1)**	**I(0)**	**I(1)***	**I(1)**	**I(1)**
	Period-2	**12.61%**	**I(1)**	**I(1)**	**I(1)**	**I(1)**	**I(0)**	**I(0)**
	Period-3	61.18%	I(1)	I(1)	I(1)	I(1)	I(0)	I(0)
Turkey	Period-1	26.22%	I(1)	I(1)	I(1)	I(1)	I(0)	I(0)
	Period-2	12.61%	I(0)	I(0)	I(0)	I(0)	I(0)	I(0)
	Period-3	61.18%	I(1)	I(1)	I(1)	I(1)	I(0)	I(0)
Venezuela	Period-1	26.22%	I(1)	I(1)	I(1)	I(1)	I(0)	I(0)
	Period-2	12.61%	I(1)	I(1)	I(0)	I(0)	I(1)	I(1)
	Period-3	61.18%	I(1)	I(1)	I(1)	I(1)	I(0)	I(0)

I(1) means the series is non-stationary and I(0) represents stationarity. *sign suggests that result of one unit test is different than others. Here period-1(pre-crisis), period-2(crisis) and period-3(post-crisis) correspond to 01st Jan 2006 to 12th Sep 2008, 15th Sep 2008 to 31st Dec 2009 and 01st Jan 2010 to 21st Apr 2016, respectively. However in case of Panama period-3 refers to 01 Jan 2010 to 04 Oct 2010 and for Peru period-1 comprises of 13 Dec 2006 to 12 Sep 2008.

Findings of unit root tests are similar for all other countries except Russia where the pair of credit risk series exhibits non-stationarity and basis series is found to be stationary. Because in period-2 (crisis period) Russia's finding is different than all other countries therefore it is mentioned in bold. Now, if a formal co-integration test suggests that CDS and BS series are co-integrated for Russia in period-2 then VECM can be used to determine that which market contributes heavily in pricing Russian credit risk during crisis. It appears that VECM cannot be applied on the pair of credit risk series for other countries during period-2, however formal test for co-integration is conducted on both spreads of every country during period-2 and reported in panel 'B' of table 2.7.

Table 2.7 presents the results of Johansen test for co-integration on the pair of credit risk series for each country for pre-crisis, crisis and post crisis periods in panels A, B and C, respectively. In panel 'A' as expected null of no co-integration is not rejected for Russia. This is expected because in table 2.6 it has already been reported that CDS-bond basis is not stationary for Russia during the pre-crisis period. For Peru the co-integration vector is reported as [1, α_1= -1.37] which suggests that CDS market participants considered Peru's bonds more risky in pre-crisis duration compared to other countries as a unit increase in its credit risk in the cash market triggered more than a unit increase (1.37 to be exact) in the CDS market. The most interesting findings are reported for the crisis period in panel B. Apart from Russia, both credit risk series are not co-integrated for any country during the crisis period suggesting that there is an absence of common trend between them as they stop following the same fundamentals. Both markets start pricing the sovereign credit risk differently when panic hits the financial system. This also suggests that two different types of participants with entirely opposite perceptions about credit risk are active in these markets; one being active only in the CDS and the other in the bond market. Results of panel C reports that once crisis period ends then this pair of credit risk series again start co-moving with each

Table 2.7: Co-integration test of CDS and bond spreads (sub-samples)

Co-integration Test on CDS and BS Series Sub-periods		
	Null hypothesis	
	Zero co-integration vector (P-value)	Co-integration vector is [1, -1] (P-value)
Panel-A		
Brazil	22.62 (0.00)	0.33 (0.56)
Colombia	32.39 (0.00)	0.58 (0.44)
Mexico	15.49 (0.04)	1.18 (0.28)
Panama	23.89 (0.00)	0.47 (0.49)
Peru	17.19 (0.02)	11.48 (0.00) α1= 1.37***
Russia	7.35 (0.54)	N/A
Turkey	26.71 (0.00)	0.38 (0.53)
Venezuela	29.03 (0.00)	0.53 (0.47)
Panel-B		
Brazil	11.57 (0.13)	N/A
Colombia	6.83 (0.60)	N/A
Mexico	8.82 (0.38)	N/A
Panama	12.75 (0.12)	N/A
Peru	8.64 (0.40)	N/A
Russia	20.23 (0.00)	12.07 (0.00) α1= 1.89***
Turkey	15.36 (0.06)	N/A
Venezuela	12.42 (0.14)	N/A
Panel-C		
Brazil	20.62 (0.00)	1.94 (0.16)
Colombia	14.94 (0.06)	0.62 (0.43)
Mexico	21.01 (0.00)	3.15 (0.08)
Panama	24.64 (0.00)	0.96 (0.33)
Peru	18.76 (0.02)	1.61 (0.21)
Russia	18.99 (0.01)	0.69 (0.40)
Turkey	34.21 (0.00)	0.59 (0.44)
Venezuela	18.70 (0.02)	15.53 (0.00) α1= 1.72***

Second column shows the results of trace statistics and their p-value (in brackets) of Johansen test of co-integration which is applied on CDS spread and bond spread of each country. SIC has used as optimal lag selection criteria. In the third column restriction of [1,-1, c] is applied on co-integration vector with non-zero constant. **Panel 'A'** presents the results for pre-crisis period or period-1. Period-1 spans from 2nd Jan 2006 to 21st April 2016 except for Peru where its starts from 13th Dec 2006. **Panel 'B'** presents the result of crisis period (period-2) and it spans from 15th Sept 2008 to 31st Dec 2009. Finally, **Panel 'C'** presents the results for post-crisis period which starts from 1st Jan 2010 till 21st April 2016 except for Panama where it ends at 4th Oct 2010. Results show that during period-1 only in the case of Russia co-integration relation is not established between the pair of credit risk series. And during crisis period only for Russia co-integration relation between the CDS and bond market has established. Therefore, Russia seems unique in terms of findings of co-integration test. In post-crisis era co-integration relationship has established for all the countries. Results from column three also show that in the case of Peru, Russia and Venezuela null hypothesis of [1, α1= -1] is not rejected during period-1, period-2 and period-3, respectively where slope parameter is greater than unity and significant at 1% level (***mentioned). **N/A** indicates that restriction cannot be applied in the absence of a co-integrating vector.

other for all the countries even for Russia where they were not found to co-move in pre-crisis era.

After running the tests for unit root and co-integration I have identified the periods for all the countries where I can use VECM to find that which market contributes heavily to the price discovery process of sovereign credit risk. Summary of these periods is given in table 2.8. Column numbers 3, 4 and 5 report the cross (X) signs for pre-crisis, crisis and post-crisis periods, respectively where co-integration has reported for different countries and VECM can be used. Clearly it can be seen that during period-1 (period-2) VECM cannot (can) be applied on Russian CDS and BS series only. However, during post-crisis period VECM will be applied to the pair of credit risk series for all the countries.

Results of the VECM applied on cross (X) marked periods (period 1, 2 and 3 in table 2.8) are given in table 2.9. These results show a total domination of CDS market in efficient pricing of sovereign credit risk. Panel 'A' reports the result of pre-crisis period and show that according to GG measure of price discovery CDS market contribution ranges from 37.17% to 99.59%. If Mexico is not considered then this contribution ranges within 70.77% and 99.59% clearly suggesting the superiority of CDS market in impounding new information. This domination continues even during the post-crisis period (see Panel 'B') where, excluding Mexico and Venezuela, CDS market contribution ranges within 61.32% and 99.63%. For Mexico I have found that default risk price is mainly discovered in bond market for both pre and post crisis era. In the case of Venezuela, sign of second error correction co-efficient i.e., λ_2 is wrong as it is expected to be positive rather negative if both series need to be converged. However, λ_2 is not statistically significant thus showing that bond series does not move and all adjustment will be done by CDS series to remove the discrepancy in order to maintain a long-run relationship with bond spread.

Table 2.8: Periods where vector error correction model needs to be applied

VECM Applied to Sovereign CDS and Bond Spread Series				
Country	Overall period	Pre-crisis (period-1)	Crisis (period-2)	Post-crisis (period-3)
Brazil	X	X	-	X
Colombia	X	X	-	X
Mexico	X	X	-	X
Panama	X	X	-	X
Peru	X	X	-	X
Russia	X	-	X	X
Turkey	X	X	-	X
Venezuela	-	X	-	X

Cross (X) signs show that where I have found co-integration relationship between two series. It can be notices that Russian is unique as, unlike other countries, its pair of series is not co-integrated during pre-crisis period. However, it is the only country for which I have found co-integration during the crisis period. I have applied reduced form VECM on credit series for periods against which 'X' is mentioned for a given country.

This has led to an extreme finding of 0% contribution of CDS market for Venezuela as CDS market is totally inefficient. During the crisis period only for Russia the pair of default risk series are co-integrated and CDS market dominates the PDP by 62.36%. Hasbrouck suggests even higher contribution of CDS market i.e. 81.22%. Panel 'D' of table 2.9 reports the mean and median contribution of CDS market in pre and post crisis periods. Because of few extreme cases I would prefer to discuss the median contribution of CDS series. According to GG (Hasbrouck) measure 72.16% (63.49%) contribution is done during the pre-crisis period and 70.75% (62.20%) during the post-crisis period by the CDS market.

