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DETERMINING SOVEREIGN CREDIT DEFAULT SWAP SPREAD BY EXTENDED MERTON MODEL IN SELECTED EMERGING MARKETS

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Abstract

This thesis examines if the Merton's structural model for corporates can be extended to emerging market sovereigns such as Brazil, Mexico, Turkey and Russia in a comparative perspective. For utilizing extended Merton model, the parameters chosen for the determination of the credit default swap spreads are the central bank foreign currency reserves and gross external debt besides the benchmark external debt's volatility incorporated into these calculations. In return, the credit default swap spread rates are estimated and compared for the named four developing markets. Empirical evidence shows that there is a significant correlation between the market rates and the model findings. A comparison of the results for these countries underlines the fact that building foreign currency reserves and diminishing the foreign currency liabilities or switching external debt to local currency debt might lower the credit risk spreads significantly. Furthermore, determining credit default swap market rates requires extensive volatility analysis.

ÜLKE KREDİ TEMERRÜT SWAP ORANLARINI TAHMİN MODELİ:
SEÇİLMİŞ GELİŞMEKTE OLAN ÜLKELERDE
GENİŞLETİLMİŞ MERTON MODELİ
UYGULAMASI

Özet

Bu çalışma, Merton'un şirketlerin kredi temerrüt swap oranlarını tahmini için kullandığı yapısal modelin gelişmekte olan ülkelere uygulanması amacıyla yapılmıştır. Model, gelişmekte olan ülkelerden seçilen dört ülke olan Türkiye, Brezilya, Rusya ve Meksika üzerine uygulanmış ve tutarlılığı test edilmiştir. Genişletilmiş Merton modeli uygulamasında merkez bankalarının yabancı para cinsinden rezervleri, yabancı para cinsinden dış borçları ana parametreler olarak yer almakta olup, gösterge dış borcun oynaklığı da hesaplamalar için kullanılmaktadır. Ampirik bulgulara göre piyasada kullanılan kredi temerrüt swap oranları ile model bulguları arasında ciddi bir korelasyon gözlenmektedir. Çalışma sonuçlarına göre merkez bankalarının rezervlerinin artışı ve dış borcun geri ödenerek azaltılması veya iç borçla takası sonucunda kredi risk primlerinde somut düşüşler sağlanabilmektedir. Yapılacak analizlerin yoğunlaştırılmış oynaklık tahminleri ile daha da geliştirilmesi mümkün gözükmektedir.

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To my family

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Table 4.4 Summary Table for the Correlation Matrix of Changes in Sovereign CDS Spreads Using Garch Methodology for Estimating Implied Country Volatility……………………………………………………………………………….88

List of Abbreviations

B(t,T)=the time t price of a default-free zero-coupon bond with maturity T

B= zero-coupon bond price

$\bar{B}$ = zero-coupon bond price, zero recovery

$B(0,T_k)$ = the prices of the default-free zero-coupon bonds

$\bar{B}(0,T_k)$ = the prices of the defaultable zero-coupon bonds with zero recovery

CDO: Collateralized debt obligation

CDS: Credit Default Swap

(DB) Strike Price: Gross External Debt of the country

$e(0,T_k,T_{k+1})$ = the value of $1 at T_{k+1} if a default occurred in T_k,T_{k+1}

F(0,T) = term structure of default-free interest rates

H(0,T) = term structure of implied hazard rates

ISDA: International Swaps Dealers Association

K=Tenor dates

LIBOR: London Interbank Offered Rate

N=The number of payment dates of the i th calibration security

N(d): is the cumulative probability distribution function for a standard normal variable

r_f : US treasury rate for the corresponding period

$\bar{s}$ = CDS rate

t: Time, Duration of the outstanding debt of the country

T_N=Maturity date of the bond

TR MARKET CDS : Turkish Market CDS rates

TR MODEL CDS : Turkish Model CDS rates

TRRESERVE : Turkish central bank reserves

TRDEBT : Turkish gross external debt

TRRF: US Treasury 5 yr rates

TRVOL : Turkish benchmark bond volatility

V : Underlying Asset, International reserves of the country

V_t : the value of the assets of the firm

π = expected recovery rate, recovery of par

σ_{Sov} sigma: Historical volatility of the eurobonds issued by the country

Chapter 1

Introduction

In its guidelines to promote stability, confidence and soundness of the international financial system, the Basel Committee (2001) suggests that every market participant do their best to develop sophisticated risk models. However, still these days there is no standard approach to country risk analysis in the financial industry. For example different methods such as balanced-score cards, ratings, structural models, interest yields and yield spreads all are used to assess country risk.

Throughout the history, the defaults have occurred frequently. However, a model has not been developed for the country risk assessment. The Merton model which is a type of structural model is already being used for the corporate risk analysis.

So the objective of this study is to extend the Merton model to value the credit risk of a country by forming a hypothetical balance sheet for the country.

The main motivation of this thesis is to determine if Merton's structural model yields reliable results when extended to determine sovereign Credit Default Swap (CDS) spreads. In the current literature, the Merton model is used to test credit default swap performance of the corporates, whereas in this thesis I propose to test its applicability to forecast the sovereign spread in emerging markets and especially on the emerging market sovereign credit spreads. In thesis corporates and sovereign be used in short for corporate firm and sovereign governments or countries. The main question in this search is that, in the absence of sovereign spreads, whether or not there are any independent variables or some combination of them that explain the credit spreads of a sovereign country.

In this case Merton model is used to see if these variables help explaining the existing spreads and how useful they are in explaining this relationship. As a result of this thesis, if a relation is found between the model output and market rates, it would imply that the parameters used in this thesis are important tools to improve a country's credit spread and rating in return. So, for instance increasing the central bank reserves, buying back foreign currency denominated debt and lowering external liabilities, would be some of the solutions to improve credit spreads. Lowering the credit default swap spreads would enable the country to finance its debt at lower rates, would enhance its credibility and eventually result in prosperity. Furthermore, having a lower level of implied volatility in foreign currency debt would be important besides others if this model yields meaningful results which would in return attract more investors.

In this thesis I will solely test the ability of the Merton model to reflect the reality of the market pricing. So, the main objective of this research will be to test the ability of the Merton model to predict spreads in the CDS market as an indication of the model's strength.

In practice, the empirical evidence found by this research will assist market participants in determining if Merton's model is useful in determining the components from which the credit risk premium is made of. In particular, I attempt to test whether the modified Merton model can be used as a forecasting tool for the credit default swap spreads. The time-varying parameters and their estimation has been one of the important topics in the literature. It has been put forward that the variation in parameters results in improved forecast performance.

Furthermore, the use of the credit risk indicators as an indicator of sovereign risk will be tested through the causality tests among the parameters and the market rates. The tests are assumed to imply a high degree of correlation between the credit risk indicators and the observed market data on spreads. Also both series are assumed to be cointegrated to have longer term co-movements. As market credit default swap spreads are treated as independent variables to be determined, the high correlation between the model rates and market rates will suggest that these indicators can be used as measures of sovereign credit risk, thus lending support to the Merton structural model which is setup in this thesis. In addition to the above mentioned analysis, principal component analysis will be done. The economic indicators will be examined in four individual country cases to determine if there is a relation with the credit spreads.

Finally, this thesis has two important implications and addresses 2 issues: central bank reserve management and debt management. On the highly debated issue of central bank's reserves, extended Merton model can be used to determine an optimum level of reserves or if the relationship between credit spreads and reserves is determined as an outcome, then the desired credit spread can be targeted through the central bank reserve accumulation to the specified degree. On the debt management side, extended Merton model can be used by the treasury as a decision tool to decide on debt buybacks or targeting a debt level for sustainability. The classical methods suggest that debt to GDP ratio is the indicator to watch for sustainability, however relating the debt level with a specific credit spread seems to be more realistic.

This thesis is structured as follows. In Section 2, credit derivatives market is explained in detail and the basis which causes the credit spreads to diverge from sovereign spreads is evaluated. Also in this section the standard CDS pricing models are elaborated and formulated to calculate the sovereign risk. Section 3 handles the literature review and structural models. In this section the Merton model is explained in detail. Section 4 shows how the model is extended to sovereigns. Besides these the implementation of the model is shown and the results are analyzed. Also this section discusses briefly how this approach can be used to evaluate potential policy choices, and it details further steps in the application of this approach to evaluating reserve management and debt sustainability.

Chapter 2

Credit Derivatives

Credit derivatives are contingent claims with payoffs that are linked to the credibility of a sovereign or a firm. The purpose of these instruments is to allow market participants to trade the risk associated with certain debt-related events. The conclusion that both sovereign and corporate debt is supported by similar incentives has important practical implications: Krueger's (2002) proposal for a Sovereign Debt Restructuring Mechanism, which is modeled after Chapter 11 of the US Bankruptcy Code.

Credit derivative contracts are bilateral contracts and enable the buyer of the protection to transfer predetermined aspects of the credit risk on a specified debt obligation to the seller of the contract. The credit risk can be defined in general as the risk that the market value of a financial instrument will change. This can be as a result of a change in either the credit rating of the issuer or a result of a failure by the issuer to meet its contractual obligations which is called as a default risk.

Credit derivatives help the investors to transfer and get rid of some of the credit risk on the assets held, while retaining their market risk and taking on credit exposure to a debt issuer without necessarily acquiring the issuer's obligations. With increased credit derivatives usage, investors can acquire more diversified credit exposures for their portfolios, while traditional lenders can hedge their risk concentrations on specific names.

Credit spread on the other hand is defined as the yield difference between a risky and a risk free bond. So in order to determine CDS spreads there are two approaches; the first is looking at asset swap spreads and secondly, discounting the expected CDS premium cash flows.

Credit spread is related to the implied default probability and credit risk of the issuer. So obviously one who has to deal with credit portfolio risk and pricing of credit derivatives such as credit default swaps, should also take into consideration the implied default probabilities. Credit derivatives enables investors to access credit markets and hedge credit portfolio risk while improving the liquidity in the market by the use of leverage. Also, besides these uses, credit derivatives enable the investors to short credit risk actively. As it can be observed from the volumes of derivatives trading in BIS statistics, as more reference entities are actively traded greater liquidity is ensured.

Instead of analyzing the credit risk through bond spreads, examining credit derivatives provides important advantages:

i) The first advantage is the higher liquidity in the credit default swaps market,

ii) The product is less complex; for instance early call features are not present in credit default swaps which help to prevent distortions unlike in bond contracts,

iii) They help to boost globalization affect and result in increasing linkages; CDS contracts allow for a more direct comparison of cross country default risk. However this can also be a negative due to contagion affects.

Nevertheless, credit default swaps remain exotic and disadvantages such as the pricing issues with more complex collateralized debt obligation (CDO) type products still exist. For instance in recent times, as a result of the massive demand for yield around the world, the returns on investment grade bonds were far below the returns on equities that they now had to replace. So, the demand was met through products like CDO's which has the low quality bond with a high rating, however this resulted in a wider spread downside affect on the US economy.

In the literature, many studies show the contagion effects in markets (Kodres and Pritsker, 2002). If Brazil goes through a crisis, the rest of the world's credit standing will be somewhat affected but that Latin America's credit standing will be affected relatively more. In this thesis, the contagion and volatility spillover issues are not addressed directly however, the high liquidity in the credit default swap markets tend to increase the credit risks broadly.

A proper analogy for CDS's can be established with the insurance policies on a risky asset. Buying protection on a bond insures the CDS holder against loss owing to default among a pool of eligible reference assets on that name. In the case of default, the protection holder delivers the defaulted bond to the seller and receives the par value of the asset. Traditionally, CDSs have been a physically settled derivative, but contracts increasingly specify the cash equivalent of this transaction. In return, the buyer pays the seller regular coupon for this protection. This payment is expressed as a notional spread in basis points and is paid quarterly in arrears over the pre-agreed-to life of the CDS contract or until a default event occurs. The flowchart of the transactions is shown in the Figure 2.1 below. In Figure 2.1, the diagram shows the case of "investor A" buying protection from "investor B" on "company C" for five years.

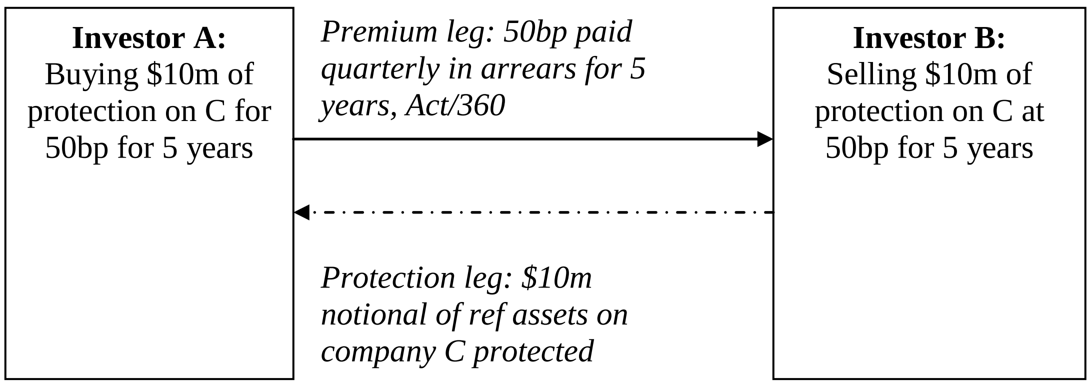


Figure 2.1 CDS Protection buying flows

In Figure 2.2 below, a default event is depicted which occurs on C and triggers the credit derivative.

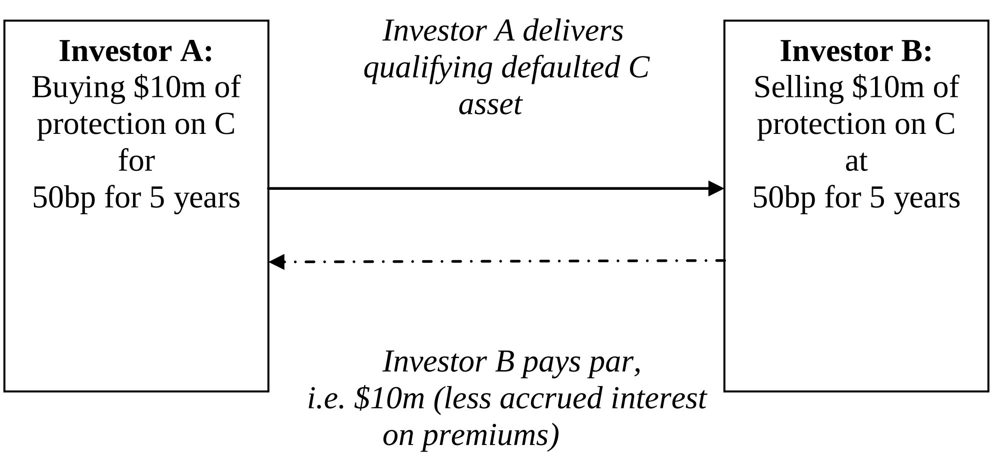
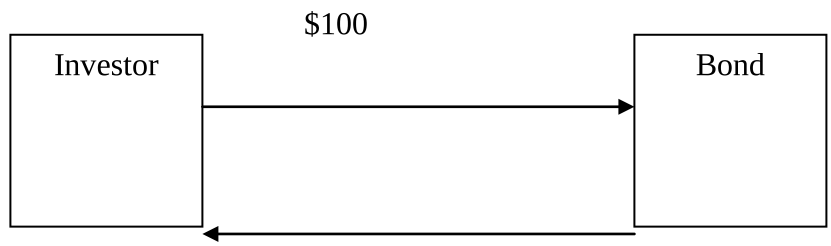


Figure 2.2 Default event

As the CDS contracts are bilateral contracts between two parties, they can't be broken without compensation. As a result, CDS contracts are used widely by the market participants as a hedge against the credit quality deterioration. This means that if an investor buys protection when spreads are tight, as spreads widen the value of that contract will rise. Therefore, a CDS can be used to hedge mark-to-market changes of a bond or as purely to take a credit view by itself. The investors prefer to use CDS contracts as hedging tools in their various investments.

It is essential to understand the bond's difference from a CDS contract. The underlying relationship is simple and is illustrated below by the Figure on how a CDS can be used to create a bond synthetically. As long as the reference entities are the same, the two transactions can be considered identical. So if there is a default, the investor will be exposed to same risk of holding the defaulted asset in both cases. Consider two portfolios shown in Figure 2.3 and Figure 2.4.



5% coupon + par at maturity

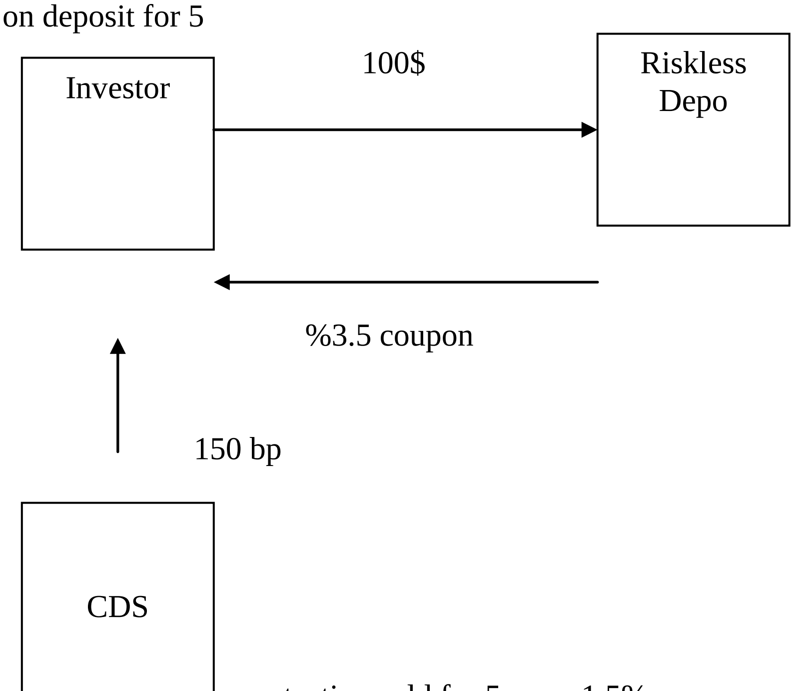
$100 invested in 5 year bond

%5 coupon received + par at maturity

Figure 2.3 Bond Portfolio

100$ placed on deposit for 5 year:

3.5% p.a.



CDS protection sold for 5 year: 1.5% p.a.

Figure 2.4 CDS Portfolio

So, synthetically a CDS can be created through asset swaps. The relationship between CDS's and asset swap spreads are close apparently.