My findings for the overall, pre-crisis, post-crisis and crisis periods suggest that CDS market is instrumental in efficient pricing of sovereign credit risk. For all the countries, on an

Table 2.9: CDS & bond market contribution to PDP of credit risk in sub periods

Contribution of CDS and Bond Markets to Price Dicovery Process in Period1,2 and 3								
						Hasbrouck		
	λ_1	t-Statistic	λ_2	t-Statistic	GG (CDS)	Lower	Upper	Mid (CDS)
Panel A								
Brazil	-0.010	-1.08	**0.025**	**1.96**	72.16%	0.39	0.88	63.49%
Colombia	-0.018	-1.56	**0.048**	**2.98**	72.67%	0.32	0.91	61.29%
Mexico	**-0.025**	**-2.87**	0.015	0.81	37.17%	0.05	0.39	21.87%
Panama	-0.011	-1.19	**0.059**	**3.49**	84.02%	0.57	0.93	75.09%
Peru	-0.009	-0.94	**0.023**	**2.01**	70.77%	0.38	0.84	61.13%
Turkey	-0.023	-1.51	**0.058**	**3.26**	72.01%	0.45	0.90	67.83%
Venezuela	-0.001	-0.09	**0.308**	**5.23**	99.59%	0.96	1.00	98.21%
Panel B								
Brazil	-0.006	-1.51	**0.22**	**3.13**	78.32%	0.54	0.87	70.77%
Colombia	0.000	-0.02	**0.015**	**2.89**	99.63%	0.89	1.00	94.32%
Mexico	**-0.042**	**-1.96**	0.009	0.78	17.24%	0.13	0.19	16.17%
Panama	-0.025	-1.71	**0.043**	**2.93**	63.17%	0.24	0.76	50.15%
Peru	-0.002	-0.62	**0.017**	**3.22**	89.65%	0.54	0.82	85.88%
Russia	-0.009	-1.47	**0.014**	**2.13**	61.32%	0.23	0.89	55.98%
Turkey	-0.010	-1.43	**0.044**	**4.73**	81.09%	0.41	0.96	68.42%
Venezuela	**-0.043**	**-3.99**	-0.005	-1.31	0.00%	0.09	0.10	9.61%
Panel C								
Russia	-0.007	-0.76	**0.012**	**3.03**	62.36%	0.67	0.96	81.22%
Panel D								
Mean for pre-crisis period					72.63%	-	-	64.13%
Median for pre-crisis period					72.16%	-	-	63.49%
Mean for post-crisis period					61.30%	-	-	56.41%
Median for post-crisis period					70.75%	-	-	62.20%

Panel A, B and C reports the results of contribution of CDS market to the price discovery process of sovereign credit risk during pre-crisis, post-crisis and crisis periods, respectively. Two price discovery measures are reported, GG(1995) is column seven and HAS-Mid(1995) in column 9. Where appropriate restriction of [1,α1= -1] on co-integration vector is applied. Panel 'D' reports the mean and median contribution of CDS market during pre and post crisis periods.

average CDS contributes towards the PDP within the range of 60% to 75%. Mostly there is one way interaction between two default series as bond market appears to follow CDS market except in the case of Mexico. During the post-crisis another exception is Venezuela where all the contribution is made by the bond market. During crisis both markets start pricing sovereign default risk differently and no common trend persist between the pair of credit risk series. This is quite intuitive as both markets appear to stop following same fundamentals during the times of distress.

Thus, I have found total support for hypothesis H(1) for the whole period and for pre and post crisis periods. H(1) is not supported during the crisis period as from 7 out of 8 countries I found no common stochastic trend between two credit risk series. Moreover, it is reported that CDS market dominates the bond market during all the periods except during crisis where VECM cannot be applied due to the absence of co-integration. On an average CDS contributes to the credit risk PDP within the range of 60% to 75%, thus supporting H2(a) and rejecting H2(b) & H2(c).

Possible explanation of CDS market's domination

As a potential reason for the CDS market's domination, I cite the difference in liquidity between the two markets. This is intuitive in that the more liquid market should have more investors impounding information in it and thus, contribute more towards the price discovery of credit risk. To examine this theory, I calculate the mean ratio of the bond to CDS bid-ask spread in each market and compute the correlation of this ratio with the GG (CDS) and Hasbrouck (CDS) measures of price discovery for each period except during the crisis. A higher ratio suggests that the CDS market is more liquid since the bond market would have a higher bid-ask spread, which is a sign of relative illiquidity.

As per the results reported in table 2.10, the correlation is close to +1 for all three periods examined. Specifically, in Panel 'A', where the results for the overall period are reported, the correlation is 0.86 between the market liquidity ratio and GG measure and 0.73 for the Hasbrouck measure. Thus, it suggests the CDS market is more likely to price sovereign credit risk efficiently when the bond market is illiquid. Results are also similar for the pre-crisis period (Panel B) and post-crisis period (Panel C), with the liquidity explanation gaining even more credence during the post-crisis period as correlations are almost +1 (0.98 and 0.97).

Finally, table 2.11 reports the Wald test of Granger Causality for periods in which no co-integration between the synthetic and cash markets is observed (please see table 2.8 again). Granger causality tests whether lagged values of one market predict current values of the other, after controlling for the lags of the subject market. In Panel 'A', the results for Venezuela for the aggregate time period are reflected in which a two-way interaction between the markets is observed, suggesting the presence of a feedback loop (p-values in parenthesis shows the null of no granger causality rejected at 1% level of significance). This overall "average" result is not surprising in light of the findings in table 2.9 which document that during the pre-crisis period, the CDS market contributed 99.59% to the PDP, which then fell to 0% post-crisis. In addition, it underscores the importance of sub-sample analysis in order to detect the existence of regime dependence. In Panel 'B', which reports the results for Russia during the pre-crisis period, I conclude that only the bond market granger causes the CDS market (null is rejected at 1% level of statistical significance) as there is no flow in the other direction. Finally, Panel 'C' reports results for all countries for the aggregate time period except Russia, which is excluded due to co-integration. As can be seen, CDS spreads

Table 2.10: Correlations between ratio of bond to CDS bid-ask spread & PD measures

Correlation between ratio of bond to CDS bid-ask spreads and price discovery measures					
	Mean CDS bid-ask spread	Mean Bond bid-ask spread	Mean Ratio of bond to CDS bid ask spread	GG (CDS)	HAS(CDS)
	a	b	c	d	e
Panel A					
Brazil	0.04	0.14	3.66	74.60%	68.10%
Colombia	0.06	0.23	3.92	82.78%	75.73%
Mexico	0.09	0.19	2.15	21.65%	22.10%
Panama	0.04	0.15	3.73	89.08%	77.81%
Peru	0.07	0.22	3.17	73.86%	76.94%
Russia	0.07	0.19	2.63	62.13%	70.20%
Turkey	0.05	0.14	2.86	75.05%	71.25%
Corr(c,d)				0.86	
Corr(c,e)					0.73
Panel B					
Brazil	0.03	0.09	3.06	72.16%	63.49%
Colombia	0.05	0.14	2.98	72.67%	61.29%
Mexico	0.07	0.17	2.47	37.17%	21.87%
Panama	0.03	0.11	3.84	84.02%	75.09%
Peru	0.06	0.16	2.73	70.77%	61.13%
Turkey	0.07	0.18	2.66	72.01%	67.83%
Venezuela	0.05	0.18	3.61	99.59%	98.21%
Corr(c,d)				0.80	
Corr(c,e)					0.75
Panel C					
Brazil	0.04	0.15	3.86	78.32%	70.77%
Colombia	0.05	0.22	4.66	99.63%	94.32%
Mexico	0.09	0.14	1.56	17.24%	16.17%
Panama	0.04	0.12	2.99	63.17%	50.15%
Peru	0.06	0.22	3.66	89.65%	85.88%
Russia	0.07	0.23	3.27	61.32%	55.98%
Turkey	0.04	0.13	3.31	81.09%	68.42%
Venezuela	0.98	0.74	0.73	0.00%	9.61%
Corr(c,d)				0.98	
Corr(c,e)					0.97

Panel A reports the bid-ask spreads of the two markets and the correlation between the mean ratio of two spreads and price discovery measure for the whole period. These correlations are highlights in panel A. The same items are reported in Panel B and C for pre-crisis and post-crisis periods, respectively.

have predictive power for bond spreads in the majority of countries, while in the case of Mexico and Venezuela, two way causal flow is observed. However, interestingly for Peru

Table 2.11: Granger causality tests conducted in the first essay

Granger Casuality Tests		
	Null hypothesis	
	BS does not granger cause CDS	CDS does not granger cause BS
Panel A		
Venezuela	108.23 (0.00)	176.43 (0.00)
Panel B		
Russia	37.65 (0.00)	0.03 (0.98)
Panel C		
Brazil	0.72 (0.70)	31.38 (0.00)
Colombia	1.18 (0.55)	14.01 (0.00)
Mexico	8.75 (0.01)	22.60 (0.00)
Panama	3.49 (0.18)	21.98 (0.00)
Peru	2.26 (0.13)	00.66 (0.42)
Turkey	0.53 (0.77)	208.78 (0.00)
Venezuela	9.08 (0.01)	25.56 (0.00)

This table reports the Wald test of granger causality of two credit spreads during the periods where I have not find co-integration between them. Here, null hypothesis states that lagged values of both spreads do not predict eachothers' present values after controlling its own lags. Within the parenthesis p-value is given. Panel A, B and C show the results for the overall period, pre-crisis and crisis periods, respectively. Panel 'A' shows that during the overall period both CDS and BS of Venezuela granger cause each other. Meaning, that for the overall period some or all the lagged values of Venezuelan BS (CDS) predicts the current value of CDS (BS) after controlling for CDS (BS) own lags. Thus, there is a feedback loop for Venezuela during the overall period. Panel 'B' shows the result of Russian spreads during pre-crisis period and reports that only BS granger causes CDS. Finally, Panel 'C' reports that during the crisis mostly CDS leads the BS for all the countries with few exceptions (Peru with no feedback loop, and Mexico and Venezuela with feedback loop).

there is no causality documented in either direction, suggesting cross market efficiency.

2.6 Implications

These findings have major implications for financial stakeholders, as they highlight the importance of the CDS market in pricing sovereign credit risk in emerging countries. Specifically, this study documents that the contribution of the CDS market to the price discovery process has increased over time and that investors in the sovereign bond market need to closely monitor the CDS market in order to make well-informed financial decisions. Theoretically, profitable trading opportunities can arise by responding to newly revealed information in the derivative market via the buying or selling in the cash market, depending on the price signal sent. However, it is important to keep in mind that the relative liquidity of these two markets plays a key role in the price discovery process. If for some reason liquidity in the bond market increases then the CDS market could lose its advantage or the bond market could conceivably become the price leader in setting credit risk prices.

The findings are also relevant for regulators, suggesting that the banning of participants from actively participating in the CDS market when they don't have a physical position in the underlying bond is very detrimental to the overall financial system as it reduces liquidity and thus introduces inefficiency in the price discovery process, at least in the case of emerging countries. In line with this rationale, it appears that the 2011 ban on "naked" CDS trading in Europe was not the right decision. If CDS markets are the price leader, then it is imperative that everyone should be allowed to participate in them.

Finally, the finding during the financial crisis that both markets start pricing credit risk differently is a reminder that investors should not blindly follow rules and that during times of extreme distress, markets may not price in risk rationally[45].

2.7 Conclusion

This essay studies the relative contributions of CDS and bond markets to the sovereign credit risk price discovery process for eight emerging countries (Brazil, Colombia, Mexico, Panama, Peru, Russia, Turkey and Venezuela) from 2006 to 2016. Although this topic has

[45] Although it is important to note that Granger causality tests suggest that CDS spreads still lead bond spreads in four out of seven countries during that time.

been researched previously, findings in the area have been conflicting. In addition, due to the ongoing euro crisis, most of the recent focus in the sovereign price discovery literature has been on developed Eurozone countries. These factors coupled with the fact that credit markets have undergone significant changes in the wake of the financial crisis make this study on emerging countries timely. Moreover, recent events such as China's financial meltdown in 2015, the impact of reduced oil prices on the credit risk of oil exporting emerging countries and the executive order issued by the Puerto Rican governor's office to declare a moratorium on a large portion of debt also re-emphasize the importance of understanding the nature of emerging sovereign credit risk and which credit market prices it more efficiently, the synthetic or the cash market.

As such, this essay contributes to the extant literature in four ways, namely by i) settling the ongoing debate on market efficiency in the area of pricing sovereign default risk, ii) analyzing data over a much longer period of time than done before, enabling a more extended study of the long-run dynamic interaction between two markets, iii) testing for time variance of the result by investigating pre-financial crisis, post-crisis and crisis period subsamples, and iv) operationalizing two different price discovery measures for the first time to check the robustness of the initial findings.

Country level analysis suggests that sovereign CDS generally dominate the price discovery process during tranquil periods, with the bond market simply following its lead. Specifically, the median CDS contribution is more than 70% towards the PDP of sovereign credit risk. This finding is attributed to the greater relative liquidity of the synthetic market. However, during the financial crisis, there is no common stochastic trend observed between CDS and bond spreads, suggesting that during times of extreme distress in the financial system, the markets start to price credit risk differently and independently of one another. Interestingly though, within the context of Granger causality robustness test, even during the crisis period, the CDS market led the bond market for most of the countries. These results have implications for emerging market investors and asset managers who engage in arbitrage between the two markets as well as financial stakeholders who monitor sovereign credit spreads to gauge the level of political and/or default risk in emerging market countries.

3 ESSAY 2: IMPACT OF STATE FRAGILITY ON SOVEREIGN CREDIT DEFAULT SWAP PRICING

3.1 Introduction

Research in the area of pricing determinants of sovereign credit default swaps has primarily focused on country specific macroeconomic fundamentals and global financial factors (Lee, Naranjo, & Sirmans, 2013). Surprisingly, little attention has been paid to explore the relationship between the country specific socioeconomic factors and sovereign CDS pricing. Deviating from the traditional approach of employing global and macroeconomic variables, few studies turned to employ other types of variables to explain derivative pricing. For example, a recent study by Hansen and Zegarra (2016) has established a strong positive relationship between sovereign credit risk and country specific political risk for 12 Latin American countries. Baldacci, Gupta, and Mati (2011) also report that lower level of political risk results in tighter sovereign bond spreads. One important aspect in this regard is the overall state fragility —a construct borrowed from foreign policy literature— as more fragile states are highly likely to default on their debt obligations. Thus, directly raising the cost of their borrowings as measured by the sCDS prices traded on their bonds. This essay will contribute towards the existing literature by formally establishing a relationship between state fragility and the sCDS premium.

In this context, this study is the first to examine how state fragility affects sCDS pricing. There has been disagreement in the foreign policy literature about the true definition of fragile states (for details kindly refer to Call (2008)). Concept of state fragility, its definition and measurement have been described in detail in the book written by Baliamoune-Lutz and McGillivray (2011). According to the authors fragile states are those states which are not able to improve their economic growth and/ or able to reduce the poverty due to their ineffective policies and governance, and poor institutional performance. This results in an inability to absorb the inflow of funds effectively —generated either through aid or loan— and therefore may result in added premium required by the creditors as compensation to bear additional risk. According to the "Fund for Peace" organization's annual report[46] for the year 2014, fragile states are those states which are more inclined to indulge in internal conflicts, thus resulting in mass violence due to fault lines emerged among different identity groups based on religion, clans, class, caste, nationality etc. This situation, obliviously, may push a country towards the brink of failure, thus resulting in higher cost of borrowing.

3.2 Literature Review

Pricing of sCDS has been an important topic of research in finance. Usually there have been two approaches adopted to find the determinants of sCDS prices. The first approach is based on comparing the observed prices with the one suggested by structural model, while the second is based on regression analysis where changes in the sCDS spread is regressed on selected independent variables.

In the later approach, two groups of variables have been identified in the current literature; one group is categorized as "global variables" and the other as "country-specific variables" which may affect the countries' credit risk and therefore, their sCDS prices. While considering country specific variables, the main emphasis rests on macroeconomic fundamentals which affect credit profile of a country.

[46] http://library.fundforpeace.org/library/cfsir1423-fragilestatesindex2014-06d.pdf

Many studies have concluded that global financial variables explain the spread more often than country specific fundamentals. Based on the co-movement of sCDS prices of different countries, the current knowledge proposes a common factor which affects sCDS in the same fashion, as they jump together. This finding was confirmed, among others, by Pan and Singleton (2008), Longstaff, Pan, Pedersen, and Singleton (2011), and Augustin and Tédongap (2014). Using data on developed and emerging countries, Longstaff et al. (2011) report that US equity, high-yield factor and fear factor embedded in VIX[47] are significantly related to sCDS spreads. Their work is built on the theoretical model developed by Pan and Singleton (2008), who demonstrate that the credit risk of Korea, Mexico and Turkey is explained by VIX and the spread between returns on U.S. BB-rated industrial corporate bonds with 10-years maturity and U.S. treasury bills of 6-months maturity.

By decomposing the sCDS spread into systemic and country specific non-systemic components, Ang and Longstaff (2013) suggest that the spread is more related to financial markets thus providing support to the opinion that global variables are more likely to drive sCDS prices. Augustin and Tédongap (2014) show the U.S. macroeconomic uncertainty and U.S. growth consumption are strongly associated with the spread. This finding is robust to the inclusion of CBOE volatility index (VIX), U.S. excess equity return and high-yield and investment-grade bond spreads, among others. Dooley and Hutchison (2009) find that U.S. financial and economic news had a strong impact on the CDS spreads in 14 emerging countries during the financial crisis. Fender, Hayo, and Neuenkirch (2012) show global and regional factors influence CDS spreads more than those related to country fundamentals. In

[47] Ticker symbol for Chicago Board Options Exchange Volatility Index which shows the market's expectation of volatility in next 30 days.

short, aforementioned papers provide evidences that global variables drive sCDS prices more than country specific factors.

In contrast a related strand of literature suggests that country specific variables are also important in explaining the sovereign credit risk spread. Most studies have considered macroeconomic variables, in an attempt to explain the pricing as they seem to be an intuitive choice which can impact the sovereign entities' ability to meet its obligation. While exploring the sCDS pricing of 24 emerging markets, Remolona, Scatigna, and Wu (2008) find the co-existence of both group of factors –global and country specific— in explaining spread. Using spread data of Eurozone area, Caceres, Guzzo, and Segoviano Basurto (2010) mention that during the recent financial crisis, global risk aversion led to increase in prices. However, as the crisis abated in October 2009 country specific fiscal measures appeared as important determinant of sCDS pricing. Aizenman, Hutchison, and Jinjarak (2013) link fiscal space –measured by debt-to-tax and deficits-to-tax— to debt pricing and report an increase of 100 basis points in the debt-to-tax ratio increases sCDS spread by 15 to 81 basis points. In another study, conducted by Aizenman, Jinjarak, and Park (2016), inflation, external debt and term-of-trade volatility appear to increase the spread, while trade openness and fiscal balance decrease it. They also conclude regime shift among economic fundamentals in explaining the spread over the study's time period as importance of variables varies over time during pre-crisis and post-crisis era. Using data from 123 developing countries over the period of 1970-2012, Zeaiter (2015) finds that accumulated arrears on interest payments and principal repayments on the debt serve as effective proxy of sovereign default. He finds that in low-income countries political risk deeply impacts these accumulated arrears. To remain in a safe zone; he suggests that indebted countries should stabilize their exchange rate, prudently manage their debt, and increase transparency in public institutions.

Other studies attempt to determine sovereign CDS spreads in unique way. Cosset and Jeanneret (2015) developed a structural model based on effectiveness of raising the tax revenues and used them effectively to price the sovereign risk. Their aim was to establish a relation between government quality and likelihood of default. They empirically test the model and confirm that efficient tax collection is negatively related to the likelihood of default and, therefore, sCDS spreads. Using sCDS data for Mexico and Brazil, Carr and Wu (2007) argue that spread co-vary with currency option implied volatility. Finally, Lee et al. (2013) show that strong property and creditors' rights are negatively related to CDS prices.

3.3 Hypothesis Development

In their book, Baliamoune-Lutz and McGillivray (2011) describe the concept of state fragility, its definition and how it is measured. According to the authors fragile states are states that cannot improve their economic growth or reduce poverty due to ineffective policies, bad governance, and poor institutional performance. They cannot absorb the inflow of funds —generated either through aid or loan— effectively as a result creditors charge higher premium as compensation for additional risk. According to the "Fund for Peace" annual report for the year 2014, fragile states are more inclined to engage in internal conflicts, thus resulting in mass violence due to fault lines emerged between different identity groups based on religion, clans, class, caste, or nationality. This situation may push a country towards the brink of failure, thus resulting in higher borrowing cost and hence higher sCDS spreads. According to another definition, the fragile state concept is related to the ability of a government to ensure peace and establishment of institutions that serve the population under its jurisdiction. This concept is rediscovered in the context of "war on terror" as western powers considered such states as a threat to their own sovereignty and to world peace (Call, 2008). Therefore, the fragile state concept is also linked with terrorism indicating that the countries are not only subject to terrorist attacks themselves but can also be a breeding ground of such attacks in other parts of the world. In a recent study, Procasky and Ujah (2016) find that terrorism is associated with higher cost of debt for sovereign entities.