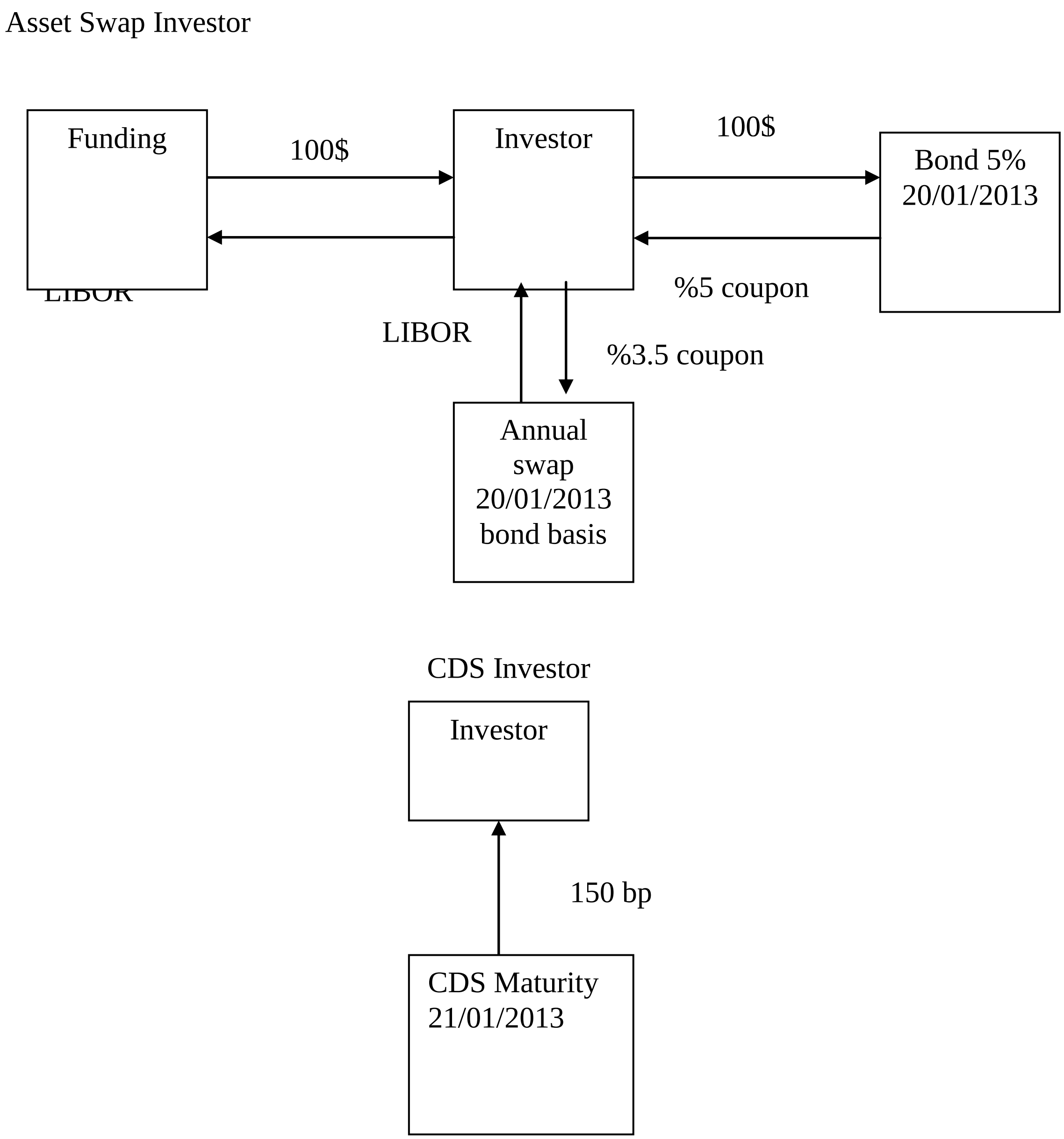


Figure 2.5 Asset Swap versus CDS Investment

So as mentioned previously, the first method to determine CDS spreads is through asset swaps. A typical assets swap transaction is depicted in Figure 2.5. Asset swaps are related to credit default swaps because both products serve to partition credit risk. In an asset swap, an investor purchases a cash bond which is most of the times priced at par and in return for that pays the bond coupon into an interest rate swap of the same maturity. The difference between the bond coupon rate and the par swap rate is known as the asset swap spread and can be used as a hedge by the investor for the default risk on the bond.

Choudhry (2006) suggests that the possibility of arbitrage between CDS and asset swaps will eventually cause the basis to decrease between the two rates. Furthermore, he suggests that other factors might keep rates from converging.

The example in Figure 2.5 depicts that an investor with an asset swap position is in almost an identical position to one who has sold CDS protection on the same entity. In both cases the investor receives the same premium flows, even in the case of default; the investor is left with a defaulted asset. So, the asset swap spread and CDS spread should remain closely related.

2.1 The Credit Default Swap Basis and Its Importance

The credit default swap basis is important in the sense that without basis the credit default swap spread would have been equal to risk free rate plus sovereign risk premium which would have been near that sovereign's bond yield. So when we are aiming to forecast the sovereign CDS spreads, it is indeed an endeavor to explain the variance of CDS basis. The reason for this is that CDS spreads can easily be found by adding asset swap spreads to CDS basis.

Basis trades are considered as a credit-risk-neutral method to benefit from the differences between asset swap spreads and CDS spreads. If an investor needs to hedge himself by converting from fixed rate to floating rate against falling rates, he can do so by swapping between a fixed coupon bond to a floating rate note, which means that he sells his bond at the current market price and simultaneously buys a floating rate note at par. Some factors in the market result in a difference between synthetically calculated credit default swap rates and its price which is traded in the cash market using asset swaps. Also these differences sometimes cause arbitrage opportunities and yield to basis trading in the markets. The basis can be regarded as the difference between the credit risk premium which is reached by synthetic means and the cash market premium. The basis difference can be generalized to be positive most of the times and rarely negative. The way to represent this is;

CDS Basis = CDS spread – asset swap spread

Therefore, a negative basis is when the asset swap spread is wider than the CDS, whereas a positive basis is where the CDS is trading wider than the asset swap spread.

Buying the basis is a trade that seeks to profit from a widening of the basis. In order to long the basis, an investor buys the bond, executes a swap and buys protection on the CDS. On the other hand, selling the basis is based on the idea of profiting from a tightening of the basis. To short the basis, one must sell the bond, do an interest rate swap and buy protection on the CDS.

In terms of credit risk basis trades do not bear any risk. However, some risks such as the credit and CDS counterparty defaulting at the same time still remain which is called the joint default probability. These probabilities depending on the location and the risk that the counterparty takes in that country might be high. So when buying a Turkish CDS protection contract from a Turkish bank will carry a joint default probability risk for the CDS buyer.

Considering that the markets are assumed to be arbitrage free, it seems inconceivable that the basis should exist at all for any length of time. The reasons behind basis may be various, either market or asset specific. The factors causing this difference can be that the bond being the cheapest to deliver, the borrowing rate, expectation of a premium and the counterparty risk. Some of the reasons for the existence of basis are mentioned below briefly:

i) Supply and demand: Despite the presence of basis, it might not be possible to obtain bonds due to supply shortage or excess demand. For instance, whenever a counterparty has a short position in a cash bond, this might result in a change in borrowing rate in the repo market from LIBOR and in this case the bond is treated as special depending on liquidity or other factors. This does not impact the default swap price which is fixed at the start of the CDS contract. This just means that as the bonds are not available at all times, the bonds can be treated special which means that they can be hard to borrow and short in the market. Therefore, even though selling the basis might sometimes look attractive, it might not be possible to realize.

ii) Calculation complexity: There might be some complexities in calculation in case of bonds trading above/below par. Whenever bonds have high coupons, they may trade above par which results in the basis trade becoming more complex. This is especially true for emerging markets where the yields and coupons are higher. A bond worth 110% will be incorrectly hedged by an equal notional amount of CDS, and the losses on the bond will be higher as the CDS contract returns par in case of default. So this is adjusted in the basis calculations by comparing Z-spread with an adjusted CDS spread, but there is no strict market convention on the topic.

iii) Increase in the volume of structured credit derivatives: When the structured credit derivatives are issued, the exposures are preferred to be hedged by selling protection into the single-name market, and mostly in large quantities. This excess supply can temporarily result in a squeeze in the spread of single names CDS's and CDS indices. Due to the tremendous increase until this credit crunch, the average basis on many bonds has been negative due to this development.

iv) The cheapest to deliver bond: Another important factor could be that the bondholder knows the bond he is holding in the event of default; however, credit default swap sellers may receive potentially any bond from a basket of deliverable instruments that have a priority rank with the cash asset, where physical settlement is required. The CDS contracts require one reference asset to be delivered at the choice of the protection buyer. The basis exists due to the risk of a mismatch which occurs between the bond in the asset swap and the cheapest to deliver in the CDS contract.

v) The problem with funding long-term positions at Libor: Since the basis itself is relatively small, basis trades require significant amount of leverage to generate substantial return on positions. These positions need to be held for some time.

vii) Regulations: Assets are mostly held on balance sheet whereas derivatives are held off balance sheet. Due to this difference some regulations regarding the economic capital calculations as well as accounting treatment can shift investors' preferences, resulting in a skew to the basis.

For those reasons listed above credit default swap prices often differ from the cash market prices for the same reference entity. Therefore banks are more widely using models they utilize for credit risk based on interest rate risk modeling.

CDS pricing models utilize expected cash flows and discount them in order to calculate CDS spreads as an alternative to asset swap spreads. The CDS spread is the internal rate of return value which is present value of expected premium payments.

2.2 Sovereign Risk and the Credit Derivatives Market Overview

Sovereign defaults have been observed repeatedly throughout the history of mankind. Even the industrialized countries have defaulted in the past. France and Spain constitute examples of this kind. Reinhart (2003) reports that France defaulted on its sovereign debt eight times between 1500 and 1800, while Spain defaulted thirteen times between 1500 and 1900. Conceivably, emerging market countries have defaulted more. The emerging markets frequently defaulted on their sovereign debts over the past quarter of a century.

While the concern for default risk remains, also the magnitude and complexity of the default cases have increased significantly in the last decade. When investing in the sovereign debt of a foreign country, an investor must consider two important risks. The first one is the political risk, which is the risk that even though the central government of the foreign country has the financial ability to pay its debts as they come due, for political reasons, the sovereign entity decides to default on its payment, called the willingness to pay factor. The second type of risk is default risk, which is the same old inability to pay one's debts as they become due.

Among these two sovereign risk types, the default risk can easily be considered the most important and the more common. The defaults are mainly caused by three factors: the value of sovereign assets, asset volatility, and leverage which is usually referred to as the debt to equity ratio. By definition whereas the determination of assets of the corporate are straightforward, for a sovereign it is more debatable. But in general, sovereign asset value is defined as the combined market value of all sovereign assets. These assets can be either cash flows generated by its trade activities or by its borrowings. Since the economic prospects for a country are not deterministic and might be highly uncertain, volatility is the only way to capture the inherent uncertainty. Leverage measures the size of the sovereign's liabilities which are measured in book value terms since these are the amounts that the sovereign is to pay. However the leverage of a sovereign might not be too easy to determine in most cases.

The approach to sovereign risk resembles and follows a similar thinking which has been used to model corporate credit risk. However, unlike the corporate, sovereign nations can't be liquidated and the assets can't be transferred from the debtor to the creditor in sovereign defaults. There are debates on whether the sovereigns should choose to default which would help them to get rid of their debt burden, and use its resources for the public welfare. It is the common sense that defaulting on ones debt will temporarily boost consumption, so it is natural to raise questions about why sovereigns do not default more frequently. But obviously some costs are incurred by the default which can be in different forms of penalties imposed by external creditors on the cost of defaulters to access future finance. Also, defaulters face the risk of losing access to borrowing from financial markets. Moreover, there might be a loss of trade financing which might cause trading volume to come down. And last but not the least, given that defaulting may cause a broader financial crisis, any attempt to boost current spending temporarily through a default may not be successful.

Overall, the empirical evidence suggests that sovereign default is not necessarily associated with a loss of market access, so fears about any such loss may not in themselves be a major deterrent to default. More generally, Gelos (2004) find that it only took defaulters three and half months, on average, to regain market access after defaulting during the 1990s compared with more than 4,5 years during the 1980s.

Although, the empirical evidence does not suggest that default necessarily closes off market access, it does point to an adverse effect on the government's cost of future borrowing. Ozler (1993) finds that, during the relatively quiet periods of the 1970s, lenders charged up to 50 basis points more for loans to previous (post-1930) defaulters. And more recently, Reinhart (2003) find that entrepreneurial market economies with a history of defaulting on their external debts received a lower credit rating over the 1979-2000 periods than non-defaulters that displayed similar financial strength.

Argentina's recent crisis in 2001 can be thought as an exception. Especially in the case of Argentina, the cyclical developments were more important. The abundance of a huge liquidity in financial markets helped Argentina to reach financing channels. And also an oil rich and politically driven neighbor Venezuela's help to provide financing can't be ignored by any means.

Respectively more important motivation for the governments may be to avoid broader losses to the domestic economy associated with default, beyond those caused by a tightening in the terms and conditions on borrowing imposed by foreign creditors.

As a consequence of the fluctuations in emerging market crises in the 1980s and 1990s, and furthermore increasing financial integration, country risk analysis has become a growing field of interest. Both for the countries itself and for international creditors besides investors, it is of crucial importance that the assessment of country risk takes place on a sound and objective basis. Easterly (2002) found that for the countries trying to re-access markets after a default, transparency and good governance are important conditions for access to international financial markets

By any benchmark, the growth of credit derivatives recently has been tremendous. The credit derivatives market has developed from being a niche to a highly liquid over the counter market within just a few years. The volumes in the market has spiked considerably as well. The popularity of credit derivative instruments can be explained by numerous factors. But all in all, they are used to protect against any possible credit event of a regular firm but largely used to protect against lower investment rated credits.

Hence these derivatives in particular have gained popularity in emerging markets which tend to be more volatile and have generally less credit-worthy private banks and corporations than do developed countries.

ISDA defines credit derivatives as credit default swaps referencing single names, indexes, baskets, and portfolios. By this definition, the outstanding notional CDS market reached to a volume of $62.2 trillion as of year-end 2007 according to the International Swaps Dealers Association (ISDA) which is shown below in Figure 2.6.

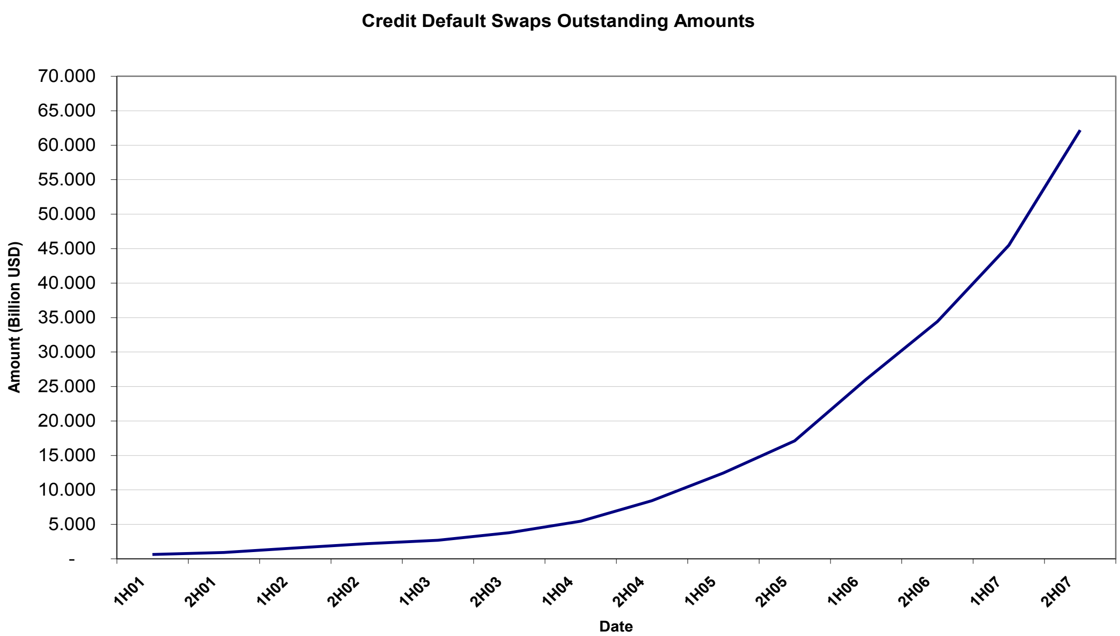


Figure 2.6 Growth of Credit Derivatives Market (US Dollars in Billions)

Source: ISDA Credit Derivative Market Survey

The market has been experiencing high double-digit growth since 2001, when it actually became liquid enough to track. At the start CDS's were thought to serve loan portfolio managers to hedge out their risks, however the demand the users of CDS are from several sources, including speculators, hedgers, structured product arrangers, and arbitrageurs. The largest volume of the credit derivatives market is traded through CDS's on a single name rather than an index CDS which are newly being developed. These contracts are used by a bondholder to protect against a default by the bond issuer. CDS's have both a protection leg and a premium leg for a transaction. The protection leg gives the right to a CDS holder to sell the bond at par which is essentially the same as a put option. This put option can only be exercised at the default time and in return the par value minus the recovery value is received from the protection seller. A CDS is an over the counter contract (OTC) in which the protection seller agrees to compensate for the losses on a defaulted bond. If default occurs before some fixed maturity date where the most liquid ones are mostly 5 years maturity, then the protection buyer can exercise his “put” on the defaulted bond to the protection seller for par. In return for this put, the protection buyer is obliged to pay the seller a premium until the earlier of default and maturity. As defaults are unlikely to occur on quarter ends, the buyer must also pay accrued interest at the default time. Once default occurs, the premium payments are stopped and the exchange of par versus the recovery rate takes place.

There are a number of factors behind the recent huge growth rate of the CDS market such as the flexibility of credit derivatives. CDS’s also offer greater liquidity which might provide investors room for trading. Regardless of the underlying bond’s issuance size, investors can go long or short any maturity and in any currency they choose. Even in some cases the credit default swaps outstanding can be a few times of the outstanding issue size of the bond of that entity. Also Citigroup report (2007) suggests that another reason why CDS market has grown so much is that products such as interest rate swaps had already paved the way for the credit default swaps in terms of expertise. Both interest rate swaps and credit default swaps required same processes and as a result CDS’s were able to benefit from what was already in place in terms of modeling and pricing.

The growth of the CDS market has lead to various outcomes as well. Adrian, Shin (2007) found that an active CDS market has a modest beneficial effect for corporate issuers with respect to their borrowing costs. However, a more interesting conclusion of their study was that nowadays the creditors have looser lending standards than prior to pre CDS periods. This suggests that the ability to transfer the credit risk easily into the markets causes lenders to be less focused on the lending standards as these credits will be also trading in the second hand market due to increased liquidity.

One potential side-effect of derivative usage in general is that they may present some problems as investors have fewer incentives to gather information and the amount of credit derivatives can exceed the amount of underlying securities. During high volatility periods, all the banks and investors run to hedge their risks which in turn result in higher volumes in credit default swap markets compared to other markets. So especially under these circumstances when there is a liquidity premium, the CDS markets underperform all the other instruments. On the other hand, they tend to overperform the other markets in times of positive mood as well. The amount of hedge required that would be provided by buying or selling protection is related to the hedge ratio, which is captured by the structural models.

2.3 Credit Default Swap Pricing Models

There are various models for pricing credit risk in the corporate sector. These models mostly concentrate on credit ratings, risk premiums and default rates. Caoulette (1998) suggests in his survey that these models depend on traditional actuarial methods of credit risk. Obviously there is no standard model for credit, part of the reason being that each of the models has its own set of advantages and disadvantages, making the choice of which to use depend heavily on what the model is to be used for.

Rating agencies utilize the default probabilities calculations more than other institutions. Altman(1977) has been the first to describe the techniques that can be used to forecast default probabilities.

Default might have various reasons which would range from macroeconomic factors such as high volatility in global economy, high interest rates, and recession to microeconomic factors such as poor management, high deficits due to populism by the governments and so on.