Based on above premise and the intuitive relationship between fragility/ instability of the state and its ability to meet its debt obligations, I hypothesize the following:

H3: *A country's* fragility *or instability is positively related to the sovereign credit default swap spreads traded on their sovereign bonds.*

3.4 Data and Methodology

This study uses annual data for 66 countries from 2007 to 2015. My main variable of interest is the "Fragile State Index" (FSI), which has been published regularly since 2006 by Fund for Peace organization for at least 146 countries. This index is constructed based on 12 socio-economic and political-military indicators; where each ranges from 0 to 10 and are added together to form the overall index (Fragile State Index Report-2014[48], page 10). Components measure demographic pressures, refugees and IDPs, uneven economic development, group grievance, human flight & brain drain, poverty & economic decline, state legitimacy, public services, human right violations & rule of law, security apparatus, factionalized elites and external intervention. The baseline panel regression is given as under:

<u>*Baseline regression*</u>

$$\ln(sCDS_{it}) = \alpha_i + \beta_1 \ln(FSI_{it}) + \beta_2\, res_{it} + \beta_3\, infl_{it} + \beta_4 \ln\left(\frac{x}{m}\right)_{it} + \beta_5\, gdp\_growth_{it} + \beta_6 \ln(tyr_t) + \beta_7 \ln(vix_t) + \beta_8 \ln(sp_{it}) + \varepsilon_{it}$$

48 http://library.fundforpeace.org/library/cfsir1423-fragilestatesindex2014-06d.pdf

Where:

$\ln(\boldsymbol{sCDS_{it}})$=*Log of the annual mean of sovereign credit default swaps in basis-points traded on the bond of 5-year maturity for the country 'i' in year 't'(dependent variable)*

$\ln(\boldsymbol{FSI_{it}})$=*Log of fragile state index variable of the country 'i' in year 't' which ranges between 0 to 120 with 0 being least and 120 being most fragile state*[49]*(main variable of interest)*

$\boldsymbol{res_{it}}$=*Ratio of change in annual foreign reserves to total GDP of the country 'i' in year 't'(country-specific variable)*

$\boldsymbol{infl_{it}}$=*Annual inflation (consumer prices) in percentage of the country 'i' in year 't'(country-specific variable)*

$\ln(\frac{\boldsymbol{x}}{\boldsymbol{m}})_{\boldsymbol{it}}$=*Log of the ratio of total annual exports to total imports for the country 'i' in year 't'(country-specific variable)*

$\boldsymbol{gdp\_growth_{it}}$=*Annual GDP growth rate of country 'i' in the year 't' (country-specific variable)*

$\ln(\boldsymbol{tyr_t})$=*Log of the annual mean of US 10-year treasury rate in the year 't' (global variable)*

$\ln(\boldsymbol{vix_t})$=*Log of the annual mean of CBOE-VIX index in the year 't' (global variable)*

$\ln(\boldsymbol{sp_t})$=*Log of the annual mean of S&P500 index in the year 't' (global variable)*

According to the hypothesis developed in this essay, I expect a statistically significant positive correlation between sovereign CDS prices and state fragility. Hence, if a country is perceived more risky and fragile then investors would demand higher interest rates on their

[49] All values are non-zero for this variable in my dataset.

sovereign bonds which in turn leads to higher CDS premiums to protect lenders' investments in the sovereign bonds of these unstable countries.

Data used in this essay comes from many different sources whose details are given in table 3.1. This information along with the description and expected relationship between dependent and independent variables are also presented in the table. The dependent variable will be the log of the annual mean on the 5-year sovereign credit default swap spread in basis points which is gathered from Bloomberg and Datastream. The main variable of interest is the log of fragile state index, which is collected from the website of Fund for Peace organization. Figure 3.1 shows the number of countries whose FSI improved or worsened from 2006 to 2014. It is notable that there is significant variation in the number of countries whose FSI have changed over this time period.

In line with the existing literature (Hilscher and Nosbusch (2010), Longstaff et al. (2011), Aizenman et al. (2013), Topbas (2013), Aizenman et al. (2016), among others), three global variables and four country specific macroeconomic control variables are included in the analysis.

Control variables

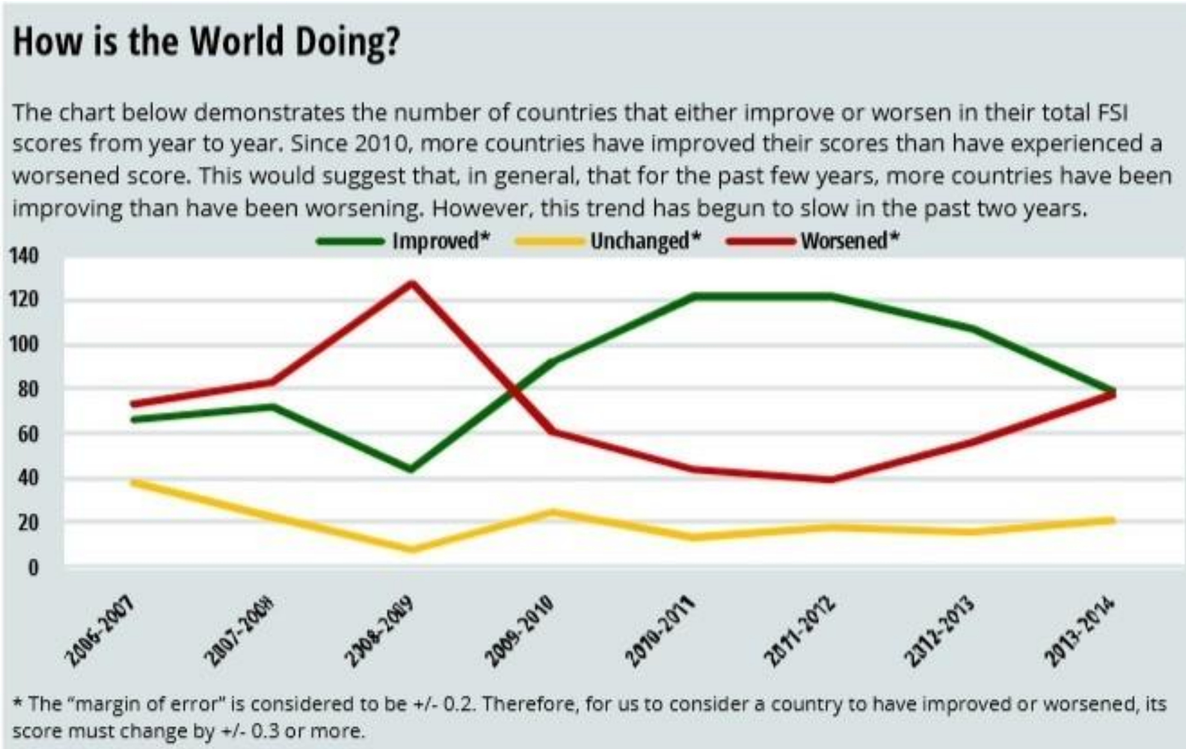
In line with the price determination literature on sovereign CDS, I have controlled for four country specific macroeconomic variables and three country invariant global variables. The four macroeconomic variables are the ratio of the annual change in foreign reserves to total GDP of the country "*res*", the country's annual inflation in percentage "*infl*", the log of the ratio of total annual exports to total imports of a country "*ln(x/m)*" and the annual GDP growth rate of a country "*gdp_growth*". Three global variables which do not vary for all the countries for a given year include; log of the annual mean of 10-year US treasury rate

Table 3.1: Description and sources of data used in second essay

Description and sources of data				
Variable type and name		Description and data source	Expected relationship	Data source
	ln(sCDS)	Log of annual mean of 5-year soveregin CDS in basis points		Bloomberg and Datastream
	ln(FSI)	Log of fragile state index on the scale of 0 to 120, where 120 means high fragility (no zero value reported)	+ (hypothesized) essay 2	fsi.fundforpeace.org
		Control variables		
Country specific variables				
	res	Ratio of change in annual foreign reserves to total GDP	negative	World development indicator
	infl	Annual inflation rate (consumer prices) in precentage	positive	World development indicator
	ln(x/m)	Log of the ratio of annual exports to total imports	negative	World development indicator
	gdp_growth	Annual GDP growth rate in percentage	negative	World development indicator
Global variables				
	ln(tyr)	Log of the annual mean of US 10-year treasury rate	negative	Federal Reserve Bank of St Louis
	ln(vix)	Log of the annual mean of CBOE volatility index	positive	Federal Reserve Bank of St Louis
	ln(sp)	Log of S&P-500 composite index value	negative	Bloomberg

Note: ln(sCDS) is the dependent variable and log of the annual mean of sovereign credit default swaps, and ln(FSI) is the main independent variable in essay two and log of fragile state index. Column three reports the expected relations between dependent variable and independent variables.

Figure 3.1: Number of countries whose FSI improves or worsens from 2006 to 2014



Source: Fragile States Index Report 2014

"*ln(tyr)*", log of the annual mean of COBE-VIX index "*ln(vix)*" and log of the annual mean of S&P500 index "*ln(sp)*".

Existing literature widely reports the negative association of "*res*" and sCDS prices as, ceteris paribus, increases in foreign reserves suggests that a country will be more likely to service its debt thus reducing its credit risk. Second country specific variable is the inflation which positively impacts the protection prices as higher inflation rate demands higher yield on the underlying bond and by definition yield is positively related to CDS spread. The third control variable which affects sCDS prices negatively is the ratio of total annual exports of a country to its import ($\frac{x}{m}$). Positive development in exports of a country relative to its imports reduce the current account deficit and therefore, increases countries ability to meet its obligations. The final macroeconomic variable is GDP growth which intuitively should have negative correlation with the dependent variable.

The three global variables are the log of annual mean 10-year US treasury rates, the COBE-VIX index and the S&P500 index. An increase in 10-year US treasury rate negatively impacts sovereign CDS of other countries. Moreover, an increase in the VIX, which is the market's expectation of volatility in next 30 days, is positively related to CDS price as more fear among investors leads to higher demand on sovereign CDS. Finally, increases in the S&P500 suggests that investors are more interested in high-yielding stock market investment rather than investing in relatively less risky assets like bonds. Thus, the sovereign CDS spread is negatively associated with the S&P500 index.

3.5 Results

Descriptive statistics of all variables are given in table 3.2. This is a panel study with 66 countries from 2007 to 2015. Thus, the maximum number of observations is 594 (66 x 9). One noticeable thing from this table is the low number of observations for the dependent variable *ln(sCDS)*. One reason for having such a low number of sovereign CDS prices is the lack of observations for many countries in 2007, as CDS trading on the sovereign bonds did not start for many countries until 2008. The dependent variable and main variable of interest are shown in bold letters in table 3.2.

Table 3.3 reports the correlation among all the variables present in the baseline regression. The correlations of all the independent variables with the dependent variable are shown in the second column and have expected signs. I expect a strong positive association between the sCDS spread and my main variable of interest i.e., *ln(FSI).* In line with this expectation table 3.3 reports a correlation of +0.52 between these two variables. Likewise, the correlations of all other control variables and the dependent variable are in accordance with the expectations.

Table 3.2: Descriptive statistics of data used in second essay

Descriptive statistics						
		(1)	(2)	(3)	(4)	(5)
variables	labels	observations	mean	sd	min	max
ln(sCDS)	**Sovereign CDS (log)**	541	4.881	1.136	1.837	9.609
ln(FSI)	**Fragile state index (log)**	594	3.901	0.443	2.821	4.713
ln(tyr)	US 10-year treasury rate (log)	594	1.040	0.274	0.593	1.535
ln(vix)	VIX-CBOE volatility index (log)	594	3.011	0.298	2.652	3.487
ln(sp)	S&P-500 composite index (log)	594	7.253	0.237	6.854	7.631
res	Change in foreign reserves/ total GDP	586	0.0152	0.190	-1.178	4.288
infl	Inflation, consumer prices (%)	587	3.636	3.477	-10.07	23.12
ln(x/m)	Ratio of export to import (log)	577	-0.0123	0.223	-0.711	1.023
gdp_growth	GDP growth rate (%)	594	2.741	4.047	-14.81	26.28
	Number of countries	66	66	66	66	66

Table 3.3: Correlation matrix of variables used in second essay

Correlation table									
variables	ln(scds)	ln(fsi)	res	infl	ln(x/m)	gdp_growth	ln(tyr)	ln(vix)	ln(sp)
ln(scds)	1								
ln(fsi)	0.52	1							
res	-0.02	-0.01	1						
infl	0.32	0.31	-0.05	1					
ln(x/m)	-0.22	-0.27	0.03	-0.17	1				
gdp_growth	-0.11	0.26	0.1	0.16	0.09	1			
ln(tyr)	-0.13	0.01	-0.02	0.24	-0.08	0.14	1		
ln(vix)	0.05	0.03	-0.04	0.29	-0.05	-0.18	0.47	1	
ln(sp)	-0.1	-0.04	0.07	-0.21	0.03	0.19	-0.44	-0.84	1

Finally results from the baseline regressions using one way and two way fixed effects are reported in table 3.4. Using the Hausman test, I formally test whether fixed effect or random effect model gives consistent estimates. The null hypothesis is that the estimates of both models are same which is rejected at 1% level, suggesting that estimates from the two models are significantly different. In this situation, fixed effect model is prefered because it gives consistent estimates while random effect model will provide inconsistent estimates.

Table 3.4: Regression results of fixed effect models from second essay

Impact of state fragility on sovereign credit default swaps				
	(1)	(2)	(3)	(4)
variables	FE-Model with main variable only	FE-Model with global variables	FE-Model with all the variables	FE-Model with all the variables
Fragile state index (log)	2.760***	2.031***	1.778***	1.596***
	(4.67)	(3.53)	(3.16)	(2.87)
Change in foreign reserves/ total GDP			-0.067	-0.044
			(-0.52)	(-0.35)
Inflation, consumer prices (%)			0.048***	0.051***
			(3.89)	(3.57)
Ratio of export to import (log)			-1.498***	-1.438***
			(-4.28)	(-4.23)
GDP growth rate (%)			-0.062***	-0.070***
			(-7.22)	(-7.09)
US 10-year treasury rate (log)		-1.474***	-1.308***	
		(-9.96)	(-8.97)	
VIX-CBOE volatility index (log)		0.396**	0.191	
		(2.27)	(1.09)	
S&P-500 composite index (log)		-0.675***	-0.514**	
		(-3.34)	(-2.55)	
Constant	-5.898**	2.108	2.358	-2.735
	(-2.56)	(0.65)	(0.73)	(-1.26)
Observations	541	541	521	521
R-squared	0.09	0.22	0.44	0.49
Number of countries	66	66	66	66
One way fixed effect	YES	YES	YES	NO
Two way fixed effect	NO	NO	NO	YES
Adj. R-Square	0.09	0.11	0.38	0.46

t-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Fixed Effect Models
Dependent variable is log of sovereign credit default swap in basis points

However, I have also reported the regression results from pooled OLS and random effect models in table 3.5.

Table 3.5: Regression results of OLS and random effect models from second essay

Impact of state fragility on sovereign credit default swap using pooled OLS and random effect models

variables	(1) OLS-Model with main variable only	(2) OLS-Model with global variables	(3) OLS-Model with all the variables	(4) Random effect model
Fragile state index (log)	1.375***	1.359***	1.292***	1.509***
	(14.29)	(14.63)	(12.63)	(8.24)
Change in foreign reserves/ total GDP			0.121	-0.051
			(0.63)	(-0.39)
Inflation, consumer prices (%)			0.082***	0.047***
			(6.47)	(4.08)
Ratio of export to import (log)			-0.179	-0.668**
			(-0.96)	(-2.56)
GDP growth rate (%)			-0.073***	-0.065***
			(-6.60)	(-7.53)
US 10-year treasury rate (log)		-1.384***	-1.262***	-1.313***
		(-6.15)	(-5.86)	(-8.84)
VIX-CBOE volatility index (log)		0.322	-0.174	0.125
		(1.20)	(-0.67)	(0.70)
S&P-500 composite index (log)		-0.749**	-0.780***	-0.578***
		(-2.50)	(-2.69)	(-2.92)
Constant	-0.490	5.410*	7.126**	4.076**
	(-1.29)	(1.90)	(2.56)	(1.97)
Observations	541	541	521	521
R-squared	0.27	0.33	0.52	
Adj. R-Square	0.27	0.33	0.51	
Number of countries				66

t-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Pooled OLS and RE Regressions
Dependent variable is log of sovereign credit default swap in basis points

There are four regression results reported in the table 3.4. The hypothesis of this research that is state fragility positively impacts sovereign CDS prices is strongly supported by all four regression models. Model (1) to (3) report the one way fixed effect model results using different specifications and model (4) reports the results of two way fixed effect regression model.

By using fixed effect models I have controlled for the possible endogeniety problem due to time and country invariant omitted variables. In all these regression models, my dependent variable is the log of annual mean of sovereign CDS spreads of different countries. Therefore, after controlling for other variables, results from models (1) to (4) reports that a 1% increase in state fragility causes sovereign CDS to increase by 2.760%, 2.031%, 1.778% and 1.596%, respectively. Model (1) includes only main variable of interest as an explanatory variable; model (2) further adds global variables to the model (1) and model (3) includes all the variables to explain the variation in sovereign CDS prices. In model (2), co-efficients of all global variables are statistically significant with expected signs. Co-effiecients on VIX index indicates that a 1% increase in the index value leads to a 0.396% increase in sCDS prices. Moreover, a 1% increase in US 10-year treasury rate and S&P500 index result in the reduction of sCDS premium by 1.474% and 0.675%, respectively. For model (3), which includes all the variables, results of global variables almost stay the same except for the VIX co-efficient as it does not remain significant even at 10% level.

In model (3), co-efficients on all the country specific macro-economic variables also have expected signs. The only exception, in terms of statistical significance, is the co-efficient on the ratio of change in annual reserves to total GDP as it does not exhibit statistical significance. Model (3) reports that a 1% point increase in the inflation results in 4.92%[50] increase in sCDS spread[51]. Likewise, a 1% point increase in the GDP growth rate

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[50] $[100*(exp^{(0.048)} - 1)]$

[51] Here independent variable in not in the log form. Therefore, log-level interpretation is required.

will result in a 6.01%[52] reduction in protection premium. Finally, a 1% increase in the ratio of total annual exports to imports suggests the reduction in protection prices by 1.50%.

The last model reported in table 3.4 shows the results of a two-way fixed effect in which time dummies are included. Global variables, which are country invariant are dropped as they do not vary across countries for a given year. In model (4), the co-efficients on country specific variables remain similar to those reported in model (3) with the same level of statistical significance. Indeed, the adjusted R-square for model (4) has improved by 8% compared to that of model (3), suggesting the presence of some individual-specific invariant omitted variables. Thus in terms of reliability, it appears that results from model (4) should be given more weight. Therefore, as mentioned earlier, from model (4) it can be concluded that on average, a 1% increase in state fragility causes sovereign CDS premium to increases by 1.60%. Therefore, author finds significant support for the hypothesis of this study using the fixed effect analysis reported in table 3.4.

Table 3.5 reports the results of pooled OLS and random effect regression models with different specification. Model (1) only includes the main variable of interest and model (2) includes global variables in addition to the main independent variable. Finally, models (3) and (4) include all the control variables with the latter one reporting results from random effect model. The co-efficient on the main variable i.e., log of fragile state index in all models is positive and statistically significant thus, overwhelmingly supports the research hypothesis. According to the random-effect model a 1% increase in state fragility increases the sCDS prices by 1.51%. This finding is very close to what two way fixed effect model has reported i.e., 1.59% increase in protection prices in response to 1% increase in state fragility.

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[52] [100*($exp^{(-0.062)}-1$)]

Therefore, I can conclude that given a 1% increase in state fragility, on average, credit derivative price increases, in basis points, by more than 1.5% for a country.

3.6 Implications

This study has formally established a link between state fragility and prices of sovereign credit default swaps. The findings of this study suggest that state fragility has a significant impact on sCDS premium and hence, the borrowing cost of a sovereign entity. Therefore, apart from global financial factors and country specific macroeconomic variables, this study has identified socioeconomic, political and military factors; incorporated in state fragility measure as key drivers of credit derivative prices.

For policy makers, this finding has some serious implications. To reduce the borrowing cost of a country, policy makers need to focus on individual components of the fragile state index. The six factors listed under the social and economic indicators in fragile state index are demographic pressures, refuges and internally displaced individuals, uneven economic development, group grievance, human flight & brain drain and finally, poverty & economic decline. Furthermore, six political and military indicators within this index are state legitimacy, public service, human rights & rule of law, security apparatus, factionalized elites, and external intervention.