There are various causes that make default very hard to predict. In the corporate sector under these cases, default is a result of an inability to pay. In the case of sovereign debt, default may not be a result of an inability to pay, but may be due to an unwillingness to pay that is driven by political motives. Due to the mentioned factors, the literature on country risk has recognized the importance of the willingness factor. There have been many studies on the willingness to pay factor. Eaton, Gersovitz, and Stiglitz (1986), for example, argued that because a country's wealth is always greater than its foreign debts, the real key to default is the government's willingness to pay. Borensztein and Pennacchi (1990) suggest that besides other observable variables that are tested, the price of sovereign debt should be related to an unobservable variable that expresses the debtor country's willingness to pay. Clark (1991) suggests that the price of sovereign debt is related to a country's willingness to pay which is motivated by a desire to avoid the penalties of default.

Besides the willingness to pay calculation difficulty, these models don't also take into account the correlation among probabilities of default and estimates of possible losses. Finally, adding to the complication of credit risk modeling is that the data collected regarding default rates are not necessarily consistent with the definition of credit events for determining a payout trigger for a credit default swap. For example, data on defaults by rating agencies do not include restructuring of debt obligations. Yet, in a trade the ISDA definition of credit events may include restructuring. As a result, a debt restructuring due to a postponement of the principal repayment must be taken into account in modeling credit risk for evaluating a credit default swap but default data would not reflect such credit events.

The standard modeling framework for valuing default has the following simplifying assumptions:

1. The risk free interest rates are deterministic.
2. In the case of a default, the recovery rate is a deterministic fraction of par value.
3. Perfect capital markets are assumed: CDS contracts are assumed to be default free.
4. The default time is random and can not be predicted. The risk neutral probability of defaulting during the short time interval (t, t +e), conditioning on surviving until t, is given by l(t)e, where l(t) is assumed to be known at inception, t = 0.

The vulnerabilities in the world due to globalization have increased in the past years, and credit risk has become more important for economic policymakers. The economies can be severely damaged during a crisis period so even this highlights the need for a comprehensive framework to assess the strength of the financial systems.

The payout on a credit derivative is commonly triggered by the occurrence of a credit event - an event that affects the credit status of the reference name and these events are defined in The International Swap Dealers Association (ISDA) definitions. These are almost standard definitions of a default in the markets.

- Moratorium
- Failure to pay
- Repudiation of the debtor's obligations
- Restructuring of the debt
- A credit event on other obligations of the reference name which triggers a cross-default
- Accelerated repayment of the debt on the reference asset

The methodology is straight forward for a credit derivatives transaction. Like any swap, a CDS has two legs: the fixed leg which is the fee-payment leg and the floating leg which is for default insurance. The protection seller has a short position in the protection leg. As a result, the protection seller loses the difference between par and the bond's recovery value at the default time whenever default occurs before maturity of the CDS. As the protection short position takes the risk of a default, he is compensated by receiving a premium in return for taking the risk, so protection seller is long the premium leg. The cash flows for the protection seller comprise of the fixed premium plus the accrued interest at the default time. Since CDS have no upfront premium, the CDS spread is the annualized premium payment rate that equates the initial value of the premium leg to the initial value of the protection leg.

A typical credit default swap pricing is formulated as below using the notations listed in Schoenbucher (2003);

$\bar{s}$ = CDS rate

T_N=Maturity date of the bond

N=The number of payment dates of the i th calibration security

K=Tenor dates

B(t,T)=the time t price of a default-free zero-coupon bond with maturity T

B= zero-coupon bond price

$\overline{B}$ = zero-coupon bond price, zero recovery

π = expected recovery rate, recovery of par

$B(0,T_k)$ = the prices of the default-free zero-coupon bonds

$\overline{B}(0,T_k)$ = the prices of the defaultable zero-coupon bonds with zero recovery

$e(0,T_k,T_{k+1})$ = the value of \$1 at T_{k+1} if a default occurred in T_k,T_{k+1}

F(0,T) = term structure of default-free interest rates

H(0,T) = term structure of implied hazard rates

So accordingly the fixed leg consists of the payment of $\delta'_{n-1}\overline{s}$ at T_{k_n} assuming no default until T_{k_n}. The value of the fixed leg is:

$$\overline{s}\sum_{n=1}^{N}\delta'_{n-1}\overline{B}(0,T_{k_n}) \tag{2.1}$$

whereas the floating leg consists of the payment of recovery rate (1-π) at T_k, again assuming no default until T_{k-1},T_k. Then the value of the fixed leg can be interpreted as follows:

$$(1-\pi)\sum_{k=1}^{k_N}e(0,T_{k-1},T_k)=(1-\pi)\sum_{k=1}^{k_N}\delta_{k-1}H(0,T_{k-1},T_k)\overline{B}(0,T_k) \tag{2.2}$$

The initial assumption made to move forward is that the market CDS spread is assumed to have the same value for the fixed and floating leg of the CDS. So with that assumption (2.1) and (2.2) can be combined to yield the market CDS rate in the model:

$$\overline{s}=(1-\pi)\frac{\sum_{k=1}^{k_N}\delta_{k-1}H(0,T_{k-1},T_k)\overline{B}(0,T_k)}{\sum_{n=1}^{N}\delta'_{n-1}\overline{B}(0,T_{k_n})} \tag{2.3}$$

For the tenor dates and payment dates being equal, for instance N=K, $T_{k_n} = T_n$, $\delta_k = \delta'_k$, then the CDS rate can be calculated as a weighted sum of the implied hazard rates over the life of the CDS:

$$\bar{s} = (1-\pi)\sum_{n=1}^{N} w_n H(0, T_{n-1}, T_n) \tag{2.4}$$

Equation (2.4) gives an idea over the size and dynamics of the implied hazard rates of default H(·). They should be of the same order of magnitude as a typical CDS rate divided by an expected loss rate in default, and the relative dynamics dH / H should accordingly resemble the relative dynamics $d\bar{s} / \bar{s}$ of the CDS rates in the market.

The weights of the implied hazard rates are given by;

$$w_n = \frac{\delta_{n-1}\bar{B}(0, T_n)}{\sum_{m=1}^{N} \delta_{m-1}\bar{B}(0, T_m)} \quad \forall \quad n \le N \tag{2.5}$$

The sum of the weights is equal to one $\sum_{n=1}^{N} w_n = 1$.

Rebonato (1998) has also calculated the result for interest-rate swap rates which resembles the equation (2.4):

$$s = \sum_{n=1}^{N} w'_n F(0, T_{n-1}, T_n) \tag{2.6}$$

Where the weights are;

$$w'_n = \frac{\delta_{n-1} B(0,T_n)}{\sum_{m=1}^{N} \delta_{m-1} B(0,T_m)} \quad \forall \quad n \le N$$

Considering that after the initial date, the value of a CDS can change, the mark-to-market value of a CDS that was originally entered as protection buyer at a CDS spread of $\bar{s}'$ is:

$$\text{The Mark-to-market value} = (\bar{s} - \bar{s}')(\sum_{n=1}^{N} \bar{B}(0,T_{k_n})\delta'_{n-1}) \qquad (2.7)$$

As $\bar{s}$ symbolizes the current CDS rate, if a short protection position is entered, the mark-to-market value should be derived from the difference between $(s - \bar{s}')$ which is to be paid over the remaining periods of the CDS. If a default occurs then the protection payments will cancel out each other, and the fee difference payment will be canceled as well. So this means that the fee difference cash flow is defaultable and must be discounted with defaultable zero-coupon bonds $\bar{B}(0,T)$.

The important conclusion that can be derived for this thesis from these equations is that the CDS's can be used to take exposure against spread movements. The CDS's are used mostly for trading default probabilities instead of as investment purposes. The sensitivity of the market value of a CDS position is the main reason for this. So, not only default risks can be hedged but CDS's can be used to trade the spreads which represents the majority of the CDS trades in the market these days. As much as default risk, the CDS market reflects liquidity conditions in the underlying bond markets and simple momentum trading. Momentum and liquidity were the main drivers of CDS prices on in the last 5 years, when the market grossly underestimated default risks; and, momentum and liquidity are the main drivers on the way up.

CDS's instead of implying default probabilities most of the time, simply reflect the imbalance of supply and demand for protection. In a market where the liquidity dries up, the protection sellers disappear, since no bank is prepared to accept the risk of margin calls and mark-to market losses if the CDS price moves against it in the short-term. In these cases, the protection buyers become price insensitive and are willing to pay almost any price to close out losses on the credit default swap positions which are sold at much lower prices. Then if the probability of default is tried to be measured in these types of markets, it will be observed that CDS prices have almost no relation to the probabilities of default which they supposedly imply. This logic applies to other index and composite type CDS products which are originally supposed to reveal insight about the default probabilities.

The bond yields and CDS rates are a function of the market liquidity in the underlying instruments and this relation has been increasing in the last few years. So rather than implying default, the liquidity has to be given more emphasis. The reason for this is that investors trading these assets under the current market conditions are obliged to value these assets on their collateral values and have to marked-to-market these assets. So the discounted cash flows or internal rate of return in this case is not important for the market players. For instance though unlike corporates, sovereigns default rarely, some sovereigns might imply higher default probabilities than the corporates operating in those countries. Despite the fact that the market knows that these issuers are not going to default, with the possibility of a widening of prices, the protection sellers know that prices would trigger sales due to margin call requirements. According to the efficient market hypothesis, the arbitrage opportunities created by the extreme widening of liquidity-based CDS spreads should fade away by selling the protection spreads and shorting underlying bonds or equity which is indeed selling the basis trade. This is however only possible if the investors can leverage themselves and find ways of financing these trades. Under the conditions mentioned, where the liquidity is lower, the markets are not capable of tightening the CDS spreads into alignment with underlying default probabilities. As a result of these developments, the market can be told to be distorted. First, CDS spreads decouple from the value of the underlying assets. Secondly, the bond and CDS pricing become a liquidity and momentum trading issue. So the CDS spreads should be treated as a trading tool rather than implication of default probabilities.

As mentioned above, the sensitivity of the market value of a CDS position means that CDSs are useful instruments to gain exposure against spread movements, and not just against default arrival risks. For simplicity, in this thesis a credit event will be equated with loan default, since the main objective is to determine the relationship of the credit default swap spread with the actual market rates. However, a credit event may be defined by the parties to include any credit risk which could materially affect the market value of the reference asset as in the case of a specified ratings downgrade.

Chapter 3

Literature Review

3.1 Traditional Studies and New Attempts to Provide a Methodology for the Determination of Corporate CDS spreads

Everything being equal, a country which experiences higher volatility in its fundamentals should also experience weakening of the fundamentals, which would result in a possible default. In return, the yields on its liabilities and credit spreads will increase. This intuition has been reflected in Merton's (1974) model of risky corporate debt, where an investor views risky debt as a combination of safe debt and a short position in a put option. The value of the option depends on the volatility of the underlying firm value; hence the value of the firm's bonds also depends on this volatility. In the case of a sovereign, higher volatility of fundamentals increases the value of the default option and thereby the spread. Despite the importance and widespread understanding of this theory, it has been largely ignored by the empirical literature on sovereign debt, which has tended to focus exclusively on the level of variables. Two exceptions are Edwards (1984), who includes variability of reserves and finds that it is insignificant, and Westphalen (2001), who finds some limited effect of changes in local stock market volatility on changes in short term debt prices. In the corporate bond context, Campbell and Taksler (2003) find a strong empirical link between equity volatility and yield spreads.

Only a few studies to date analyze the influence of theoretical determinants of credit risk on CDS spreads. Benkert (2004) concentrates on the influence of different volatility measures on CDS premia, finding that option implied volatility has the strongest effect; Cossin *et al* (2002) argue that rating is the most important single source of information in the spread; Ericsson *et al* (2004) investigate the influence of leverage, volatility and interest rates on single-firm CDS concluding that these variables are important determinants of CDS spreads. Other empirical studies covering the CDS market include Hull *et al* (2004), who compare credit risk pricing between bond and CDS markets, and found out that differences are quite small. Furthermore, their evidence suggests that CDS spreads are helpful in predicting negative rating events. Houweling and Vorst (2005) came out with the result that the reduced form models outperform bond yield spreads. They compared market prices of credit default swaps with model prices and concluded that a simple reduced form model prices credit default swaps better than comparing bonds yield spreads to CDS premiums.

The variables influencing CDS spreads in structural default models are various. For instance, the short rates are one of the factors affecting the default probability. An increase in the short rate should decrease the default probability. The theoretical argument supporting this is that the short rate influences the risk neutral drift in the firm value process: a higher short rate raises the risk neutral drift and lowers the probability of default. Besides the short term rates, the slope of the yield curve is considered important. The steeper the yield curve, the higher the expected future short rate and thus we expect a negative relationship between both the short rate and the slope of the yield curve and the CDS spread. Low interest rates are often observed during periods of recession and frequent corporate defaults. In addition the steepness of the yield curve is an indicator of an increase in future economic activity. Fama (1984) and Estrella and Hardouvelis (1991)'s work support this idea.

Default data are considerably less in comparison to the data available for the modeling of interest rate risk. It is rather difficult to form time series of defaults whereas Treasury prices are available to every individual on a daily basis for many decades.

Longstaff (2003) argues that the bond market is lagging the derivatives market in terms of price discovery. However, a bias is present in the econometric results of this study since the potential cointegration relationship across the markets is ignored.

In the light of these and other pragmatic considerations, studies of sovereign debt pricing have focused primarily on models based on the intensity processes that have been exogenously specified. Merrick (1999) has studied Russian and Argentinian bonds and has calibrated a discrete-time model to these bonds which utilize models with a constant intensity. Keswani (1999) and Pages (2000) have studied and implemented special cases of the modeling framework of Duffie and Singleton (1999) to data on Latin American Brady bonds. Dullmann and Windfuhr (2000) apply a similar framework to pricing European government credit spreads under the European Monetary Union. Implicit in these formulations are the assumptions that holders of sovereign debt face a single credit event default, with liquidation upon default and that the bonds issued by a given sovereign are homogeneous with regard to their credit characteristics.

There are few studies in the literature regarding the defaultable bonds and several models have been proposed for this purpose. (Duffie and Singleton (2003)) lists three main approaches:

i) Merton's (1974) option pricing based model, which computes the payoff at maturity as the face value of the defaultable bond minus the value of a put option on the issuer's value with an exercise price equal to the face value of the bond.

ii) Structural models, which are the followers of the Merton model relax one of the unrealistic assumptions of Merton's model that default occurs only at maturity of the debt, when the issuer's assets are no longer sufficient to face its obligations towards bondholders. On the contrary, these models assume that default may occur at any time between issuance and maturity of the debt and that default is triggered when the issuer's assets reach a lower threshold level (Black and Cox (1976) and Longstaff and Schwartz (1995)).

iii) Reduced-form models, which do not condition default explicitly on issuer's value, and therefore are, in general, easier to implement. These models are different than structural models in the sense that they approach in a different way to defaults. The degree of predictability of default differs, as the reduced form models which are developed by Jarrow, Lando and Turnbull (1997) and Duffie and Singleton (1999)) accommodate defaults coming as sudden surprises.

Structural models like the Merton model, assume that the modeler has the same information set as the officials- complete knowledge of all the assets and liabilities. Due to this assumption regarding the symmetry of information, the default time is assumed to be predicted in advance. For cases where an issuer's outstanding bond amount is too large in the market, reduced form models are expected to do better. However, for the structural models, Merton model is rather useful but has simplifying assumptions; and appropriate modifications to the framework are necessary.

Making more deterministic assumptions is clearly not possible to realize. If the assumptions lead to predictions that are good enough by making plausible and enough realistic assumptions, that would be the most desired and optimized outcome.

This insight presented applies to the current debate regarding structural and reduced-form models. While much of the debate rages about assumption and the underlying theory, relatively little work is done about the empirical applicability of these models. The research result obtained by this thesis is expected to improve the understanding of the empirical performance of several widely known credit pricing models.

For corporate credit spread calculations, there are a few practical methods developed in the market by using Merton model. Two of those approaches will be mentioned here briefly. These methodologies are called CreditMetrics and KMV models. These models rely on the firm value or so called asset value model which are originally proposed by Merton (1974). However, their implementation has quite different features and assumptions. These models differ quite substantially in the simplifying assumptions they require in order to facilitate its implementation. In fact, the framework to analyze credit risk calls for the full integration of market risk and credit risk. Yet there are no models satisfying this criterion and reached the sophistication.

The first of these models is CreditMetrics. CreditMetrics is developed by JP Morgan, first published and well publicized in 1997. The CreditMetrics approach is based on credit migration analysis which is based on the probability of moving from one credit quality to another, including default, within a given time horizon, which is often taken arbitrarily as 1 year. CreditMetrics models the full forward distribution of the values of any portfolio where the changes in values are related to credit migration. In this case the interest rates are assumed to evolve in a deterministic fashion. Credit value at risk of a portfolio is derived in the same methods as for market risk. It is simply the percentile of the distribution corresponding to the desired confidence level.

The second model is the KMV model which is developed by a firm specialized in credit risk analysis. KMV Corporation has developed a credit risk methodology over the last few years, as well as an extensive database, to assess default probabilities and the loss distribution related to both default and migration risks. KMVs methodology differs somewhat from CreditMetrics as it relies upon the ``Expected Default Frequency", or EDF, for each issuer, rather than upon the average historical transition frequencies produced by the rating agencies, for each credit class.

From the actual comparison of these models on various benchmark portfolios, it seems that any of them can be considered as a reasonable internal model to measure credit risk, for straight bonds and loans without option features. All these models have in common that they assume deterministic interest rates and exposures. While, these models are convenient for simple vanilla bonds and loans, they are inappropriate to measure credit risk for swaps and other derivative products.

In order to measure credit risk of derivative securities, the next generation of credit models should allow at least for stochastic interest rates, and possibly default and migration probabilities which depend on the state of the economy. For instance the policy measures such as reserves, debt and even other factors like the level of interest rates and the stock market should also be taken into account if possible.

The insights of Black Scholes (1973) and Merton (1974) have changed the credit pricing methodology and understanding. By suggesting that these types of models systematically underestimate observed spreads, Jones (1984) has opposed to these structural models of default. His research reflected a sample of firms with simple capital structures observed during the period 1977-1981. Ogden (1987) confirmed this result, finding that the Merton model under predicted spreads over US Treasury securities by an average of 104 basis points. Moody’s KMV revived the practical applicability of structural models by implementing a modified structural model called the Vasicek-Kealhofer (VK) model (Vasicek, 1984; Crosbie and Bohn, 2003; Kealhofer, 2003). Black and Cox (1976) treat the point at which the default occurs as an absorbing barrier. Geske (1977) on the other hand deals with the liabilities and solves the liability claims by treating them as compound options. Geske assumed the firm has the option to issue new equity to service debt.

Longstaff and Schwartz (1995) have introduced stochastic interest rates into the structural model framework to create two-factor specification. Leland and Toft (1996) studied the structural models and the affect of taxes and bankruptcy costs on this model output. In their framework, they assume the firm issues a constant amount of debt continuously with fixed maturity and continuous coupon payments. Collin-Dufresne and Goldstein (2001) extend the Longstaff and Schwartz model by introducing a stationary leverage ratio, allowing firms to deviate from their target leverage ratio in the short run only.

While empirical evidence is still scarce, a few empirical researchers have begun to test these model extensions. Lyden and Saraniti (2000) compare the Merton and the Longstaff-Schwartz models and find that both models underpredict spreads; the assumption of stochastic interest rates does not seem to change the qualitative nature of the finding. Eom (2003) find evidence contradicting conventional wisdom on the bias of structural model spreads. In his study Eom concluded structural models that depart from the Merton framework tend to overpredict spreads for the debt of the firms with high volatility or high leverage. The structural models for safer bonds are thought to underpredict spreads with the exception of Leland-Toft.