Though many of these indicators indeed are interrelated, government can prioritize them based on a certain criterion e.g., relevant ease in improving an individual factor to have an immediate positive impact on the borrowing cost. Therefore, while attempting to reduce the cost of borrowing for their country, in addition to economic development policy makers should need to focus on socioeconomic factors as well. For example, under the component of group grievance issues related to ethnic, communal, sectarian and religious violence are listed. For a country with miserable track record of group grievance, policy analysts should focus more on tackling violence related issues rather than window dressing the macroeconomic indicators in order to achieve sustainable economic growth and to reduce borrowing cost for their country.

3.7 Conclusion

Unlike the existing literature, this study focuses on establishing a relationship between non-traditional factor and sovereign credit default swap prices. Most studies in the area have considered global financial and country specific macroeconomic variables as key determinants of sCDS premium. This study reports that apart from these factors another socioeconomic construct –borrowed from foreign policy literature— called state fragility has significant impact on sovereign credit derivative prices. State fragility is defined in different ways in the foreign policy literature. However, the most modern definition in the context of the war on terror is that a country is a fragile state if it poses a threat to its own internal peace and to world peace. Fragile states find it more difficult to meet their debt obligations thus, level of state fragility is positively associate with sCDS as latter one is the pure measure of sovereign credit risk. State fragility is operationalized by the Fund for Peace organization through their fragile state index (FSI). Using the data from 66 countries over the period of 2007 to 2015, this study unveils a significant positive relationship between state fragility and derivative prices. Thus, I found significant support for the hypothesis developed in this study across different regression models and specifications. Moreover, signs on all the control variables are found as expected. Using a two way fixed effect model, this research concludes that a 1% increase in state fragility causes the sovereign credit default prices to increase, on average, by 1.60% for a country.

4 ESSAY 3: IMPACT OF SOCIAL CAPITAL ON SOVEREIGN CREDIT DEFAULT SWAP PRICING

4.1 Introduction

In explaining the premium[53], the literature on sovereign credit default swap (sCDS) pricing mainly focuses on global factors and country specific macroeconomic variables. Little attention has been paid to socioeconomic constructs which may affect a country's credit risk and hence, its sovereign credit default swap premium. One related socioeconomic concept that may impact sCDS price is social capital whose advantages on country's financial and economic development, among other matters, have been thoroughly established in political economy, management and accounting literature (Oyotode & Raja, 2015). According to Fukuyama (2001), social capital represents the "*instantiated informal norms*" that allows collaboration among different parties. Countries with high social capital have high levels of generalized trust. In such societies people try to abstain from devious behaviors to avoid internal and external guilt as society collectively punishes people who behave opportunistically.

In a recent study, Oyotode and Raja (2015) find high social capital is linked with efficient debt enforcement because interest rates, the duration and cost of bankruptcy process are lower in countries with high social capital. Moreover firms are more likely to kept going concern in high social capital states. Their results are robust to controlling for countries' income, legal origin and other related debt enforcement characteristics.

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[53] Price of the sovereign credit default swaps

In view of aforementioned discussion, if high social capital is positively related to efficient debt enforcement, because individuals are deeply concerned about loss of in-trust group and society's punishment, then, intuitively, their governments might be more likely to fulfill their international debt obligations to avoid global isolation, tougher sanctions and bad publicity. This would, most likely, lead their governments to adopt policies to ensure solvency and reduced credit risk. Hence, it results in lower sCDS premium on their sovereign bonds.

In this backdrop, this essay contributes to the extant literature on sCDS pricing by linking social capital to sCDS spreads.

4.2 Literature Review

The existing literature on sCDS pricing focuses on global financial variables and country specific macroeconomic variables as determinants of sCDS premium. Pan and Singleton (2008), Dooley and Hutchison (2009), Longstaff et al. (2011), Fender et al. (2012), Ang and Longstaff (2013) and Augustin and Tédongap (2014), among others, find global variables predict sCDS prices. In addition to global variables, Remolona et al. (2008), Caceres et al. (2010), Aizenman et al. (2013), Aizenman et al. (2016) and Zeaiter (2015) report that the sCDS spread is also explained by macroeconomic variables. Not much attention is given to socioeconomic variables as determinants of the protection prices[54]. One such socioeconomic construct which can affect a country's sCDS spread is social capital whose positive impact on the country's financial and economic development has been widely reported in the political economy and accounting literature.

[54] Another term used for CDS prices

According to Fukuyama (1999) informal culture that facilitates the collaboration between the members of civil society is called social capital. Owing to higher level of mutual trust and informal network, people have greater incentive to cooperate with each other in countries with high social capital (Guiso, Sapienza, & Zingales, 2004). Countries with high social capital have greater "generalized trust". Because of the general understanding that other party to the transaction will keep its part of the bargain, individuals are more motivated to keep their promises in countries with high social capital.

In high social capital countries, the overall level of trust increases the efficiency of countries institutions by limiting the use of "formal law and organization" (Fukuyama, 1999). In fact, individuals are able to collaborate through informal networks, reducing contracts' counterparty risk. A higher level of trust reduces the tendency for one party to profit at the expense of the other.

Research in political economy, accounting and management have thoroughly examined and established the advantages of social capital. Studies show that countries with high social capital have fewer avenues for devious conduct because opportunistic behaviors are punished by a loss of in-group trust**.** Thus, corruption, crime, monitoring costs, and dishonesty are lower in these countries (Guiso et al., 2004; Jha & Chen, 2014).

Social capital is therefore associated with both economic and financial development (Knack & Keefer, 1997). In countries with low quality education and law enforcement, "generalized trust" facilitates financial development. There is also a positive association between "generalized trust" and quality of law enforcement (Putnam, 1993). Absence of "generalized trust" leads to low quality of law enforcement, which contributes to financial and economic backwardness. Thus, countries with a high level of "generalized trust" experience better quality of law enforcement, financial and economic development.

Social capital as measured by norms and informal networks foster compliance with country's laws and regulations. Stronger social norms and networks boost individuals' commitment (P. S. Adler & Kwon, 2002). Internal and external penalties i.e. guilt and shame linked with norms and networks increase the benefits of cooperation. In fact, people are more likely to cooperate to avoid punishment from society. Thus, social norms and networks reduce the costs of enforcing and monitoring contracts. Therefore, countries with high social norms and networks will also experience better quality of law enforcement, financial and economic development. In sum, social capital is a set of the trust, norms and networks that foster better quality of law enforcement, financial and economic development.

This study proposes that apart from traditional global and country specific macro-economic variables; country specific socioeconomic factors such as social capital can significantly impact the prices of sovereign credit default swaps as it directly affects the credit profile of the country.

4.3 Hypothesis Development

The literature on sovereign credit risk has linked financial and economic development with lower default risk and therefore tighter sCDS spreads (Fontana & Scheicher, 2010; Georgievska, Georgievska, Stojanovic, & Todorovic, 2008; Mellios & Paget-Blanc, 2006; Reinhart & Rogoff, 2009; Sutton & Catão, 2002). As mentioned above, social capital is strongly positively associated with economic development (Knack & Keefer, 1997). This means that social capital might lower sovereign CDS premium through positively affecting economic and financial development in a country. Therefore following can be hypothesized:

H4: *Social capital is associated with lower sovereign credit default swap spreads*

Because democratic (authoritarian) and developed countries have stable (fragile) economies, institutions and governance, therefore I hypothesize the following:

H5 (a): *Sovereign CDS spread is lower for the countries with full democracies vs. those which have hybrid or authoritarian governing regimes*

H5 (b): *Sovereign CDS spread is lower for the developed countries*

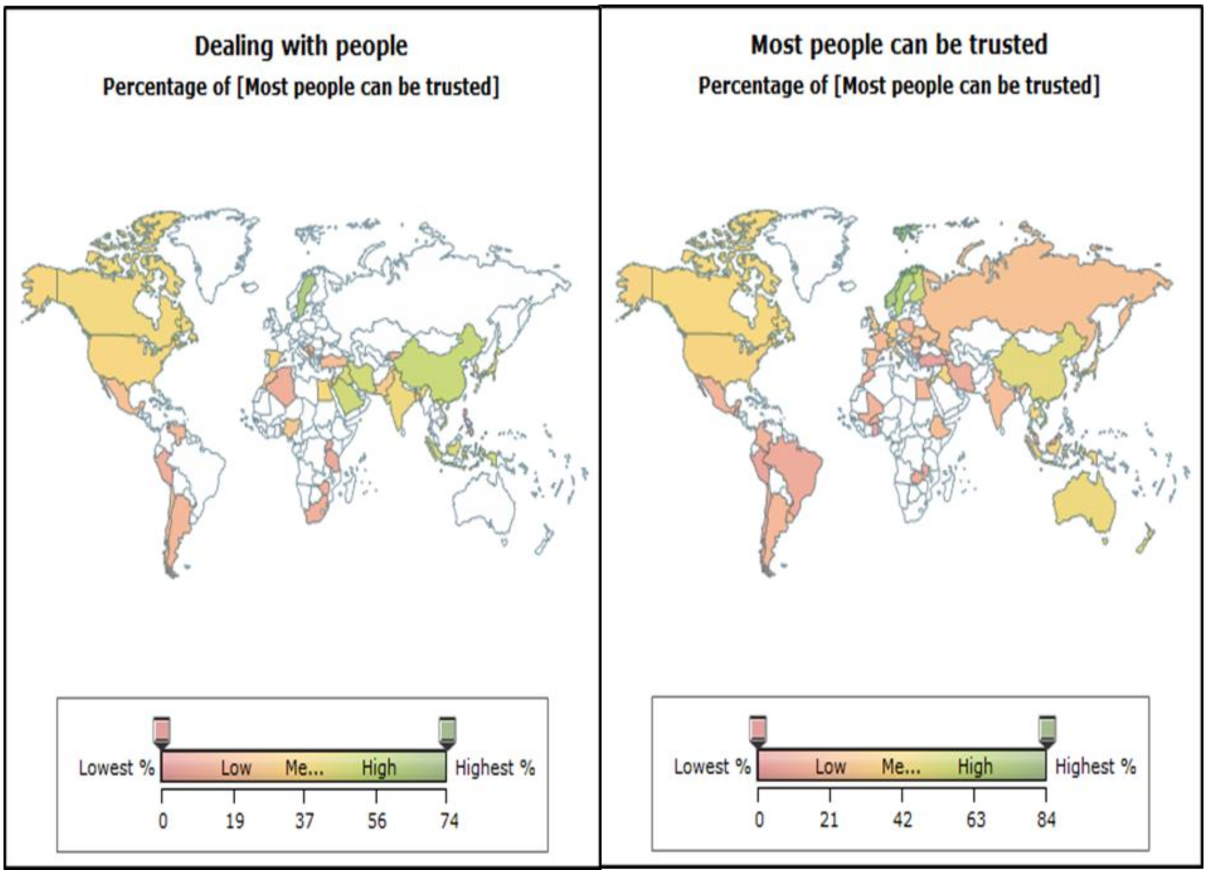
4.4 Data and Methodology

This essay use cross sectional data for the year 2015 for 52 countries. The dependent variable is the log of annual mean of 5-year sovereign CDS in basis points, the main independent variable is social capital "*SC*". Following Knack and Keefer (1997) I have used level of trust in the society to proxy for social capital. This concept is operationalized by Oyotode and Raja (2015) using data from World Value Survey (WVS). This survey has conducted in six waves starting from 1981 to 2014 and data from almost 100 countries has been gathered. Therefore this data is not collected through a single big survey but in episodes which they call a wave. Here, it is assumed that beliefs and values do not change rapidly in a society, hence social capital of a country surveyed in wave #1(1981-1984) would likely be the same even in 2015 (please see figure 4.1). Though two graphs in the figure represent two different waves, their similar coloring suggests the same level of social capital for a given country across different time periods.

In the World Value Survey (WVS), the question used to measure the level of trust of people in their fellow citizens and therefore, the social capital is "*Generally speaking, would you say that most people can be trusted or that you need to be very careful in dealing with people?*" The proxy for social capital is the percentage of people in each country who replied, *"Most people can be trusted"*. The higher the percentage of people who trust their countrymen, the higher is social capital in that country.

Data used in this essay comes from many different sources whose details are given in the table 4.1 along with the description and expected relationship between dependent and independent variables.

Figure 4.1: Social capital around the world for wave 1999-2004 and wave 2005-2009



Source: Oyotode and Raja (2015)

<u>Control variables</u>

Control variables are carefully selected from the existing literature[55]. These variables include four country specific macroeconomic variables. I have also added the log of fragile state index as this has been shown to increase sCDS prices in the second essay of this

[55] Exact references given in the second essay

Table 4.1: Description and sources of data used in third essay

Description and sources of data			
Variable type and name	Description and data source	Expected Ralationship	Data Source
ln(sCDS)	Log of 5 years soveregin credit default swap in basis points		Bloomberg and Datastream
sc	Percentage of people mention that they can trust others in a country	- (hypothesized)	www.worldvaluessurvey.org
	Control variables		
Country specific variables			
ln(FSI)	Log of fragile state index on the scale of 0 to 120, where 120 means high fragility (no zero value reported)	positive	fsi.fundforpeace.org
res	Ratio of change in annual foreign reserves to total GDP	negative	World development indicator
infl	Annual inflation rate (consumer prices) in precentage	positive	World development indicator
ln(x/m)	Log of the ratio of annual exports to total imports	negative	World development indicator
gdp_growth	Annual GDP growth rate in percentage	negative	World development indicator

Note: ln(sCDS) is the dependent variable and log of the annual mean of sovereign credit default swaps. Social capital (sc) is the main independent variable in essay three and measured in term of percentage. It suggests that how many percent of people involved in the survey for a given country trust their country men. Column three reports the expected relations between dependent variable and other independent variables.

dissertation. The first macroeconomic variable is the ratio of change in annual foreign reserves to total GDP of a country (*res*). Previous studies largely report the negative association between foreign reserves and sCDS prices as; an increase in foreign reserves makes it easier to pay its debt and thus reduce sovereign credit risk. The second country specific variable is the inflation rate "*infl*", which increases the protection prices as higher inflation results in higher yield on the underlying bond and by definition yield is positively related to CDS premium. The third control variable is the ratio of annual total exports of a country to its imports ($\frac{x}{m}$). Increase in total exports relative to a country's imports will reduce current account deficit and therefore, increases a country's ability to service its debt. The last macroeconomic variable is GDP growth (gdp_growth) which should have a negative relationship with the dependent variable. Credit rating of the countries with sound economic growth is usually high as lenders consider them less risky. Finally as proposed in the second essay, fragile state index (FSI) is a construct borrowed from foreign policy literature which is hypothesized to increase sCDS prices. Seller will demand high sCDS price for a country which is perceived to be more fragile and risky.

<u>Baseline regression</u>

The final regression question is therefore:

$$\ln(sCDS_i) = \alpha_i + \beta_1 SC_i + \beta_2 \ln(FSI_i) + \beta_3 res_i + \beta_4 infl_i + \beta_5 \ln\left(\frac{x}{m}\right)_i + \beta_6 gdp\_growth_i + \varepsilon_i$$

Where:

$\mathbf{ln}(\boldsymbol{sCDS_i})$=*Log of the mean of observed daily values for sovereign credit default swaps in basis-points traded on sovereign bond having 5-years to maturity for country 'i' (dependent variable)*

$\boldsymbol{SC_i}$=*Proxy for social capital, measured as % of people of country 'i' showing trust in their countrymen (main variable of interest)*

$\ln(\boldsymbol{FSI_i})$=*Log of the fragile state index variable of country 'i' which ranges between 0 to 120 with 0 being least and 120 being most fragile state*[56]

$\boldsymbol{res_i}$=*Ratio of change in annual foreign reserves to total GDP of country 'i'*

$\boldsymbol{infl_i}$=*Inflation (consumer prices) in percentage of country 'i'*

$\ln(\frac{X}{m})_i$=*Log of the ratio of total exports to imports for country 'i', and*

$\boldsymbol{gdp\_growth_i}$=*GDP growth rate of country 'i'.*

4.5 Results

After merging all the data on above mentioned variables I am left with 52 countries for the year 2015. Descriptive statistics of variables are given in table 4.2.

Table 4.2: Descriptive statistics of data used in third essay

Descriptive Statistics					
	(1)	(2)	(3)	(4)	(5)
VARIABLES	Obs	mean	sd	min	max
Sovereign CDS (log)	52	4.865	0.698	3.120	5.999
Social capital (%)	52	27.29	15.05	4.350	69.25
Fragile state index (log)	52	3.961	0.418	2.981	4.652
Change in foreign reserves/ total GDP	52	0.0105	0.0315	-0.0855	0.105
Inflation, consumer prices (%)	52	4.520	2.912	-0.360	18.68
Ratio of export to import (log)	52	0.0199	0.259	0.551	1.023
GDP growth rate (%)	52	3.703	2.890	-1.917	13.38

<u>*Results of baseline regressions*</u>

Results of the baseline regression is given in table 4.3. Model (1) provides the regression results when dependent variable i.e. log of sovereign CDS is regressed only on the social capital variable. In line with the expectation, co-efficient on the social capital is negative (-0.024) and statistically significant at the 1% level. This suggest that sellers charge

[56] All values are non-zero for this variable.

low sCDS premiums in country where social capital is higher. A one percentage point increase in the social capital (say, from 4% to 5% or 30% to 31% etc.) of a country causes reduction in sCDS premium by 2.4%[57]. I re-ran the regression including all the control variables and its results are given under model (2) of table 4.3. Again significantly negative association is reported between the main variable and the dependent variable.

Table 4.3: Results from baseline regression of third essay

Effect of social capital on sovereign credit default swaps		
	(1)	(2)
VARIABLES	OLS-Model with main variable only	OLS-Model with all variables
Sovereign CDS (log)-Dependent Variable		
Social capital (%)	-0.024***	-0.012**
	(-4.39)	(-2.19)
Fragile state index (log)		0.957***
		(4.62)
Change in foreign reserves/ total GDP		-2.557
		(-1.29)
Inflation, consumer prices (%)		0.074***
		(2.82)
Ratio of export to import (log)		0.210
		(0.70)
GDP growth rate (%)		-0.076***
		(-2.97)
Constant	5.532***	1.379
	(31.91)	(1.59)
Observations	52	52
R-squared	0.28	0.67
Adj. R-Square	0.26	0.62

t-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Cross-sectional OLS Regressions
Dependent variable is log of sovereign credit default swap in basis points

Results suggest that after controlling for the county specific macroeconomic and

[57] $[100*(exp^{-0.024} - 1)]$

socioeconomic variables, a one percentage point increase in the social capital reduces the sCDS prices by 1.2%[58].

In table 4.3, signs on all the control variables are as expected and listed in table 4.1 with the exception of the log of the ratio of total annual exports to imports [$ln(\frac{x}{m})$]. However, the ratio co-efficient is not significant at a 10% level. T-statistics for other variables suggest the co-efficient on fragile state index, inflation and GDP growth rate are statistically significant at the 1% level. Although ratio of the change in annual foreign reserves to total GDP has the expected sign, its t-statistics is very low (-1.29). The results suggest that a one percent increase (NOT percentage *point* increase) in the fragile state index leads to an increase of sCDS prices by 1.0%. Moreover, a one percentage point increase in the inflation rate increases the derivative price by 7.1%[59] and a one percentage point increase in the GDP growth rate decreases the protection prices by 7.3%[60]. Because the adjusted R-Square is 0.62, this suggests that almost 62% of the cross-sectional variation in the dependent variable can be explained by the main variable and set of five country specific control variables. In order to ensure the correct specification of the cross-sectional model in this study I have conducted a Jarque-Bera Test (JBT) of normality on the residuals of the regression equation. The null hypothesis of JBT is that residuals are normally distributed. The p-value is 0.47, meaning the null hypothesis is not rejected, implying the residual is normally distributed. Therefore, hypothesis H4 is strongly supported by the empirical analysis.