Some of the underprediction found in the standard testing of the Merton model likely results from choosing the wrong benchmark curve in the sense that the spread over US Treasuries includes more than the compensation for just credit risk. The assumption here is that the appropriate default risk free curve is closer to the US swap curve which typical estimates are 10-20 basis points less than the US swap curve. All of these modifications contribute to producing a more usable structural model.

The Merton model is particularly useful for practitioners in the credit portfolio and credit risk management fields. The intuitive economic interpretation of the model facilitates consistent discussion regarding a variety of credit risk exposures. Corporate transaction analysis is also possible with the structural model. If an analyst wants to understand the impact of increased borrowing and debt buybacks, the structural model aids to understanding the transaction’s implications. In general, the ability to diagnose the inputs and outputs of the structural model in terms of understandable economic variables such as asset volatility for risk and the market's assessment of the credit value, facilitates better communication among lenders, credit analysts and credit portfolio managers.

3.2 The Structural Model vs. Reduced Form Models

As sovereign defaults can be rarely seen unlike corporates, modeling credit risk is a difficult task for sovereigns. Default data are considerably less in comparison to the data available for the modeling of interest rate risk where time series of U.S. Treasury prices are available on a daily basis for many decades. Such models concentrate on default rates, credit ratings, and credit risk premiums. In order to value credit derivatives, it is a prerequisite to be able to model credit risk. On the other hand, models for credit risks have long existed in the corporate finance literature. Beaver (1966) has developed the first univariate statistical model of financial distress, however Altman's (Altman (1968)) Z-score discriminant model has become the market standard as prototypical statistical model in the field.

The traditional models focus on diversification and assume that default risks can be diversified away in large portfolios. Models of this kind are along the line of portfolio theory that employs the capital asset pricing model. In capital asset pricing models, only the systematic risk or so called market risk matters. For single name credits, the models calculate risk premiums as markups and add on the top of the risk-free rate. Since the default risk is not diversified away, capital market line is used to compute the correct markup for bearing the default risk. The Sharpe ratio is commonly used to measure how credit risks are priced which divides the return by its standard deviation.

Modern credit derivative models can be partitioned into two groups known as structural models and reduced form models.

The structural models were first developed by Black and Scholes and Merton. These models consider that if the value of the assets of a company falls below a certain default point, the company is to default on its debt. For this reason, these models are also known as firm-value or asset value models. It is also called the structural approach because it relies upon the sharing rule for the value of the assets of the firm, V, between shareholders and bondholders. Structural models relate the probability of default to the implied volatility of a corporate which is derived from the volatility of a firm's assets and claim that the probability of a default is closely related to the implied volatility of the corporate. Merton's contingent claims analysis is used to value the component parts of a firm's liability mix. In general, the value of each component will depend upon the stochastic variables which determine the evolution of the firm's asset value, the evolution of the interest rate, the payouts to the various debtors, and the bankruptcy.

Merton's contribution by this model is that it is a simplified model that yields useful insights and a methodology for complete valuation. The method makes it possible to analyze and measure the impact on credit risk spreads of a change in asset volatility, a change in interest rates volatility, different maturities of debt and such. According to Merton, firms with more volatile assets tend to default more. Because CDS is protection against defaults and default rates are the critical inputs to CDS spreads. These structural models imply that volatility should be closely related to CDS spreads. In these models it has been demonstrated that default can be modeled as an option and, as a result, researchers were able to apply the same principles used for option pricing to the valuation of risky corporate securities. The application of option pricing theory avoids the use of risk premium and tries to use other marketable securities to price the option. The use of the option pricing theory set forth by Black-Scholes-Merton provides a significant improvement over traditional methods for valuing default risky bonds. It also offers not only much more accurate prices but provides information about how to hedge out the default risk which was not obtainable from traditional methods.

During the development of the structural models, Fischer Black and Myron Scholes explained how equity owners hold a call option on the firm. After that Robert Merton extended the framework and analyzed risk debt behavior with the model. Robert Geske extended the Black-Scholes-Merton model to include multiple debts. Recently many barrier models appear as an easy solution for analyzing the risky debt problem. In these models, the default behavior is modeled in an option theoretical framework, and, as a result, one can apply the same principles used for option pricing to the valuation of risky corporate securities. The use of option pricing theory set forth by Black-Scholes-

Merton hence provides a significant improvement over traditional methods for valuing defaultable bonds. It also offers not only prices that are more accurate but provides information about how to hedge out the default risk, which was not obtainable from traditional methods.

Furthermore, the key assumption of these models makes intuitive sense. The default behavior is a result of the value of the firm's assets falling below the value of its debt. In the case of Black-Scholes-Merton or barrier model, the outputs of the model show how the credit risk of corporate debt is a function of the capital structure and the asset volatility of the issuer. The structural model framework is a useful tool in the analysis of counterparty risk for banks when establishing credit lines with companies and a useful tool in the risk analysis of portfolios of securities. However, structural models are difficult to calibrate and thus are not suitable for the frequent marking to market of credit contingent securities. Structural models are also computationally harder.

Implementing the structural models to corporates, the liability side of the balance sheet consists of the shareholder's value, which is represented by S, as opposed to the bondholder's value, D for debt. When evaluating the risk, one has to consider that there is the limited liability feature of the corporation. Accordingly, the downside risk is limited as the maximum loss of the shareholders is limited to the nominal amount of its shares. The shareholders also have a claim on the value of the assets. Thus, the profile of the shareholder's value can be well represented by the value of the call, written on the assets of the firm.

The shareholder's payout is similar to a call on the assets of the firm, while the bondholder's payout is similar to having a long position in the debt and short position in a put option on the value of the firm to the shareholders.

The application of option pricing theory avoids the use of risk premium and tries to use other marketable securities to price the option. Merton model also offers not only much more accurate prices but provides information about how to hedge out the default risk which was not obtainable from traditional methods. Subsequent to the work of Merton model, there have been many extensions.

The reduced form models, which are the second group of credit models, are more recent. This approach assumes a firm's default time is inaccessible or unpredictable and driven by a default intensity that is a function of latent state variables. Jarrow and Turnbull (1995), Duffie and Singleton (1999), Hull and White (2000), and Jarrow (2001) present detailed explanations of several well-known reduced form modeling approaches. The name reduced form was first given by Darrell Duffie to differentiate from the structural form models of the Black-Scholes-Merton type. Both types of models are arbitrage free and employ the risk-neutral measure to price securities. The principal difference is that default is endogenous in the BSM model while it is exogenous in the Jarrow-Turnbull and Duffie-Singleton models. The reduced form models do not look inside the firm. Instead, they model directly the possibility of a default or a downgrade. Not only is the current probability of default modeled, some researchers attempt to model a forward curve of default probabilities that can be used to price instruments of varying maturities. Specifying defaults exogenously greatly simplifies the problem because it ignores the constraint of defining what causes default and simply looks at the default event itself. The computations of debt values of different maturities are independent, unlike in the Black-Scholes-Merton model that defaults of the later-maturity debts are contingent on defaults of earlier-maturity debts. Modeling a probability has the effect of making default a surprise where the default event is a random event which can suddenly occur at any time.

The reduced form models deal with defaults as an unpredictable event and don't handle the cause of default. Agrawal and Bond (2005) explain that the default is the result of the outcome of a random jump process. However, due to the dependence on fundamentals, the structural approach has a wide set of empirically testable determinants of default. Structural models of default risk are cause-and-effect models. In structural credit risk models of Merton (1974), Black and Cox (1976), and Longstaff and Schwartz (1995) or Zhou (2001) default occurs when the asset value falls below a certain threshold level, which is commonly modeled as an increasing function of the leverage. Also, assuming a particular stochastic process for the firm value allows risk neutral valuation to be used for pricing credit risk sensitive instruments. Nosbusch and Hilscher (2004) used reduced form model to capture empirical variation in sovereign spreads. In their study they found that, consistent with standard option and debt pricing intuition, volatility affects debt prices. By using terms of trade and debt to GDP ratios, the results seem to be highly correlated with the sovereign spreads.

Due to the fact that most structural models assume complete information, Jarrow and Protter (2004) argue that reduced-form models are more appropriate in information theoretic context. They base their arguments on the fact that we are unlikely to have complete information about the default point and expected recovery. Jarrow and Protter's claim rests on the premise that a modeler has only as much information as the market, making the reduced-form approach more realistic. In practice, however, the complete information assumption in structural models is an approximation designed to facilitate a simpler way of capturing the various economic differences of how a firm operates. The strength or weakness of a model should be evaluated on its usefulness in real-world applications. A reduced-form model, while not compromising on the theoretical issue of complete information, suffers from other weaknesses including lack of clear economic rationale for defining the nature of the default process.

Clearly, both structural models and reduced form modeling frameworks have their own set of advantages and disadvantages, making the choice of which to use depend heavily on what the model is intended for.

Bohn (2000) finds that some of the most successful work and results based on the Merton model are models that use the so called hybrid approach. Usually these models use the structural model as the foundation, but build some flexibility into the model for adjustment. And extensive empirical studies are used to adjust the model to fit the market or historical observed data. Accordingly, in developing the model, using a barrier model enhanced by other financial and market information, so called enhanced-structural model seems more plausible.

However, there is yet no standard model for credit. Part of the reason for this lack of standardization is that each of the models has its own set of advantages and disadvantages, making the choice of which to use depend heavily on what the model is to be used for.

3.3 Advantages and Drawbacks of Structural Models

As in other fields, Merton's structural model has brought a new perspective for credit spread calculations. Built on the arbitrage-free pricing methodology, credit risk arises from the potentiality of default. The credit risk occurs when the value of the assets falls below a certain threshold value. Merton's framework is straightforward due to ease of option pricing. Crouhy and Galai (1997) derive the implicit assumptions of Merton's framework for the default probability and the expected recovery rate, the two essential components of credit risk. The leverage ratio is proved to play a crucial role in the decomposition. Whenever the profile is easily understandable, it assumes that the strategy is replicable and that therefore credit risk is hedgeable which is controversial. Moreover, using asset size, V, as the underlying process supposes that V is a traded asset.

Structural models have many advantages. Some of the advantages of the structural approach show up as:

i) The availability of an economic context underlying the event of default and the clear definition of the default. Modeling default has a reasonable assumption that it is a result of the value of the firm's assets falling below the value of its debt. In the case of the Black-Scholes-Merton model, the outputs of the model show how the credit risk of a corporate debt is a function of the leverage and the asset volatility of the issuer.

ii) The term structure of spreads also appears realistic and empirical evidence argues for and against their shape.

iii) The possibility to relate this to standard option pricing allowing: a) an easy pricing framework; b) a nondeterministic randomness for the event of default since the whole formulation depends on the process for the value of the assets; c) the use of option relationships to link both claimholders' values and infer the parameters from real market data.

The disadvantages also exist which hinder the use of structural approach compared to reduced form models:

i) One of the difficulties with structural models is their calibration. They are difficult to calibrate and not suitable for the frequent marking to market of credit contingent securities.

ii) They also require high load of computations such as in the case of the pricing of a defaultable zero-coupon bond. And furthermore, addition of coupons makes the problem harder, turning the problem into the similar calculation for a compound option. Pricing any subordinated debt requires the simultaneous valuation of all of the more senior debt.

iii) Poor empirical performance can be said to be another major drawbacks of structural models. It has been suggested in some researches that it is very difficult to generate reasonable levels of short-term bond yields from structural models, because almost all structural models assume that the firm's value changes smoothly. Eom *et al* (2002) puts forward in their paper that the accuracy of the predictions by structural models is very questionable. Another advocator of this idea is Huang and Huang (2002), who suggest that structural models tend to systematically underpredict the credit risk in the corporate bond market.

The structural models due to these mentioned reasons, are not used where there is a need for rapid and accurate pricing of many credit-related securities. Instead, the main application of structural models is in the areas of credit risk analysis and corporate structure analysis.

An alternative way of characterizing the differences between the two models is that structural models are closer to models that use fundamentals for pricing, whereas the reduced-form models are closer to models that rely on relative pricing. Reduced-form models are flexible and their functional form can easily be modified. This flexibility can either be strength or a weakness depending on the perspective. Considering the flexibility of the reduced-form models, fitting of credit spreads is easier comparatively. However, this can also be a negative. This flexibility in functional form may result in a model with strong in-sample fitting properties, but poor out-of-sample predictive ability. Since this type of model reflects a framework not directly rooted in an explanation of why a firm defaults, diagnosing how to improve performance of these models can be challenging. In addition, difficulties in interpretation of results can be acute when modeling large cross sections of debt instruments- particularly when there is a high degree of heterogeneity in terms of credit quality. Without empirically testing the costs and benefits of any particular modeling approach, it is premature to draw conclusions based on purely theoretical arguments.

Despite some of the disadvantages, some of the more recent structural models have addressed many of the limitations and assumptions of the original Black Scholes Merton model. A structural model is more likely to be able to predict the credit quality of a corporate security than a reduced form model. It is convenient and useful in the analysis of counterparty risk when establishing credit lines with companies. Besides it is also a useful tool in the risk analysis of portfolios of securities. In order to analyze how to structure the debt and equity, structural models are still commonly used.

3.4 Background of Merton Model

In their earliest credit model that employed the option pricing theory Black-Scholes explicitly articulated that corporate liabilities can be viewed as a covered call: own the asset but short a call option. In the simplest setting where the company has only one zero-coupon debt, at the maturity of the debt, the debt holder either gets paid the face value of the debt in which case, the ownership of the company is transferred to the equity holder or takes control of the company and in such a case, the equity holder receives nothing. The debt holder of the company therefore is subject to default risk for he or she may not be able to receive the face value of his or her investment. Black-Scholes-Merton effectively turned a risky debt evaluation into a covered call evaluation whereby the option pricing formulas can readily apply.

Merton (1974) is known as the developer of the contingent claims model for pricing corporate debt that is based on the Black and Scholes (1973) option pricing model. In this option pricing framework, corporate liabilities are treated as combinations of option contracts according to their cash flows and boundary conditions. Under Merton's model, in order to measure the default probabilities, the theoretical measure of the default risk premium on bonds is used. The calculation is done by taking the difference between the yield on a risky bond and a risk free bond with the same maturity.

Jones *et al* (1984, 1985) extend Merton's (1974) model to include the sinking fund provision and generalize the model to allow for multiple issues of a given firm's debt. Ogden (1987) empirically tests this modified version of the contingent claims model. His study compares the modified contingent claims model of the default risk premium with market yield premiums. The model yield premiums explain nearly 60% of the variation in market yield premiums. According to this modified version of the contingent claims model, the default premium for a given maturity is a function of two variables - leverage, and the standard deviation of firm value, Ogden finds that these two variables explain approximately 78% of the variation in agency ratings on the bonds. The default risk premium is incorporated into risky bond yields to compensate for default risk. However, Ogden's study ignores the larger issue of the probability of default.

Default is sometimes modeled as the event that, at maturity, there are insufficient assets to pay down the debt, as in Merton (1974), or the event that the debtor's cash-flows or asset-liability ratio falls below some cut-of level for the first time, as in Fischer, Heinkel, and Zechner (1989).

It is important to characterize the assumptions required for the consistency of the application of standard option pricing to corporate credit risk. The Merton (1974) framework relies on many hypotheses, from the Black and Scholes option pricing theory.

The objective of this simple methodology is to provide the price of a straight loan granted to a defaultable firm for a given period of time. The following hypothesis set the context in which the value process of this firm evolves through time.

Cossin and Pirotte (2000) lists some of the assumptions made for the calculation of corporate credit spreads are briefly mentioned below:

Assumption 1: The markets are assumed to be frictionless. The transaction costs or taxes are assumed to be zero and no short selling restrictions are in place. Also, the assets are perfectly divisible and are traded continuously. The absence of bid-ask spreads and asymmetry translates into borrowing rates that are equal to lending rates.

Assumption 2: Another implicit assumption is that there are sufficiently many investors with comparable level of wealth such that they can buy or sell as much as they want at a given market price. The problem is placed into a partial equilibrium framework that rules out any free-arbitrage opportunity.

Assumption 3: There is a risk free asset whose rate of return per unit of time is known and constant over time. This implies a flat and constant term structure of risk free interest rates. Thus, the price of a risk free bond paying \$1 at time T will be $B_0(T) = \exp(-rT)$, where r is the instantaneous risk free interest rate.

Assumption 4: V_t, the value of the assets of the firm, follows Ito dynamics:

$$\frac{dV_t}{V_t} = \mu dt + \sigma dZ_t \tag{3.1}$$

where μ is the instantaneous expected rate of return, σ is the variance of the return of the underlying assets which is assumed to be constant over time, and Z_t a standard Wiener process under the risk neutral measure. Note the special case where C is total cash outflow per unit time. Note that C is assumed to be zero.

$$\frac{dV_t}{V_t} = (\mu - C)dt + \sigma dZ_t \tag{3.2}$$

Assumption 5: On the liability side of the balance sheet of the firm, the total value is financed by equity, E, and one representative zero-coupon non callable debt contract, D, maturing at time T with face value F.

$$V_t = D_t + E_t \qquad (3.3)$$

Together with assumption 1, the assumption 5 implies that the value of the firm and the value of assets are identical and do not depend on the capital structure itself. This also implies that the drift and the volatility of the returns on assets should not depend upon the level of the value of the firm.

Assumption 6: Another assumption is regarding the shareholder wealth maximization: It is assumed that the management acts to maximize shareholder wealth.

Assumption 7: The debt contract is fixed with the initial hypothesis that the firm is not already at default.

Assumption 8: There are neither cash flow payouts, nor issues of any type of security during the life of the debt contract, nor bankruptcy costs. This implies that default can only happen at maturity, if the firm can not meet the reimbursement of the face value of the debt, F.

Assumption 9: The absolute priority rule can not be violated; shareholders obtain a positive payoff only in the case that debt holders are perfectly reimbursed.

Thus the firm has two classes of securities: a single homogenous class of zero-coupon discount bonds, with face value F and maturity T, and equity. The certificate of the bond issue contains the following simplified event of default act suggesting that if the required face value payment is not met, the bondholders receive the entire value of the firm and the owners of the firm receive nothing. In this framework, the firm is prohibited from issuing any senior claims on the firm nor can it pay dividends or repurchase shares prior to the maturity of the debt.

Hence, the value of the bond at maturity is

$$D_T(V,T) = \min(V_T, F) \tag{3.4}$$

$$= V_T - \max\ \ V_T - F, 0 \tag{3.5}$$

$$= F - \max\ \ F - V_T, 0 \tag{3.6}$$

The equations provide two interpretations. Equation (3.5) decomposes the risky debt into the asset and a short call. This interpretation was first given by Black and Scholes that equity owners essentially own a call option of the company. If the company performs well, then the equity owners should call the company; or otherwise, the equity owners let the debt owners own the company. Equation (3.6) decomposes the risky debt into a risk-free debt and a short put. This interpretation explains the default risk of the corporate debt. The issuer who is the equity owner can put the company back to the debt owner when the performance is bad. The default risk hence is the put option.

Note that the value of the equity and debt when added together must equal the assets of the firm at all times, V_t = E(t) + $D(V_t, T)$. Clearly, at maturity, this is true as we have as required.

$$\begin{aligned} &E(T) + D(V_T, T) = \max\ \ V_T - F, 0\ \ + \min\ \ V_T, F \\ &= V_T \end{aligned} \tag{3.7}$$

$$\sigma_E = N(d_1) \cdot \sigma_V \cdot \frac{V}{E}$$

For the corporate since the value of the equity can be observed and calculated easily with the standard deviation of the equity, the calculation of the option value is straightforward. What is missing in this equation is the value of the underlying assets or the volatility of the assets derived from the liabilities. Thus in addition to the definition of the equity as a call option, a model that relates the equity-sigma to the asset-sigma is needed. Though asset volatility is related, it is still different from the equity volatility. A firm’s leverage has the effect of increasing its underlying asset volatility.

If the equation is studied a few points have to be made. If the N( ) term is ignored, it can be seen that the equity sigma is directly proportional to the asset sigma. So this implies that with the increasing leverage, the equity sigma increases. Mainly, the N(d1) term is related to the probability of not defaulting. As the default occurs in zero equity value, regardless of the value of the underlying assets, the value of the firm and hence the value of the debt can be solved. Overall, if the market value and volatility of sovereign can be reached, it is possible to estimate the implied value for sovereign assets and volatility, through the simple Black and Scholes option formula.

Since any corporate debt is a contingent claim on the firm's future asset value at the time the debt matures, this is what must be modeled in order to capture the default. As mentioned above Black Scholes Merton assumed that the dynamics of the asset value follow a lognormal stochastic process as in equation (3.1).

This is the same process as is generally assumed within equity markets for the evolution of stock prices and has the property that the asset value of the firm can never go negative and that the random changes in the asset value increase proportionally with the asset value itself. As it is the same assumption used by Black-Scholes for pricing equity options, it is possible to use the option pricing equations developed by Black Scholes Merton to price risky corporate liabilities. The company can default only at the maturity time of the debt when the payment of the debt is made. At maturity, if the asset value lies above the face value, there is no default, else the company is in bankruptcy and the recovery value of the debt is the asset value of the firm. For this one-period case, the probability of default at maturity can be formulated as below;

$$p = \int_{-\infty}^{F} \phi \; V_T \; dV_T = 1 - N(d_2) \tag{3.8}$$

where ϕ – represents the log normal density function, N(-) represents the cumulative normal probability, and

$$d_2 = \frac{\ln V_T - \ln F + (r - \sigma^2 / 2)(T - t)}{\sigma \sqrt{T - t}} \tag{3.9}$$

Equation (3.8) implies that the risk neutral probability of in the money N(d2) is also the survival probability. To find the current value of the debt, D(t,T) (maturing at time T), we need to first use the result to find the current value of the equity. As shown above, this is equal to the value of a call option:

$$E(t) = V_T N(d_1) - e^{-r(T-t)} F N(d_2) \tag{3.10}$$

Where $d_1 = d_2 + \sigma\sqrt{T-t}$, The current value of the debt is a covered call value:

$$D(t,T) = V_T - E(t) \tag{3.11}$$

$$= V_T - \left[V_T N(d_1) - e^{-r(T-t)} F N(d_2) \right]$$

$$= V_T \left[\ 1 - N(d_1) \ + e^{-r(T-t)} F N(d_2) \right]$$

Note that the second term in the last equation is the present value of probability-weighted face value of the debt. It means that if default does not occur (with probability N(d2)), the debt owner receives the face value F. Since the probability is risk neutral, the probability-weighted value is discounted by the risk-free rate. The first term represents the recovery value. The two values together make up the value of debt.

The yield of the debt is calculated by solving $D(t,T) = Fe^{-\gamma(T-t)}$ for y to give

$$y = \frac{\ln F - \ln D(t,T)}{T-t} \tag{3.12}$$

So when the yield is obtained, it is straightforward to calculate the risk premium by taking the difference of y and risk free rate.

The Black-Scholes formula contains two unknowns, the value of assets and the volatility of assets. As the formulas imply, whenever the asset value increases, the firm's solvency probability increases and the probability of a default drops. When default is extremely unlikely, the risky debt will be surely paid off at par, the risky debt will become risk free, and yield the risk-free return. In contrast, when the default probability approaches 1 and the probability is getting higher, the debt holder is to take over the company; the debt value should be the same as the asset value which approaches zero.

The Merton model captures some important properties of risky debt, where the risky yield increases with the debt-to asset leverage of the firm and its asset volatility.

By using the equations, the maturity dependency of the credit spread can also be calculated which is the difference between the risky yield and the risk-free rate. So, Merton's models attractiveness comes also from the shapes of the credit spread term structures resembling the market rates. The model produces correct qualitative properties of the spread curve of a company, which suggests that, the term structure of the spread curve of a high grade company is upward sloping and the spread curve of a high yield company is usually downward sloping. So depending on the high debt ratio of the firm the credit spreads tend to increase. The credit spreads in this case starts high which indicates that if the debt was to mature in the short term, it would almost certainly default with almost no recovery. However as the maturity increases, the likelihood of the firm asset value increasing to the point that default does not occur increases and the credit spread falls accordingly. For the medium leveraged firm, the credit spread is small at the short end—there are just sufficient assets to cover the debt repayment. As the maturity increases, there is a rapid increase in credit spread as the likelihood of the assets falling below the debt value rises. For the low-leveraged company, the initial spread is close to zero and so can only increase as the maturity increases and more time is allowed for the asset value to drop. The general downward trend of these spread curves at the long end due to the fact that on average the asset value grows at the riskless rate and so given enough time, will always grow to cover the fixed debt.

Empirical evidence in favor of these term structure shapes has been reported by Fons (1994) who observed similar relationships between spread term structure shapes and credit quality. Contrary evidence was reported by Helwege and Turner (1997) who observed that the term structure of some low quality firms is upward sloping rather than downward sloping.

The probability of a sovereign default increases when the market value of its assets decline relative to its debt. Default occurs when the sovereign assets fall below its liabilities. The liabilities or its debt constitute a distress barrier, and sovereign distress is measured by the relationship between sovereign assets relative to this distress barrier. The default risk increases when the value of sovereign assets declines towards the distress barrier or when asset volatility increases such that the value of sovereign assets becomes more uncertain and the probability of the value falling below the distress barrier becomes higher.

3.5 Sovereign Credit Default Swap Pricing

In the literature, in order to determine the credit default swap spreads for the sovereigns, the MfRisk model, which is a contingent claims approach, is developed by Gray *et al*. (2003). This model is currently being utilized by IMF for the purpose of constructing a marked-to-market balance sheet for the sovereign, and deriving a set of credit-risk indicators that serve as a barometer of sovereign risk. In the study done by Gray *et al*. (2003) the combined balance sheet of the government and monetary authorities is utilized.

In their study, the contingent claims approach applied to 12 emerging market economies claim that the indicators derived are proven to be highly correlated with market spreads and the risk indicators are robust. The idea behind the contingent claim analysis is to model the sovereign's balance sheet similarly to a firm's balance sheet by grouping the main accounts into assets, liabilities and equity. Merton (1974) shows how a firm's equity can be modeled as a junior contingent claim on the residual value of its assets. In the event of default, equity holders receive nothing if the firm's assets are all consumed to pay the senior stake holders who can be thought of as debt holders; otherwise equity holders receive the difference between the value of assets and debt. As explained previously, the equityholders are assumed to own a call option on the company. In this regard, this approach treats the equity of the firm as a call option on the residual value of the firm's assets. One of the differences from this thesis lies in the fact that the economy is viewed as a set of interrelated balance sheets with three types of aggregate sectors - corporate, financial, and public sector. It relies on observable market information about the value and volatility of sovereign liabilities of the sovereign balance sheet to derive the value of non-observable quantities, such as the sovereign asset value and corresponding volatility. In that case, the sector equity value is valued as a call option on the sector assets with the default barrier derived from the default-free value of corporate debt which includes domestic and foreign debt. In the case of deriving external default probabilities, external debt is generally considered the more senior liability whereas domestic debt and base money represent the equity portion of the sovereign balance sheet and thus can be viewed as a contingent claim on the residual value of sovereign assets.

So, in the study of Gray *et al*. (2003) assets include: Foreign currency reserves and contingent foreign currency reserves, present value of taxes and revenues, other public assets (equity in public enterprises, land, mineral assets, and social overhead capital), and value of the public sector's monopoly on the issue of money. On the liabilities side, the following items are included: Present value of government expenditures, local-currency debt, foreign-currency debt, financial guarantees and base money. The sovereign is assumed to default whenever the value of its implied assets derived from market information on the liabilities and the Black and Scholes option pricing formula falls below a distress barrier. Following Moody's KMV, the distress barrier (DB) is defined for senior debt as short-term debt (maturity ≤ 1 year), plus interest payments due within a year and a fraction (usually a number between 0.5 and 0.8) of long-term debt (Hull (1999) and Crouhy *et al*. (2001)). Gray *et al* (2003) treats debt securities such that the debt's 50% falls due in year 1. However, for most of the emerging markets this differentiation is not publicly available and not published by the authorities. So accordingly making those assumptions would be based on subjective and will be rather not repeatable in that case.

The difference between the asset value and the distress barrier, scaled by the asset volatility, is referred to as the distance-to-distress, while the area of the distribution that falls below the distress barrier represents the sovereign's default probability. The study looks into the relationships between items in four categories: fiscal activities, monetary and foreign currency reserve activities, risky debt, and financial guarantees. In this framework, the sovereign is assumed to default on its domestic debt when the value of its implied assets falls below an augmented distress barrier, which incorporates FX-indexed and floating rate domestic debt and this makes the case a bit more complicated. In the case of domestic debt, the issue is somewhat more difficult to disentangle since there are typically no market credit spreads available on domestic debt. So, in order to have replicability and ease of use, some simplifying assumptions need to be made.

Van den End and Tabbae (2005) also applied this MfRisk model to the Netherlands economy as an application of measuring financial stability. By using the model they arrived to the conclusion that transferring risks from financial institutions to households would have favorable effects.

As a proponent of the applicability of the Merton model to sovereigns, there are other researches in the literature. The theoretical research by Chan-Lau and Kim (2004) explains why the willingness-to-pay does not affect the linkages between debt and equity prices implied by Merton's model. In the Chan-Lau and Kim (2004)'s study, the conceptual model is built such that the debt is held by foreigners, and the equity is held by the country. The model also assumes that the country pays nothing if the country's assets are worth less than the face value of the country's debt for simplicity. Default is defined as the event of the country paying bondholders less than the face value of the bond and furthermore, the default may occur even if the country is technically solvent.

Three conditions have been proposed in the MfRisk conceptual model, and they are reasonable for any sovereign default condition. The first of those three conditions is the balance sheet identity requiring that the country's asset value is equal to the sum of its debt and equity values. The second condition is that countries will not prefer to default as defaulting would put these countries in a worse situation. And the third condition is called the limit condition which suggests that the country always fulfills its obligations if its assets largely exceed its debt.

As a result of these assumptions, the value of debt is equivalent to a cash-or-nothing call option. The value of equity is discontinuous; just prior to default, equity is worth nothing and upon default, and its value is equal to the country's nominal debt.

These assumptions listed above can be captured by three main characteristics shared by all feasible functions for the value of debt and equity. The first of the three main characteristics is that despite the country being technically solvent, it defaults. By this assumption, the willingness to pay factor is captured by the model. Second, as the country's asset value is increasing, the value of debt and equity are also increasing. This implies positive correlation between bond and equity prices, as in Merton's model. As a third assumption the value of debt can be thought to be less sensitive to changes in credit risk value when the value of the country's assets is large relative to the face value of debt which would bring around simplicity. And deriving from that conclusion the opposite is true for the value of equity. As a result they conclude the Merton model is applicable for sovereign issuers.

Chapter 4

Methodology, Research Paradigms and the Analytic Frameworks Governing Basic Assumptions

4.1 Rationale for the Research Method

For corporate sector, default is expected to occur whenever the asset value falls below the corporate liabilities. The logical flow for this is shown as;

Asset value = Value of equity + Value of liabilities

The above formula should hold and from this equation it can be suggested that while the holders of the equity receive the residual value from the corporate, however if the liabilities are greater than its assets the value of the equity is negative. So the equity owners exercise their put option, as they are assumed to hold a put option, and leave the company to its creditors. The equity holders have a limited liability in this case. As the asset value is smaller than the value of liabilities, creditors' claims are not fully covered, meaning that the firm is in default. This put option can be priced with standard approaches from option pricing theory. For this reason the structural models are also called contingent-claim models.

4.2 Test Methodology

Once Merton model is applied to the variables and model CDS rates are reached, the time series will be analyzed by using a few techniques and econometric methods, which will supposedly help to derive meaningful conclusions about the relation of the parameters used to determine the extended model CDS spreads.

Since the main objective of this paper is to examine the long-term consistency and short-term linkages between the extended Merton model CDS spreads and the market CDS spreads, modern time series techniques will be carried out in this thesis. So the methodology for these econometric tests will be briefly mentioned for Granger causality tests, and principal component analysis.

Time series analysis is used to calculate statistical models for the data. For time series such as interest rates and so on, the univariate time series have all been written in the literature. However, the explanatory property of the model is apparent once these series are combined into multivariate models. These models are used for investigating relationships between certain variables over time.

Alexander (2001) suggests that the assumption of the series being stationary might be misleading most of the times since the expectation, variance and covariance are assumed to be the same for every date. In financial markets, this restriction is often violated leading to fake relations as put forward by Granger and Newbold (1974). As a consequence the time series should be differenced once since returns are generally stationary, however, by differentiating any possible long term relationships between time series are lost.

To investigate the dynamic relationship between the CDS rates and debt, central bank reserves, volatility and risk free rates, the Granger causality test will be utilized as a starting point to provide insightful clues to the direction of the linkage. As correlation does not necessarily imply causation in any meaningful sense of that word, a causality test is necessary. There might be great number of tests where a strong correlation is found, however these relations might be meaningless or spurious relations. Interesting examples include a positive correlation between raindrop per area in the world and the birth rate type relation.

In this thesis in order to determine if the factors determining most of the variance in the model and market CDS rates are explained by the parameters used, the principal component analysis will be used. It will help to interpret the variances in the CDS rates and independent variables. So, in other words it will be possible to examine whether the patterns of correlations between sovereign CDS spread changes and the model CDS rates besides the other independent variables can be explained in terms of a smaller number of common factors.

4.2.1 Granger Causality Tests

The Granger (1969) causality test helps to solve the question of whether x causes y. This relationship tests how much of the current y can be explained by past values of y and then to see whether adding lagged values of x can improve the explanation. So provided that this relations holds, the y can be told be caused by x. Or by other means if the coefficients on the lagged x 's are found to be statistically significant, y is said to be Granger-caused by x where x helps in the prediction of y. It might be the case that the causality will run two ways where x Granger causes y and y Granger causes x. For the interpretation of the results, one thing needs to be clarified though. This causality does not imply one is the effect or result of the other. So in that sense it is important to note that the statement "x Granger causes y" does not imply that y is the effect or the result of x. In this respect Granger causality measures precedence and information content but does not by itself indicate causality in the more common use of the term.

In the test regressions of Granger causality, 2 lags are used since there should not be a longer term affect in the results in this case. The lag length “l” is chosen smaller so that it corresponds to comparable results of the outcome of the model and market rates.

The tests are done using econometrics software Eviews 6.0. Eviews runs bivariate regressions of the form:

$$
\begin{aligned}
y_t &= \alpha_0 + \alpha_1 y_{t-1} + ... + \alpha_l y_{t-l} + \beta_1 x_{t-1} + ... + \beta_l x_{-l} + \varepsilon_t \\
x_t &= \alpha_0 + \alpha_1 x_{t-1} + ... + \alpha_l x_{t-l} + \beta_1 y_{t-1} + ... + \beta_l y_{-l} + u_t
\end{aligned} \qquad (4.1)
$$

for all possible pairs of (x,y) series in the group. If there is Granger causality from Y to X, then some of the β coefficients should be non-zero; if not, all of the β coefficients are zeros. The Granger causality test is performed by testing the hypothesis that there is equality among the parameters for each equation:

$$\beta_1 = \beta_2 = ... = \beta_l = 0 \tag{4.2}$$

The null hypothesis is that x and y does not cause each other in 2 different equations, and if there is a relation this null hypothesis has to be rejected separately for each equation. So, the Granger causality test gives an answer to the causality relationship.

4.2.2 Principal Components Analysis

The goal of the analysis is to study the relationships among different activities, to derive common dimensions along which one can classify these activities, and to map into those dimensions different population groups.

Principal components analysis models the variance structure of a set of observed variables using linear combinations of the variables. These linear combinations, or components are used in subsequent analysis, and the combination coefficients, or loadings are used in interpreting the components. While as many components as variables are required to reproduce the original variance structure, less components are preferred to account for most of the original variability. After forming linear combinations of the observed variables, the data reduction is achieved by creating a few measures that describe overall properties. The coefficients in these linear combinations may be used to provide interpretation to these measures.

The principal components of these variables are obtained by computing the eigenvalue decomposition of the observed variance matrix.

The first principal component is the unit-length linear combination of the original variables with maximum variance. Subsequent principal components maximize variance among unit-length linear combinations that are orthogonal to the previous components. Principal components are calculated on the ordinary Pearson correlation matrix.

In order to calculate principal components from the singular value decomposition, a representation of (n x p) data matrix Y of rank r as:

$$Y = UDV' \tag{4.3}$$

where U and V are orthonormal matrices of the left and right singular vectors, and D is a diagonal matrix containing the singular values. More generally:

$$Y = AB' \tag{4.4}$$

A and B both has a rank of r , where A is an n x r, and B is a p x r matrix, and

$$\begin{aligned} A &= n^{\beta/2} U D^{1-\alpha} \\ B &= n^{-\beta/2} V D^{\alpha} \end{aligned} \tag{4.5}$$

so that $0 \le \alpha \le 1$ is a factor which adjusts the relative weighting of the observations and variables singular vectors, and the terms involving β are scaling factors where $\beta \in \ 0, \alpha$. The basic options in computing the scores A and the corresponding loadings B involve the choice of (loading) weight parameter α and (observation) scaling parameter β .

In the principal components, Σ will be called as the cross-product moment dispersion matrix of Y, and perform the eigenvalue decomposition:

$$\sum = L \Lambda L' \tag{4.6}$$

where L is the p x p matrix of eigenvectors and Λ is the diagonal matrix with eigenvalues on the diagonal. The eigenvectors, which are given by the columns of L, are identified up to the choice of sign. Note that since the eigenvectors are by construction orthogonal, $L'L = LL' = I_m$.