Analysis based on the type of governing regime and development level in a country

Recognizing the idiosyncratic characteristics of different countries I further conducted the analysis based on the fact that 1) what type of regime governs the country and

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[58] [100*($exp^{-0.012} - 1$)]
[59] [100*($exp^{0.074} - 1$)]
[60] [100*($exp^{-0.076} - 1$)]

2) whether the country is a developed or developing country. In order to determine the governing regime I followed the categorization proposed by democracy index formulated by Economist Intelligence Unit of the Economist Group. They categorize the governance structure in a country in the following ways:

- Full democracies
- Flawed democracies
- Hybrid regimes, and
- Authoritarian regimes

For the purpose of this study I have created two dummy variables only for full democratic (*d_democracy*) countries and countries ruled by authoritarian regimes (*d_auth_regime*). 14 out of 52 countries analyzed in my sample are identified as full democracies and 7 out of 52 are classified as authoritarian regimes. The remaining 31 countries are either flawed democracies or hybrid regimes. For the latter categories I have not created dummy variables as I only intended to investigate how the relationship between social capital and sCDS prices differs for, either, true democratic countries and authoritarian regimes. That is, true democracies vs. (authoritarian regimes + flawed democracies + hybrid regimes) and authoritarian regimes vs. (true democracies + flawed democracies + hybrid regimes).

Second, I have classified all 52 countries either developed or developing countries as classified by International Monetary Fund (IMF). 19 countries are marked as developed and the other 33 as developing countries. Only one dummy variable is created for developed countries (*d_developed*). Therefore, the co-efficient on dummy variable of developed countries will report that how the relationship between social capital and protection prices differs from that of developing countries. I would expect that CDS premium will be lower in democratic and developed countries. Also it should be higher for the countries governed under authoritarian regimes. This is because fully democratic (authoritarian) and developed countries have stable (fragile) economies, institutions and governance.

Results are given in table 4.4. Model (1), (2) and (3) include dummy variables for democratic, authoritarian and developed countries, respectively.

Table 4.4: Impact of social capital on sovereign CDS in different regimes

Effect of social capital on sCDS prices in democratic, authoritarian and developed countries			
	(1)	(2)	(3)
variables	Sovereign CDS (log)	Sovereign CDS (log)	Sovereign CDS (log)
Social capital (%)	-0.011*	-0.013**	-0.012**
	(-1.96)	(-2.19)	(-2.13)
Fragile state index (log)	0.852***	0.926***	0.970***
	(3.59)	(4.08)	(3.65)
Change in foreign reserves/ total GDP	-2.493	-2.159	-2.551
	(-1.25)	(-0.94)	(-1.27)
Inflation, consumer prices (%)	0.078***	0.074***	0.075***
	(2.91)	(2.74)	(2.76)
Ratio of export to import (log)	0.183	0.182	0.216
	(0.61)	(0.59)	(0.69)
GDP growth rate (%)	-0.081***	-0.077***	-0.076***
	(-3.09)	(-2.96)	(-2.92)
One if country has democracy (dummy)	-0.177**		
	(-1.97)		
One if country has authoritarian regime (dummy)		0.083	
		(0.35)	
One if country is a developed country (dummy)			-0.017*
			(-1.70)
Constant	1.817*	1.509	1.324
	(1.83)	(1.59)	(1.18)
Observations	52	52	52
R-squared	0.67	0.67	0.67
Democracy dummy	YES	NO	NO
Authoritarian regime dummy	NO	YES	NO
Developed country dummy	NO	NO	YES
Adj. R-Square	0.62	0.61	0.61

t-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Cross-sectional OLS Regression
Dependent variable is log of sovereign credit default swap in basis points

Signs on all the dummy variables are in line with my expectation. In model (1) the co-efficient on the dummy variable for democratic countries is statistically significant, suggesting that on average CDS spread is 16.2%[61] lower for the countries having democratic regime compared to those which lack true democracy. Model (2) reports insignificant co-efficient on dummy variable of authoritarian regime with positive sign which I have earlier anticipated. Lack of enough observations seems to be a plausible reason why significance has not been established in this case. Finally model (3) reports the co-efficient on the dummy variable of developed countries. Its co-efficient is statistically significant at the 10% level, suggesting that CDS prices traded on developed countries' bonds are 1.7% lower than those traded on developing entities debt. All other variables i.e., main variable (social capital %) and control variables in table 4.4 have similar signs and levels of statistical significance as reported in table 4.3. Therefore, I found support for both H5(a) and H5(b).

4.6 Conclusion

Extant literature widely reports global financial and country specific macroeconomic variables are key determinants of sovereign credit default spreads. Therefore, not much attention has been given to country specific socioeconomic variables like social capital as possible predictors of sovereign CDS premiums. In an attempt to fill this gap in the current literature, this study formally investigate the relationship between social capital and sovereign credit default swap spread. Social capital represents the "*instantiated informal norms*" that allows collaboration among different parties. Countries with high social capital have high level of generalized trust. In such societies people try to abstain from devious behaviors to avoid internal and external guilt as society collectively punishes people with an

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[61] $[100*(exp^{(-0.177)} - 1)]$

intent of opportunistic behaviors. Existing literature in political economy, management and accounting have found positive impact of social capital on the financial and economic development. On the other hand, in the sovereign CDS pricing literature a negative association between CDS spread and economic growth of sovereign entity is firmly established. Therefore, a negative impact of social capital on CDS premium is hypothesized in this study.

This research finds strong support for the hypothesis and reports that social capital impacts CDS prices after controlling for country specific macroeconomic variables. A one percentage point increase in social capital of a country, ceteris paribus, causes the reduction in its CDS spread by 1.19% after controlling for country specific macroeconomic variables. Moreover, I found that CDS spread is 16.22% lower for countries which have full democracies compared to one which does not have a true form of democracy in the year 2015. Finally, for developed countries protection prices are lower by 1.69% compared to that of developing sovereign entities.

This study highlights the importance of socioeconomic variable which should not be over looked by the stakeholders in determining the protection prices. Therefore, in addition to global and macroeconomic variables due consideration should be given to related country specific socioeconomic variables while assessing the country's default risk and hence, in measuring the sovereign credit default swap prices.

5 CONCLUSIONS

The first essay studies the relative contributions of CDS and bond markets to the sovereign credit risk price discovery process for eight emerging countries (Brazil, Colombia, Mexico, Panama, Peru, Russia, Turkey and Venezuela) from 2006 to 2016. Although this topic had been researched previously, findings in the area were conflicting. In addition, due to the ongoing euro crisis, most of the recent focus in the sovereign price discovery literature has been on developed Eurozone countries. These factors coupled with the fact that credit markets have undergone significant changes in the wake of the financial crisis make this study on emerging countries timely. Moreover, recent events such as China's financial meltdown in 2015, the impact of reduced oil prices on the credit risk of oil exporting emerging countries and the executive order issued by the Puerto Rican governor's office to declare a moratorium on a large portion of debt also re-emphasize the importance of understanding the nature of emerging sovereign credit risk and which credit market prices it more efficiently, the synthetic or the cash market.

As such, the first essay contributes to the extant literature in four ways, namely by i) settling the ongoing debate on market efficiency in the area of pricing sovereign default risk, ii) analyzing data over a much longer period of time than done before, enabling a more extended study of the long-run dynamic interaction between two markets, iii) testing for time variance of the result by investigating pre-financial crisis, post-crisis and crisis period subsamples, and iv) operationalizing two different price discovery measures for the first time to check the robustness of the initial findings.

Country level analysis suggests that sovereign CDS generally dominates the price discovery process during tranquil periods, with the bond market simply following its lead.

Specifically, the median CDS contribution is more than 70% towards the price discovery process of sovereign credit risk. This finding is attributed to the greater relative liquidity of the synthetic market. However, during the financial crisis, there is no common stochastic trend observed between CDS and bond spreads, suggesting that during times of extreme distress in the financial system, the markets start to price credit risk differently and independently of one another. Interestingly though, within the context of Granger causality robustness test, even during the crisis period, the CDS market led the bond market for most of the countries. These results have implications for emerging market investors and asset managers who engage in arbitrage between the two markets as well as financial stakeholders who monitor sovereign credit spreads to gauge the level of political and/or default risk in emerging markets.

The second essay focuses on establishing relationship between non-traditional factor and sovereign credit default swap prices. Most studies in the area have considered global financial and country specific macroeconomic variables as key determinants of sovereign CDS premium. The second essay reports that apart from these factors another socioeconomic construct –borrowed from foreign policy literature— called state fragility has significant impact on sovereign CDS pricing. State fragility is defined in different ways in the foreign policy literature. However, the most modern definition in the context of war on terror is that a country is fragile state if it poses threat to its own internal and world peace. Fragile states find it more difficult to meet their debt obligations thus, level of state fragility is positively associate with sovereign CDS spreads as latter one is the pure measure of sovereign credit risk. State fragility is operationalized by the Fund for Peace organization through their fragile state index (FSI). Using the data from 66 countries over the period from 2007 to 2015, the second essay unveils significant positive relationship between state fragility and derivative prices. Thus, I unanimously found support for the developed hypothesis across different types of regression models with varying specifications. Moreover, signs on all control variables are found as expected. Using two way fixed effect model, this research concludes that a 1% increase in state fragility causes the sovereign credit default prices to increase, on average, by 1.596% for a country.

Finally, the third essay is closely related to the second essay as it also attempts to establish the relationship between another socioeconomic construct, namely social capital, and sovereign CDS pricing. Social capital represents the "*instantiated informal norms*" that allows collaboration among different parties. Countries with high social capital have a high level of generalized trust. In such societies people try to abstain from devious behaviors to avoid internal and external guilt as society collectively punishes people with an intent of opportunistic behaviors. Existing literature in political economy, management and accounting have reported positive impact of social capital on the financial and economic growth of a country. On the other hand, in the sovereign CDS pricing literature a negative association between CDS spread and economic growth of sovereign entity is firmly established. Therefore, a negative impact of social capital on CDS premium is hypothesized in the third essay.

Empirical analysis conducted in the last essay finds strong support for the hypothesis and reports that social capital negatively impacts CDS prices after controlling for country specific macroeconomic variables. I found that a one percentage point increase in social capital of a country, ceteris paribus, causes a reduction in CDS spread by 1.19% after controlling for country specific macroeconomic variables. Moreover, I found that on average

CDS spread is 16.22% lower for countries which have full democracies compared to one which does not have true form of democracy in the year 2015. Finally, for developed countries protection prices are less by 1.69% compared to that of developing sovereign entities.

The second and third essays highlight the importance of socioeconomic variables which should not be over looked by the stakeholders in determining the sovereign credit default swap prices. Therefore, in addition to global and macroeconomic variables due consideration should be given to related country specific socioeconomic variables while assessing the country's default risk and hence, pricing sovereign credit default swaps.

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Graduate Research Assistant and Instructor

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- **Intro to Financial Accounting** (ACC 2301-301, Summer-I 2016 and 2017)
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