$U = YLD^{-1}$, V=L, and $D = (n\Lambda)^{1/2}$, so that:

$$A = n^{\beta/2} YLD^{-\alpha}$$

$$B = n^{-\beta/2} LD^{\alpha} \tag{4.7}$$

"A" may be interpreted as the weighted principal components scores, and B as the weighted principal components loadings. Then the scores and loadings have the following properties:

$$\begin{aligned} A'A &= n^{\beta} D^{-\alpha} L'Y'YLD^{-\alpha} = n^{\beta} (n\Lambda)^{-\alpha/2} (n\Lambda)(n\Lambda)^{-\alpha/2} = n^{\beta} (n\Lambda)^{1-\alpha} \\ B'B &= n^{-\beta} D^{\alpha} L'LD^{\alpha} = n^{-\beta} (n\Lambda)^{\alpha} \\ BB' &= n^{-\beta} LD^{2\alpha} L' = n^{-\beta} L(n\Lambda)^{\alpha} L' \end{aligned} \tag{4.8}$$

Through appropriate choice of the weight parameter α and the scaling parameter β, scores and loadings are constructed with various properties. The normalized loadings, which is JK, are defined by decomposition where $\alpha = \beta = 0$. Substituting into equation (4.7), and using equation (4.4) yields $Y = JK'$, where:

$$\begin{aligned} &J=YL \\ &K=L \end{aligned} \tag{4.9}$$

From equation (4.8), the scores J and loadings K have the norms:

$$\begin{aligned} J'J &= n\Lambda \\ K'K &= I_p \end{aligned} \tag{4.10}$$

The rows of J are said to be in principal coordinates, since the norm of J is the diagonal matrix with the eigenvalues on the diagonal. The columns of K are in standard coordinates since K is orthonormal (Aitchison and Greenwood, 2002). The JK specification has a row preserving metric since the observations in J retain their original scale. On the other hand, the normalized scores are defined (covariance) decomposition where $\alpha = 1$. Then we may write $Y = GH'$ where:

$$G = n^{\beta/2} YLD^{-1}$$
$$H = n^{-\beta/2} LD \tag{4.11}$$

Evaluating the norms using equation (4.8), we have:

$$G'G = n^{\beta} I_p$$
$$H'H = n^{-\beta}(n\Lambda) \tag{4.12}$$
$$HH' = n^{-\beta} L(n\Lambda)L' = n^{1-\beta} \sum$$

For this factorization, G is orthonormal and the norm of H is proportional to the diagonal matrix with the n times the eigenvalues on the diagonal. The specification is said to favor display of the variables since the H loadings are in principal coordinates and the scores G are in standard coordinates. The GH specification is sometimes referred to as the column metric preserving specification.

In interpreting results for the covariance decomposition, the Euclidean distances between observations are proportional to Mahalanobis distances. Furthermore, the norms of the columns of H are proportional to the factor covariances, and the cosines of the angles between the vectors approximate the correlations between variables.

In the decompositions, observation scaling of the scores and loadings are allowed and parameterized by β. There are two obvious choices for the scaling parameter β.

First, we could ignore sample size by setting $\beta = 0$ so that:

$$A'A = (n\Lambda)^{1-\alpha}$$
$$B'B = (n\Lambda)^{\alpha} \tag{4.13}$$

With no observation adjustment, the norm of the scores equals $(n\Lambda)^{1-\alpha}$, the variance of the scores equals $\Lambda^{1-\alpha} / n^{\alpha}$, and the norm of the variables equals n^{α} times the eigenvalues raised to the α power. Note that the observed variance of the scores is not equal to, but is instead proportional to $\Lambda^{1-\alpha}$, and that the norm of the loadings is only proportional to Λ^{α}.

Alternately, we may set $\beta = \alpha$, yielding:

$$
\begin{aligned}
A'A &= n^{\alpha}(n\Lambda)^{1-\alpha} = n\Lambda^{1-\alpha} \\
B'B &= n^{-\alpha}(n\Lambda)^{\alpha} = \Lambda^{\alpha}
\end{aligned}
\qquad (4.14)
$$

With this sample size adjustment, the variance of the scores equals $\Lambda^{1-\alpha}$ and the norm of the variables equals Λ^{α}.

Gabriel (1971), for example, recommends employing a principal components decomposition for biplots that sets $\beta = \alpha = 1$. From equation (4.8) the relevant norms are given by:

$$
\begin{aligned}
G'G &= nI_P \\
H'H &= \Lambda \\
HH' &= \sum
\end{aligned}
\qquad (4.15)
$$

By performing observation scaling, the scores are normalized so that their variances are equal to 1. Furthermore the Euclidean distances between points are equal to the Mahalanobis distances (using $\sum^{-1}$), the norms of the columns of H are equal to the eigenvalues, and the cosines of the angles between the vectors equal the correlations between variables. Without observation scaling, these results only hold up to a constant of proportionality. In this thesis by default, observation scaling is performed, setting $\beta = \alpha$.

4.2.3 Volatility Calculation Methodology

Engle (1982) was the first to introduce Autoregressive Conditional Heteroskedasticity (ARCH) type models. His followers Bollerslev (1986) and Taylor (1986) generalized ARCH models as Generalized Autoregressive Conditional Heteroskedasticity (GARCH). The GARCH model is one of the ways of capturing a common feature of financial data. As financial return volatilities tend to cluster and they are driven by the past return shocks, volatilities can be predictable. These models are commonly used in econometrics for various purposes and especially in financial time series analysis.

In cases where there is need to analyze the risk of holding an asset or the value of an option or there is need to forecast confidence intervals which may be time-varying then modeling and forecasting volatility might be necessary. In case where you need to forecast intervals, the error of variance can be minimized more accurately. Furthermore, if heteroskedasticity in the errors is handled properly, then more efficient estimators can be obtained.

Autoregressive Conditional Heteroskedasticity (ARCH) models help to model and forecast conditional variances. So, dependent variable's variance is calculated through the past values of the dependent variable and independent variables.

From the first equation the second equation can be derived and the simplest Garch(1,1) can be specified:

$$Y_t = X'_t\,\theta + \varepsilon_t \qquad (4.16)$$

$$\sigma_t^2 = \omega + \alpha\,\varepsilon_{t-1}^2 + \beta\,\sigma_{t-1}^2 \qquad (4.17)$$

The mean equation (4.16) is written as a function of exogenous variables by adding an error term. The conditional variance, σ_t^2, is the one-period ahead forecast variance based on past information. This conditional variance equation (4.17) is a function of three terms.

In the equation there is first a constant term ω, secondly there is a term for news about volatility from the previous period which is measured as the lag of the squared residual from the mean equation ε_{t-1}^2 which is called as the ARCH term. Also the third term is the last period's forecast variance which is symbolized as σ_{t-1}^2 and called the GARCH term.

The (1,1) term in Garch(1,1) refers to the presence of a first-order autoregressive GARCH term which is the first term and a first-order moving average ARCH term which is respectively the second term in parentheses.

The two representations of the variance equation in interpreting the model can be written as follows. If the lagged variance is substituted in the equation (4.17), the conditional variance can be written as a weighted average of all of the lagged squared residuals:

$$\sigma_t^2 = \frac{\omega}{(1-\beta)} + \alpha \sum_{J=1}^{\infty} \beta^{j-1} \varepsilon_{t-j}^2 \tag{4.18}$$

Then the Garch(1,1) variance specification is analogous to the sample variance. However, this interpretation down-weighs more distant lagged squared errors.

The error in the squared returns is given by $\nu_t = \varepsilon_t^2 - \sigma_t^2$. Substituting for the variances in the variance equation and rearranging terms the model can be written in terms of the errors:

$$\varepsilon_t^2 = \omega + (\alpha + \beta)\varepsilon_{t-1}^2 + \nu_t - \beta\, \nu_{t-1} \tag{4.19}$$

In this equation, the squared errors pretend to follow a heteroskedastic ARMA(1,1) process. The autoregressive root governs the persistence of volatility shocks and is denoted by the sum of α plus β. This is important in the sense that this root is very close to unity so that shocks die out rather slowly.

Regarding the distribution assumptions, an assumption has to be made regarding the conditional distribution of the error term ε. The default assumption used for GARCH specifications is the normal (Gaussian) distribution.

4.3. Empirical Data and Their Collection

4.3.1 Country Selection

In this thesis for the purpose of selecting the relevant 4 countries, a few criteria were taken into account. Diversificiation, experience of default or consolidation are among the criteria in that sense. Also participation in the global bond indices and having high turnover in the credit default swap market is considered to be important facts. These countries are included in the IMF's classifications of "developing countries" and "countries in transition". These 4 countries are also listed in the JPMorgan Chase's Emerging Bond Index (EMBI) index, which is a weighted average of the returns to sovereign bonds for 15 emerging market countries from Latin America, Eastern Europe, and Asia.

The Emerging Markets Bond Index Plus (EMBI+) is used to track the total returns for traded external debt instruments in the emerging markets. The instruments include foreign currency denominated bonds, Brady bonds, loans and Eurobonds, as well as U.S. dollar local markets instruments. The importance of the EMBI index lies in the fact that it serves as a guide for investors. As well as serving as a benchmark, it provides investors with a definition of the market for emerging markets external-currency debt, a list of the instruments traded, and a compilation of their terms. The index comprises a set of traded debt instruments with high volume through brokers and quoted by market makers. The instruments in the EMBI+ must have a minimum of $500 million outstanding. Brazil, Turkey, Mexico and Russia have the highest weights in the composition of EMBI Global Index. As it can be checked from the table 4.1, Brazil's weight in the index is 22,49%, Mexico's weight is 17,30%, Russia's weight is 16,84%, Turkey's weight is 10,04% as of 19/04/06.

Table 4.1 EMBI Country Weightings

EMBI+ Market Capitalization Weights %	
19.04.2006	Market Cap %
Brazil	22,49
Mexico	17,30
Russia	16,84
Turkey	10,04
Philippines	8,43
Venezuela	7,31
Colombia	3,62
Argentina	2,57
Peru	2,33
Ecuador	1,84
South Africa	1,82
Panama	1,17
Poland	1,16
Ukraine	0,79
Bulgaria	0,71
Nigeria	0,70
Egypt	0,55
Morocco	0,33
Total	100,00

Source: J.P. Morgan Emerging Local Markets Index (EMBI)

The performance of the EMBI index has been volatile; though positive for most of last few years which is analyzed for the credit derivative spreads of these countries. In 1998, EMBI index declined over 27% in a month which is an evidence of the high volatility. Once again, it is worth pointing out that credit risk is not all one sided.

The commonality of these 4 countries is that they all experienced crisis through 1994 to 2001. Russia is used on purpose, as it is one of the few recent sovereign countries in the world which restructured its debt. In August 1998 the Russian government defaulted on its outstanding bonds causing a contagion affect and resulting in a downward spiral in the emerging bond market. Due to this, introducing capital controls in 1998–99, Russia declared a unilateral moratorium on private sector external debt obligations while still publicly stating their intention to honor sovereign external debt. While declaring moratorium on external debt and defaulted, Russia did not default on the local currency debt and preferred to only consolidate their debt to longer maturities.

Unlike Russia, Turkey has not defaulted on any principal or interest of any external debt represented by bonds issued in public international markets since it began issuing such bonds in 1988. Turkey has from time to time experienced volatile political, economic and social conditions and two financial crises in 1994 and 2001. It is possible that these kinds of risks may occur in the future, and affect the Turkey's financial condition. Starting from 1978 to 1980, Turkey consolidated $3.95 billion worth of external debt consisting of commercial and government credits. During that time this amount represented 20.6% of Turkey's total outstanding external debt. The rescheduling was done in order to avoid a possible default on its external debt. Turkey has not failed on any of its payments since the consolidation then and always paid, when due, the full amount of principal and interest on its direct and indirect external debt. Turkey was done with its all payments related with this consolidation by July 1992.

The improvements achieved on the macroeconomic front since the 2001 crisis, and the associated gains in the market value of Turkish assets, are impressive. Furthermore, the asset-liability structure on Turkish balance sheets has changed considerably, as have interlinkages between various sectors and notably the sovereign, banking and corporate sectors. These developments have improved Turkey's overall sovereign risk profile, although the country remains subject to high volatility, as evidenced most recently in the May/June 2006 market turbulence. Turkish economy can still be considered fragile and is still not rated as an investment grade country unlike other countries in this thesis. Russia, Mexico are rated as investment grade and Brazil is rated as an investment grade by one rating agency and close to being investment grade by others as well.

Mexico and Brazil have been liberal economies and they opened their markets to foreign investments for quiet a long period. Their reliance on foreign debt to finance its development still continues. In fact, the debt crisis of 1982 was born in South America and a large percentage of outstanding Brady bonds is still associated with these borrowers. These countries have bought back their external debt or switched them with longer dated debt by the market will. These auctions were done in order to lengthen the debt of the maturity and to benefit from the low rates globally.

Brazil is still one of the largest economies among the Latin American economies. However, Brazil has been through crisis as well. Brazil officially announced the devaluation of its currency, the Real on January 13, 1999. This brought about a real depreciation of 35% of the currency in the eight weeks following that event, and the economy went through a recession period.

Besides having the largest stock markets in the region, these countries in our thesis are also major international borrowers with the high levels of outstanding foreign debt that are necessary for the existence of a financial risk premium that needs to be evaluated in this thesis.

4.3.2 Estimating the Asset Value of the Sovereigns

In this thesis, the assets of a country are treated as one of the key variables. As the assets of a country are not a readily available concept and rather abstract notion, it is necessary to come up with a proxy.

Ronn and Verna (1986) suggest that the total value of all traded claims can be used to infer firm value. The analysis brings out the firm value that is consistent with the observed value of all traded claims. This implied total asset value can then be used to predict credit spreads. If all claims are publicly traded, then the value can easily be observed and prices for all claims, relative to the observed firm value, can be predicted. However as in the case of a sovereign, where claims are not publicly traded, an alternative approach has to be taken.

Scholtens and Hameeteman (2007) also utilized foreign exchange reserves in their calculation of joint default probability. It is obvious that a company has observable assets which can easily be extracted from its balance sheet, whereas a country hardly has any assets that can be liquidated in case of default. Under normal conditions, a country most of the time has no direct access to the securities or investments of its inhabitants.

The sovereign has fixed assets as land and such which are not likely to be sold in case of an urgent need, so they do not enter into the expected government revenues and should not be included in this definition of asset.

Krugman and Obstfeld (1997) in their paper suggest that one can consider a country's assets in an international context from two different perspectives. The first of these methodologies is the generation of export earnings. As a fact the sovereign rarely can access or use these resources to pay down its debt. Therefore, this approach is not considered to be a useful method within the context of this paper. The second and more reliable methodology is the international reserves of a country. This item is within the control of the sovereign so it is a possibility to utilize this methodology. Consequently, the foreign exchange reserves will be used as the proxy for the assets of a country. The benefits of the use of central bank reserves are numerous. The data on foreign exchange reserves are widely available for these emerging markets and these data are provided on a short-term notice by institutions such as the International Monetary Fund and such.

From the standpoint of an investor, it makes sense his investments which comprise the principal and interest will be paid if there is a corresponding asset in the reserves. Otherwise the solvency of the country will be in question. Also it is an important fact that foreign exchange reserves have observable market prices, whereas the other items on the government balance sheet lack observable market prices.

As Merton suggests, the assets of a country which are the foreign exchange reserves will generally decline to a certain critical threshold level before the country will default. Eaton *et al* (1986) suggests that solvency and liquidity are two important indicators that show signs of the ability of a country to repay its foreign debt. However, the illiquidity of a country is directly observable unlike insolvency. Observing the usable reserves of a country, which consist of the foreign exchange reserves reveals important results. Other data and macro economic variables though important, such as growth rate of GDP or primary surplus ratio lack the skills to lay down the connection with country default. So these variables will not constitute appropriate candidates for a proxy for a country's assets. Also there are many studies which underline the importance of keeping high foreign exchange reserves though on the other hand some studies put forward that these reserves are costly. However still it is important to emphasize the importance of these foreign exchange reserves due to stability factors. For example, Feldstein (1999) argues that liquidity is the key to self-protection against the devastating effects of crises. Krugman and Obstfeld (1997) claims that a country which has large foreign exchange reserves is less likely to default if it wishes to maintain a fixed exchange rate.

4.3.3 Estimating the Implied Volatility for Each Country

One of the key variables for calculating the risk spread is the volatility. The implied volatility of a country can differ across countries. This maybe due to the level of debt, or the level of international reserves, exchange rates, global liquidity or other macroeconomic internal and external factors.

The concept of implied country volatility and the methods for measuring it depends on some assumptions. However its relation to country risk assessment seems self explanatory. In standard Merton model the volatility of assets are utilized however in emerging markets where the foreign currency denominated liabilities dominate the foreign exchange assets most of the time, it makes more sense to utilize the liability volatility. The country is more sensitive to changes in its liability increases or exchange rate depreciations due to the fact that the amounts of outstanding debts are subject to exponential rises in those cases. Countries with lower debt volatilities are generally able to borrow longer dated and larger amounts in financial markets easily, while countries with higher debt volatility would have harder time to find buyers of their debt as the risk rises. The probability distribution is widened by the increased volatility and results in a higher probability of default as probability distribution area underneath the distress barrier increases. So, the volatility stands to be one of the reliable tools in measuring country's credit spreads.

It is shown in the literature that foreign demand shocks can destabilize debt even though they don't have a fundamental cause. Furthermore Guembel and Susman (2005) shows that more volatile foreign demand reduces a country's debt capacity. In order to capture this, the volatility of the benchmark bonds is utilized on the liability side.

Relying on these assumptions, a different methodology will be applied, where liabilities will be utilized to measure the volatility of a country. These outstanding debts and their underlying volatility are already traded in the market and through options; their volatility is observable as well as traded. So they have implied volatilities as well as historical volatilities. However, the time series of this benchmark bond's implied volatilities are not available to all the market players but only to market makers might have a hold of these numbers. Therefore, the historical volatilities of benchmark bonds will be the variable used in this thesis. So, one of the challenges would be the estimation for the market value and volatility of sovereign. While the amount of debt can be determined from the balance sheet, in order to derive the volatility, some calculations need to be made.

A few methods can be used to measure the volatility of liabilities. The two procedures that will be used to estimate the standard deviation or volatility for the liabilities of a sovereign will be mentioned below. Besides, the two methodologies will be compared in the empirical findings section.

The first methodology would be based on forming a daily time series for the value of the benchmark outstanding debt using the data for the calculation of rolling 12 months annualized volatility. The logarithmic return on the benchmark bond is calculated and the standard deviation of these returns determined. The formula below is applied by using the standard procedure for scaling standard deviations of return.

Accordingly, the Eurobond price changes in percentage over T periods from t=0 to t=T is expressed as;

$$P_T / P_0 = R_{0,T} = R_1 * R_2 * R_3 * \ldots * R_T \tag{4.20}$$

P corresponds to price and R to the simple return. With logarithmic returns r = ln(R) and as it can be recalled that the following

$$r_{0,T} = r_1 + r_2 + r_3 + \ldots + r_T \tag{4.21}$$

Assuming that the returns are independent over different time periods, the T-period variance is just the sum of the one-period variances

$$Var(r_{0,T}) = Var(r_1) + Var(r_2) + Var(r_3) + \ldots + Var(r_T) \quad (4.22)$$

If return variances are identical across time,

$$Var(r_1) = Var(r_2) = Var(r_3) = \ldots = Var(r_T) = Var(r_t), \quad (4.23)$$

According to these equations written

$$Var(r_{0,T}) = T * Var(r_t) \quad (4.24)$$

For the standard deviation of returns, it follows that

$$\sigma(r_{0,T}) = \sqrt{T}\sigma(r_t) \quad (4.25)$$

So the standard deviation of natural logarithm daily returns of bond prices is multiplied with the square root of 260 to get the annualized standard deviation of returns. The annualized standard deviation is also called volatility.

The second methodology is the volatility calculation by using the GARCH methodology. Garch(1,1) will be applied to the benchmark bond data for a rolling period of 52 weeks again to get annualized volatility and the results will be used with be applied a Hodrick Prescott filter in order to smoothen out the volatility.

The Hodrick-Prescott Filter is a smoothing method that is widely used in practice to obtain a smooth estimate of the long-term trend component of a series. This methodology was developed and used to determine the U.S. postwar business cycles and analyze more in depth.

Technically, the filter is a two-sided linear filter. It is utilized to compute the smoothened series s of y by minimizing the variance of y around s, subject to a penalty that constrains the second difference of s. That is, the HP filter chooses s to minimize:

$$\sum_{t=1}^{T}(y_t - s_t)^2 + \lambda\sum_{t=2}^{T-1}((s_{t+1} - s_t) \ -(s_t - s_{t-1}))^2 \qquad (4.26)$$

As in the equation (4.26), the penalty parameter λ controls the smoothness of the series σ. The larger the λ, the smoother the σ. As $\lambda = \infty$, the parameter denoted s approaches a linear trend.

While the Black-Scholes Merton model assumes constant volatility, this extended model utilizes adjustments to volatility and deviations from strictly lognormal distributions of asset value.

4.3.4 Estimating the Face Value of the Debt

The face value of debt can be treated as an exercise price as in the Black Scholes formula. Merton's formula requires that a unique maturity number should be used for the debt. The classical Merton model has an assumption which has been mentioned in the literature section, which suggests that the debt profile has to be consolidated to a single debt issue. In order to deal with this issue there might be a few methods. It might be possible to compute a weighted average duration of all long-term liabilities where the liability structure is assumed to remain constant over time. This is rather a static analysis. It is also assumed that no default can happen before maturity.

In the case of a country the only parameters that can be observed in the market are the reserves, value of the debt and the risk free rates. Accordingly, the market value of debt will be utilized in this case. Adjusting for the duration of the credit default swap or the horizon of the debt, this analysis can be run.

Compared to a corporate, the balance sheet of a sovereign displays some differences. On the liability side of the balance sheet, the corporate liabilities may include senior debt, subordinated debt, and equity. And from this the market capitalization of the firm is equal to price of equity multiplied by the number of shares issued. However, the sovereign liabilities include foreign currency debt, local currency debt and financial guarantees.

The frequency of default in the local currency denominated debt is much lower than the default observed on foreign currency debt. The governments in general are more willing to serve local currency debt due to the taxation control over the public and control of the domestic financial system by using seignorage and issuance of local currency debt. So for these reasons, governments most of the times have a stronger capacity and willingness to service local currency than foreign currency debt. And due to this fact, in many instances Standard & Poor's like rating agencies assign higher ratings to sovereigns' local currency debt than for their foreign currency debt as shown in the appendix A.

A foreign currency rating reflects Standard & Poor's opinion of an obligor's willingness and ability to service commercial financial obligations issued in a foreign currency on time. This incorporates the ability of nonsovereign obligors to access the foreign exchange needed to meet foreign-currency liabilities. Due to regulations and barriers implied by the sovereigns, except for the monetary unions, a sovereign or the central bank generally controls access to foreign exchange.

On the other hand, for the local currency debt, as sovereigns are not intended to restrict access to local currency, even in a crisis situation, local currency ratings are less likely than foreign currency ratings to be constrained by sovereign considerations.

A sovereign's local currency rating normally equals or exceeds its foreign currency rating. A higher local currency rating reflects the flexibility afforded by the sovereign's authority over domestic financial and monetary systems. So considering the default probability of local debt is relatively low, this thesis is concentrated on the default on external debt. In the literature, most papers on sovereign debt concentrate only on foreign currency debt.

Kremer and Mehta (2000) also support this idea and so they have reached a conclusion about the foreign holdings of debt and observed that a government is more inclined to default if a large proportion of its debt is held by foreigners. Also a sovereign can decide not to default by making a rather political decision and might increase their seignorage to some extent or might decide to default whenever there is an only small amount of debt outstanding.

Eichengreen *et al* (2002) has also supported the idea that foreign currency debt can be considered as senior liability. The corporate sector does not have incidences where there is a seniority of local and foreign currency debt; however seniority of sovereign liabilities may be seen from the behavior of government policymakers under stressful positions. Under such times, governments have a tendency to meet their foreign currency obligations, which suggest that the concentration should be directed towards foreign currency liabilities rather than local currency. The capacity of the governments is limited in the producing and expanding of foreign currency reserves whereas the same is not true for the local currency. The governments might prefer to issue, repurchase and restructure local currency debt in times of stress. It has also been evidenced in the past that governments prefer to introduce capital controls and hold on to international reserves to service sovereign external debt obligations which have been a part of IMF policies. This has been the case in Turkey during 2001 crisis as well.

In general the foreign currency debt is issued as Eurobonds in international markets. The foreign currency debt of these countries is mostly fixed-rate and single bullet maturity debt which results in easier to calculate flows. A lower portion of the debt is amortizing, however these payments are usually well-specified. The problematic calculations arise when the debt payments are linked to changes in interest rates, exchange rates, or inflation. These problems arise rather in the local currency debt as opposed to international capital markets.

For the foreign currency debt statistics, the short term liabilities of outstanding debt is available quarterly but debt is not in terms of rolling amounts for 5 years. So even if the outstanding debt would be provided by the governments, it would not be possible to obtain time series data historically for the 5 years rolling debt. So due to these restrictions and other assumptions in this thesis the gross external debt data is utilized, which consists of the outstanding amount of those actual current and not contingent liabilities owed to non-residents of the central banks, public and private sector institutions and households of the country. The gross external debt is all denominated in US Dollars for comparability purposes. Outstanding debt liabilities of residents to non-residents are converted into US Dollars at year-end exchange rates and expressed in millions of USD. As a precondition residence is the key criterion and utilized for determining whether to include the liability in gross external debt. Hence, onshore and offshore financial institutions debt to the rest of the world is included in the gross external debt which is a realistic assumption. Non-resident holdings of local currency debt instruments which will be paid back in US dollars are also included in gross external debt. Equity foreign direct investment and portfolio equity investment are excluded from gross external debt since they are not contractual debt. FDI which is explicitly funded by borrowing is included in the gross external debt as well.

In the next section the implementation of Merton's methodology to derive the risk premium will be explained. By applying the methodology on the change of the liabilities and assets of a sovereign, the unobserved variables will be reached.

4.3.5 Sample Collection and Descriptive Statistics for Sovereign CDS Spreads

This thesis focuses on specific four emerging markets and uses a different methodology than previous methodologies. In the empirical data and their collection section the reasons for selecting the parameters were already mentioned. For those reasons besides simplicity and general applicability purposes, only default on the external debt will be taken into consideration for liabilities. The foreign reserves will be considered as the country's assets and the volatility calculations derived for the assets will be the taken from the annualized benchmark bond volatility. As also implied by the previous studies, estimating the observed value and volatility of sovereign assets directly is difficult. Therefore only international reserves will be utilized as they are directly observable on the asset side of the public sector balance sheet.

The 4 sovereign underlying utilized in this thesis are namely Turkey, Brazil, Russia and Mexico. The daily quotes of CDS indices are used for these 4 emerging market countries of different ratings. The analysis is also restricted to a maturity of 5 years, since they contain the most liquid CDS's. Due to its origination from loans, CDS has become a bond hedger and arbitrage tool but still bank lending books are a key user of the CDS market. Due to this fact the most liquid point on the CDS curve is almost always the 5 year point which is proportional to the tenor of most bank loan agreements. The data period starts from the beginning of January 2003 to July 2007 which is the date when the CDS market depth has increased remarkably. Before that period the market was almost absent. The data set therefore covers 237 quotes for each country in the corresponding period after extending the foreign currency debt to a higher frequency level.

For the selected countries, the calculations presented in this thesis are all measured in U.S. dollars. This eases comparison and provides unity for all the countries publish the numbers currently in USD terms which is the most used reserve currency globally.

Following the assumptions regarding which data would best fit for making the required analysis, the collection of data has taken place. The data set consists of the country data for the model's implementation which comprises the international reserves, gross external debts, historical volatility of the benchmark hard currency denominated Eurobonds outstanding and risk free rates combined with data on actual CDS spreads used to test each model's predicted prices. The international reserves data is provided by each country's central bank and IMF. The liabilities of the countries are managed by the treasuries of each country, however in this study Fitch Peer Analysis Tool system is utilized in order to collect the liability data which serves them in an orderly fashion.

For the purpose of calculating the volatility of liabilities the benchmark bonds selected are USD denominated foreign liabilities which can be listed as; Turkey 15/01/2030 bond, Russia 31/03/2030 bond, Brazil 06/03/2030 and finally Mexico 15/08/2031 bond. By using the historical time series of these bonds, the historical annualized standard deviation besides Garch(1,1) was applied.

The data collection was initiated by obtaining a list of all the CDS securities with spreads available on Bloomberg. The credit default swap data that will be used in this thesis are obtained from a composite pricing of major London banks over Bloomberg system. The data will consist of "Bloomberg Generic" data source which are the composite of the quoted prices. It is Bloomberg's market consensus price for corporate and government issues. These prices are calculated by using prices contributed to Bloomberg and any other information that is considered relevant. The methodology is basically proprietary and depends on the type of pricing and the markets involved. So these prices are consensus prices in the markets. A two way quote in an OTC market is just the quote to either sell or to buy a specific instrument for some specific price. The traded data on the other hand is market cleared data, hence it represents the market consensus on the fair value of the credit default swap at transaction time. Therefore this analysis will be restricted to the observations of recent dated CDS pricing during the period from January 2003 to July 2007, with consensus observations over the period.

On this sample, the CDS are constant-maturity credit default swap spreads which always have 5 year maturity in order to prevent a shortening of the maturity which would hinder the calculations. Cossin and Lu (2005) argue that this CDS quote represents the market price for the credit risks of the borrower and is thus adequate for our purposes. The sample is then merged with the data obtained from Fitch Peer Tool Analysis and IMF central bank reserves statistics.

The period of thesis is particularly interesting as it covers consecutively low volatility in recent years despite the Iraq war in 2003 and so on. This time period also includes government's debt buyback programs in Latin America which are assumed to have direct affect on the credit rating changes by the rating agencies as the outstanding amount of debt is reduced and the credibility of the country enhanced.

The reason for the tightening credit spreads is the globally low yields in developed countries which helped an enormous amount of liquidity injection into the financial system. Due to this basic reason, the emerging markets were preferred by many investors due to relatively higher yields and high risk appetite. And as a result of this investor behavior emerging, the strong performance of investment returns in emerging markets during recent years seems to have consolidated the role of emerging markets in international investment portfolios. The emerging markets' fundamentals have also improved in this period. This happened despite of the crisis occurring during the first half of the 2000s.

The Global Financial Stability Report published by the International Monetary Fund (2004) emphasizes the fact that the strong risk-adjusted returns in emerging securities, especially in sovereign bonds, have led many institutional investors to make strategic portfolio allocations in emerging markets. These facts have created excess liquidity since 2003, when the emerging market sovereign spread fell from historical high levels.

The data regarding the debt are reported only on quarterly basis for many countries However, the central bank's foreign exchange reserves data is provided on weekly basis. The credit default swaps have a daily frequency which is traded in the markets every day. So, the data have been extended to a high frequency level by applying a 7th degree polynomial which has been shown for every 4 country which is shown in the Figures 4.1 to 4.4. The degree of fit varies from 0,9458 to 0,9960 for the graphs and imply a significant fit level for the corresponding gross external debt time series data.

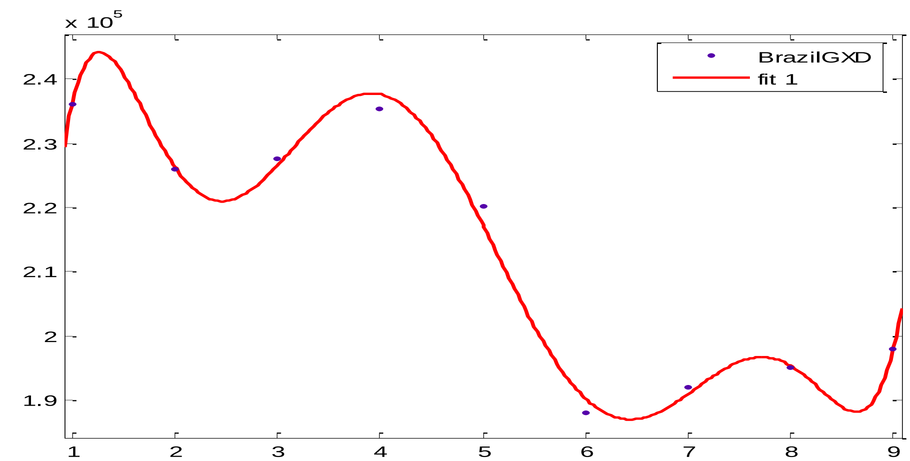


Figure 4.1 External Debt Curve Fitting: Brazil

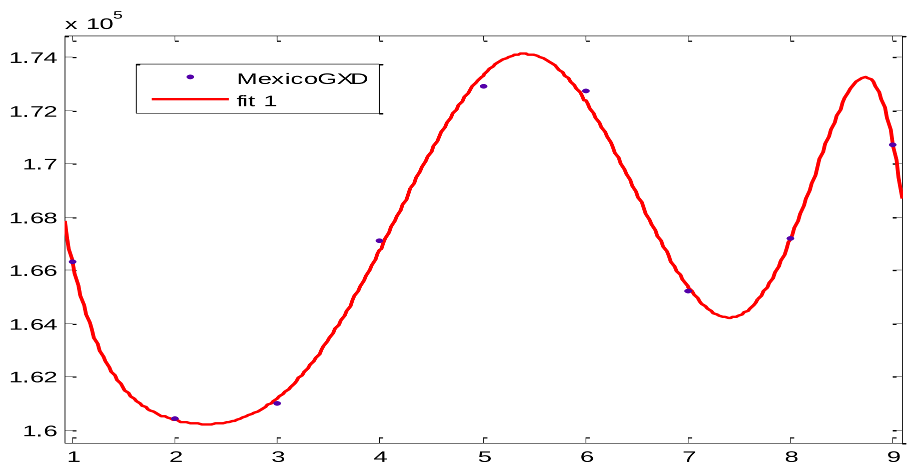


Figure 4.2 External Debt Curve Fitting: Mexico

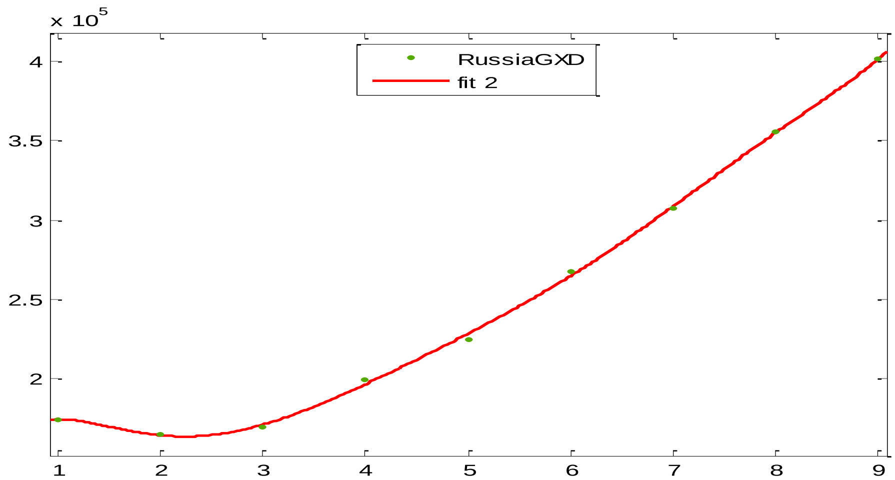


Figure 4.3 External Debt Curve Fitting: Russia

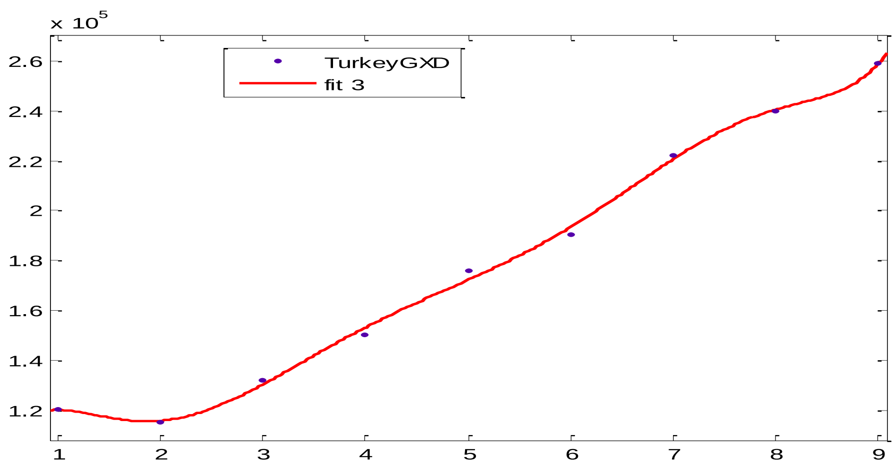


Figure 4.4 External Debt Curve Fitting: Turkey

The degree of fit is high enough and the formula has been applied to utilize the data in a relatively higher frequency as the quarterly data would be useless to make an analysis on whether the relationship is good enough for deriving a conclusion.

The table below reports descriptive summary statistics for five-year sovereign CDS spread values for the January 2003 to July 2007 period. CDS spreads are measured in basis points.

Table 4.2 Sample Sovereign CDS Descriptive Statistics

	Brazil CDS	Mexico CDS	Russia CDS	Turkey CDS
Mean	458,49	102,03	147,01	367,69
Standard Error	26,49	3,63	6,39	16,51
Median	352	90	122	275
Standard Deviation	408	56	98	254
Sample Variance	166.257	3.121	9.674	64.609
Kurtosis	3,89	0,92	-0,47	1,25
Skewness	1,85	1,11	0,71	1,45
Range	2.229	243	399	1.147
Minimum	61,33	28,92	37,63	119,55
Maximum	2.290,00	271,67	436,67	1.266,25
Sum	108.662,37	24.180,80	34.842,19	87.141,91
Rating by S&P	BB+	BBB+	BBB+	BB-
Count	237	237	237	237

The obvious relationship that emerges from Table 4.2 is that for a given year the CDS spreads with higher rating countries tend to be less volatile and have tighter spreads compared to lower rated companies. Turkey most notably stands out as having consistently higher and more stable CDS spreads. In Table 4.2, the ratings of the sample countries are also listed. In the sample period from 2003 to 2007, the spreads for all the sample countries have declined, as the general liquidity in the credit markets improved. Spreads also tend to increase with worsening credit rating. Furthermore, in bond spreads, there is a considerable overlap in spread ranges for adjoining rating categories and this has been well documented in prior studies. Ericsson *et al*. (2004) suggest that the increase which occurs in spreads when moving from investment grade ratings to those in non-investment grade is most of the time dramatic.

Though the standard deviation on Brazil CDS seems higher than Turkey CDS's, the recent performance of Brazilian economy which started from 2003 brought stability to Brazil and resulted in a better rating performance. The range of CDS spreads also lead to the same results that though the CDS spreads had higher volatility, ended up better in the current state. Furthermore, CDS spreads on all maturities have decreased over the period for our sample suggesting an overall improvement in credit quality in the emerging market world.

Figure 4.5 below displays the time series of central bank reserves using the IMF data. At a first glance, these series move close to each other at the beginning, however Russia has diverged from the group and Brazil also outperforming its peers' reserves.

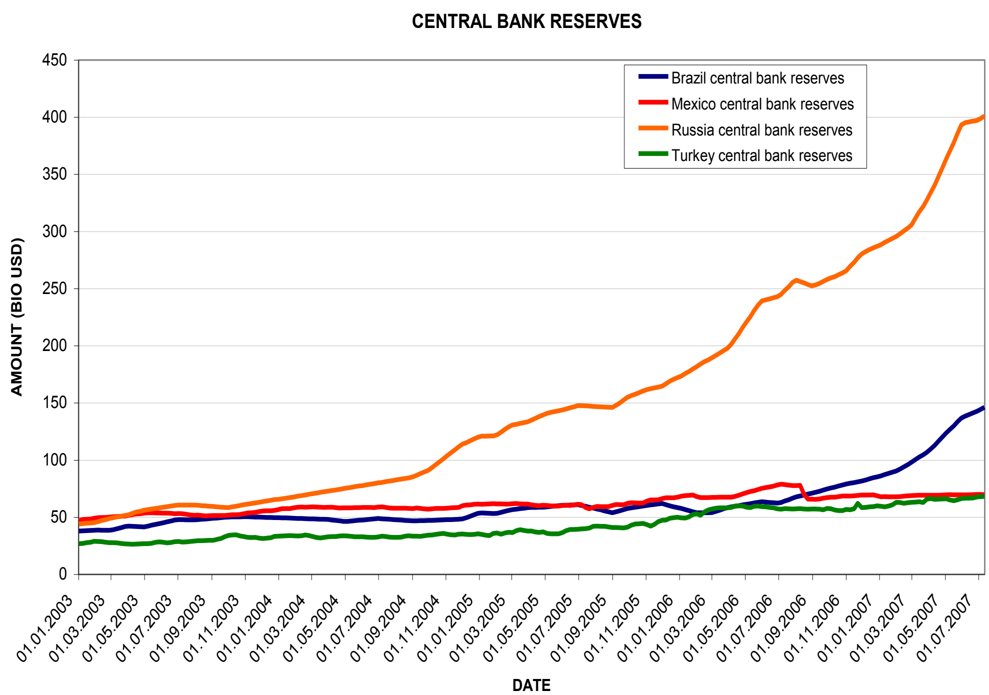


Figure 4.5 Central Bank Reserves

Source : IMF

CDS premia for each of the 4 issuers are shown in Figure 4.6 below. Apparently, with the help of the liquidity conditions improving globally and the central bank reserves growing rapidly, the CDS rates are tightening and converging. It also shows that credit conditions for most entities were in worse conditions in 2003, reflecting the slowdown of the global economy and the sharp decline in the equity markets. From 2003 to date, overall credit conditions improved substantially reflecting the improving financial conditions and abundance of liquidity.

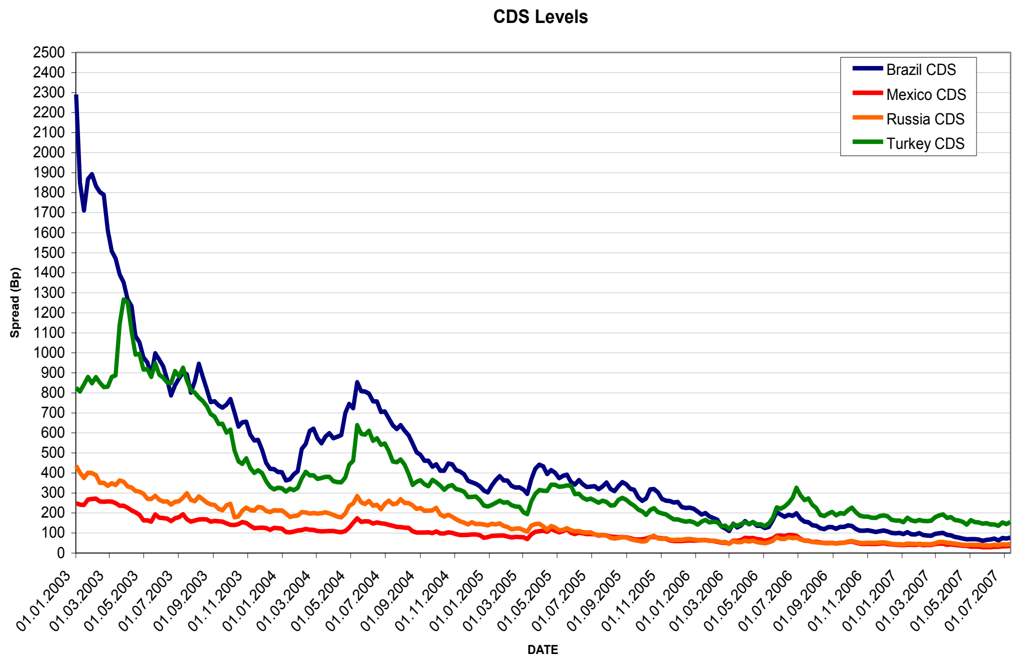


Figure 4.6 CDS Graphs

Source: Bloomberg

Regarding the volatility of the country, all the structural models contain the volatility as an input. To capture the nonlinearity of changes in risk, volatility is crucial. Especially during times of stress when small shocks can gain momentum and trigger systemic repercussions, determining the volatility gains more importance. The credit spread is expected to increase with a higher volatility. As a proxy for the variability in the country's international reserves, the Garch(1,1) and historical annualized variance derived from the Eurobond benchmark bonds have been applied for which the methodology has been explained.

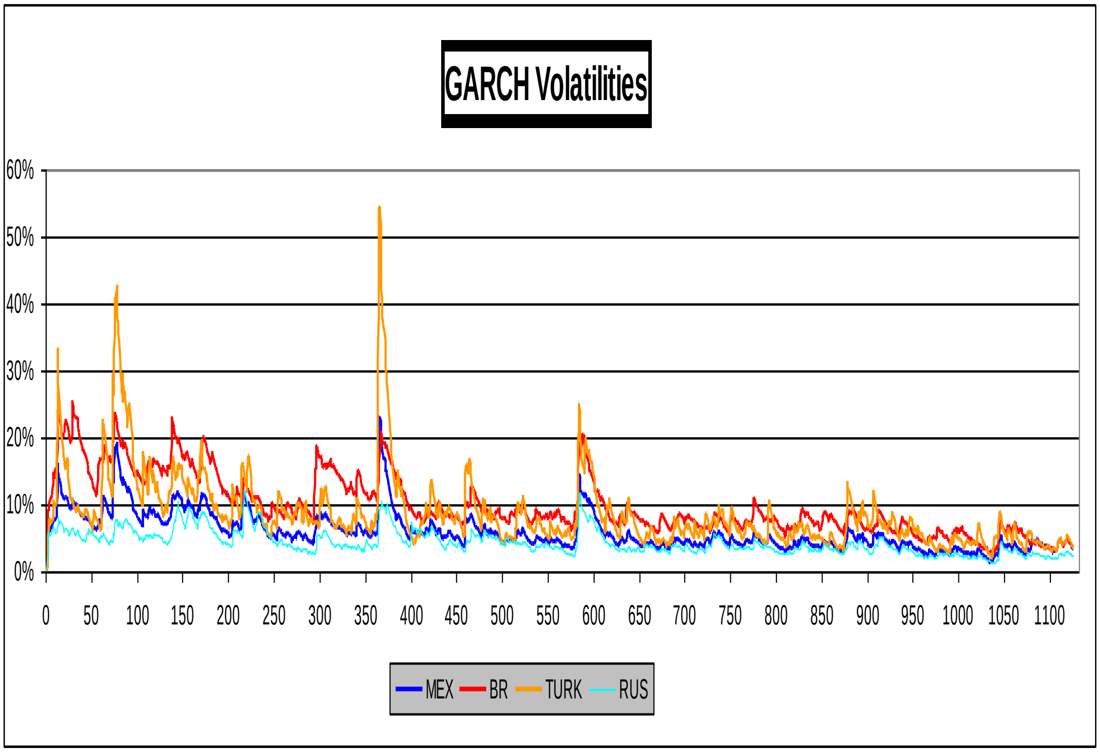


Figure 4.7 Garch(1,1) Historical Volatility Graph for the Selected Countries

Also in order to smoothen the volatility derived from Garch(1,1) the Hodrick Prescott filter is also applied to the results. The Matlab code for calculating volatilities and the graphs for the volatilities are attached in appendix B.

Furthermore, Figure 4.8 below displays the Garch correlation graphs and by observing the graph it can be concluded that the recent spike in the correlation between all the benchmark bonds shows that the volatilities have co-movement due to global factors. This also is another reason why the credit spreads show the signs of tightening at the same time. The notations used in the graph represent the initials of the countries.

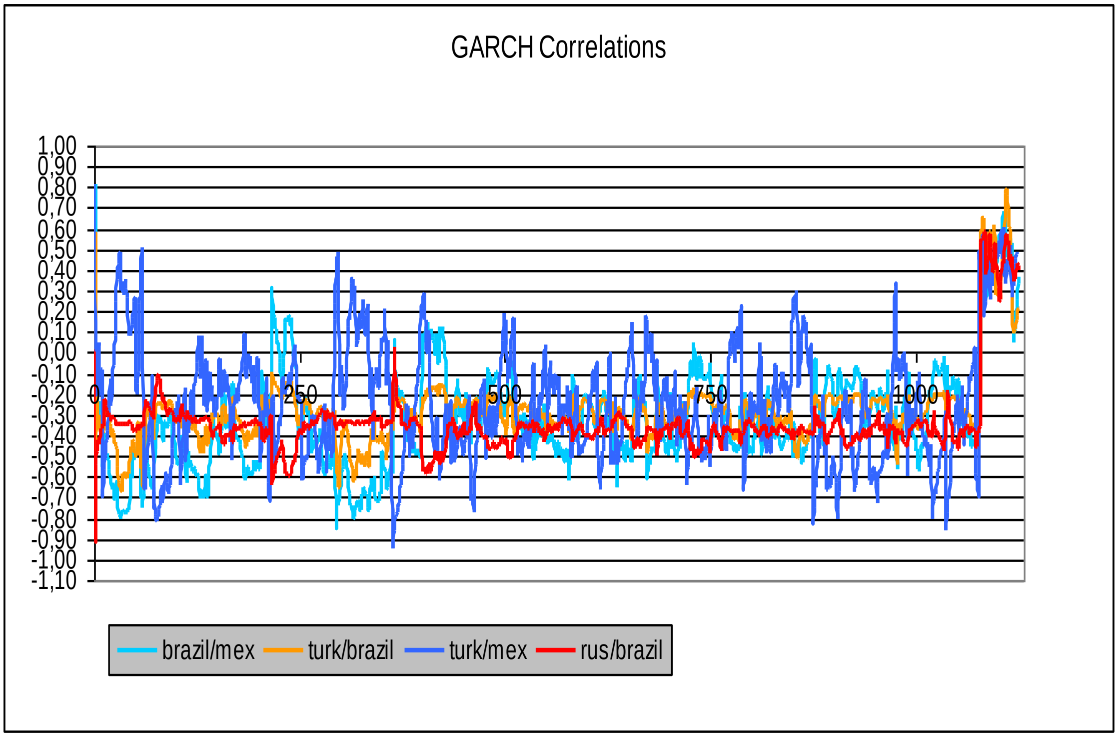


Figure 4.8 Garch Correlations for the Selected Countries

The historical volatility data are estimated using the daily quotes reported by Bloomberg of the benchmark bond. However, this can also be done by calculation of the duration of the all issues considering them as a portfolio and then creating a synthetic yield and calculating a historical volatility of the portfolio. This study uses the historical variance because the implied volatilities are not provided as time series for the corresponding bonds or portfolios of the underlying in our sample which makes it impossible to use the implied volatility from traded option prices.

The factors to be analyzed in the econometric analysis and the reasons for utilizing those variables were mentioned previously, the choice of those variables is justified by the existing theoretical literature on the pricing of credit derivatives. Overall, structural models stress the influence of the value of the assets of the company which is to be the international reserves of the country in this thesis, its underlying volatility derived from the liabilities, the level of interest rates and the maturity.

Despite these some limitations might occur in the model. As suggested by many studies which were mentioned in the literature section, there might be a tendency of Merton model to overestimate spreads for riskier bonds and underestimate spreads for safer bonds. In which case Mexico's and Russia's credit default swap rates might be underestimated whereas Turkey's and Brazil's credit default swap rates might be overestimated.

4.3.6 Implementing the Merton Model

In this dissertation, Merton model will be applied to sovereign issuer's credit default spreads but not the corporate credit default swap spreads. In order to implement the extended Merton model, the assumptions are made in this thesis regarding the parameter selection. The most liquid and available assets of a country under the financial solvency circumstances are the international reserves of that country. They are similar to the corporate assets which will be paid first at a short notice. In this sense the international reserves of a country are closely monitored as an indicator of that country's strength to pay down its debts. The gross external debt of the country, which matches the duration of the credit default swaps, is taken as the liabilities of that country. The volatility of the assets is assumed to be reflected in the most active eurobond traded in the market, which is the benchmark dollar denominated bond for calculations. The historical volatility of the eurobond mentioned above will be taken into consideration as the implied volatility of the sovereign. The rest of the assumptions are listed below;

(V) Underlying Asset: International reserves of the country
(Liquid assets of the country)

(DB) Strike Price: Gross External Debt of the country
(the distress barrier or value of default-free debt)

(t) Time: Duration of the outstanding debt of the country
(Term of zero-coupon debt which is the time to maturity on a default-free bond in years)

(r_f): US treasury rate for the corresponding period

(risk-free rate)

(σ_{Sov}) sigma: Historical volatility of the eurobonds issued by the country

N(d): is the cumulative probability distribution function for a standard normal variable

In Merton's model, value and risk flows from assets to liabilities. Market value balance sheets of an entity or a sector assumes: value of liabilities flows from assets; liabilities have some priority; and assets have a stochastic element. So when applying in this study Merton model to sovereigns, the equity portion is assumed to be akin to the junior claims which is the implicit call option part and the foreign debt portion, similar to foreign debt plus guarantees which is Default Free Value of Debt (DB) minus the Implicit Put Option.

Where in the Merton model, equity is the call option over the assets of the firm, in our case the equity is the call option over the international reserves of the country. The face value of debt corresponds to the outstanding amount of debt of the duration of the credit default swap.

Valuation of sovereign liabilities in international capital market differs from firm valuation in domestic markets in the sense that the sovereign assets are more complex and the junior claims have to be adjusted according to the exchange rate which in return yields the call option for the sovereign assets.

The Black-Scholes option pricing formula is used to relate the value and volatility of liabilities to the value and volatility of sovereign assets. The value of liabilities as a call option on sovereign assets is,

$$V = V_A N(d_1) - DBe^{-r_f t} N(d_2) \qquad (4.27)$$

Inserting the above parameters where applicable in the equations;

$$d_1 = \frac{\ln(\frac{V_A}{DB}) + (r_f + \frac{1}{2}\sigma_L^2)t}{\sigma_{Sov}\sqrt{t}} \tag{4.28}$$

$$d_2 = d_1 - \sigma_{Sov}\sqrt{t} \tag{4.29}$$

and σ_{Sov} is the standard deviation of return of the sovereigns liabilities. The Black-Scholes formula above contains two unknowns, sovereign assets and volatility of sovereign. The relationship between volatility of sovereign and volatility of domestic currency liabilities is given by,

$$V_L = \frac{\sigma_A}{\sigma_{Sov}} V_A N(d_1) \tag{4.30}$$

Here, N(d1) is the change in the price of liabilities with respect to a change in sovereign assets, or $\frac{\delta V_L}{\delta V_A}$. This ratio is also referred to as the option delta. However, the main implication of the above relationship is that the standard deviation of liabilities can be derived from historical data and used to solve for sovereign volatility. Using standard iterative techniques, equations (4.27) and (4.30) can be solved simultaneously for the implied value of sovereign assets and sovereign asset volatility. Utilizing the outcome of the formula, the formula to measure distance to distress is d_2 as displayed in equation (4.28-4.29).

$$d_2 = \frac{\ln(\frac{V_A}{DB}) + (r_f - \frac{1}{2}\sigma_{Sov}^2)}{\sigma_{Sov}\sqrt{t}} = \frac{\ln(V_A * \exp((r_f - \frac{1}{2}\sigma_{Sov}^2)t)) - \ln(DB)}{\sigma_{Sov}\sqrt{t}} \tag{4.31}$$

The probability of default is analogous to the likelihood of future sovereign asset value falling below the distress barrier. Therefore, computing probability of default requires calculating the cumulative normal distribution function, N(.). This can be done using numerical methods or polynomial approximation. A table of the cumulative probabilities of the standard normal distribution function N(.) is included in appendix L for x>0.

For x<0, N(x)=1-N(-x)

Using one of these methods will yield the probability of default as,

Risk-Neutral Probability of Default = $N(-d_2)$ (4.32)

The face value of senior foreign currency debt can be derived from equation (4.27) and the balance sheet relationship, where V_L represents the value of foreign currency liabilities. Using these relationships together yields the value of foreign currency liabilities as,

$$V_L = V_A(1 - N(d_1)) + DBe^{-r_f t} N(d_2) \tag{4.33}$$

which is also equal to,

$$V_L = DBe^{-r_f t} - \left[DBe^{-r_f t} N(-d_1) - V_A N(-d_2) \right] \tag{4.34}$$

when modeled as the default free value minus the implicit put option (present value of expected loss). The term, DBe^{-rt}, is the distress barrier discounted to the present by the risk free rate.

In order to find the yield to maturity the following equation is used;

$$y_t = -(1/t)\ln(V_L / DB), \tag{4.35}$$

if the risk free rate is subtracted from the yield to maturity which is found in equation(64), the credit default swap spread estimate will be derived. So the equation can be expressed in terms of a credit risk premium as,

$$y_t - r_f = -\frac{1}{t}\ln\left\{\frac{V_A}{DBe^{-r_f t}}N(-d_1) + N(d_2)\right\} \tag{4.36}$$

The left hand side of the equation represents the yield to maturity on risky debt less the risk-free rate of interest and is therefore equivalent to a risk premium. In addition to the risk-free rate and time, examination of equation (4.36) reveals that sovereign risk premium is a function of only two variables: the implied volatility of sovereign and the ratio of the value of sovereign assets to the present value of the promised payments on foreign currency liabilities, discounted by the risk free rate. It can be observed that the assets and volatility are related. So, if the ratio of assets to liabilities increases, this results in a decrease in the risk premium; on the other hand if this ratio decreases this result in a decrease in the sovereign risk premium.

As described in the body of the paper there is a strong relationship of the sovereign risk neutral default probabilities with the market implied default probabilities $P_{implied}(d)$. The risk neutral probability of default is N(-d2). Its relationship with the estimated default probability $P_{est}(d)$ is,

$$N(-d_2) = N(N^{-1}(P(d)) + \lambda\sqrt{t}), \text{ where } P_{implied}(d) = \frac{1-e^{-st}}{1-R} \approx P_{est}(d) \tag{4.37}$$

where λ is the market price of risk, s is the observed spread, and R is the assumed recovery rate. If we use the market implied default frequencies $P_{implied}(d)$ implied from observed sovereign CDS spreads as a proxy for the estimated default probability $P_{est}(d)$, then,

$$N^{-1}(N(-d_2)) - N^{-1}(\frac{1-e^{-st}}{1-R}) = \lambda\sqrt{T} = \frac{\mu_{Sov} - r}{\sigma_{Sov}}\sqrt{T} \qquad (4.38)$$

where Sov μ is the return on sovereign assets, r is the risk-free rate, and sov σ is the implied volatility of sovereign.

There are some shortcomings of the Merton model for its underlying assumption that interest rates are constant. If this assumption is to be relaxed to be able to capture interest rate risk, Shimko (1999) suggests that accounting for stochastic interest rates that are assumed to follow a Vasicek (1977) model that provided a closed formula solution to this problem. In this context, the Black and Scholes formula would need to be slightly modified so as to incorporate information on the term structure of interest rates as well as the correlation between movements in interest rates and movements in asset prices. This requires the application of the Vasicek model, for example, to estimate the 1- year ahead interest rate.

4.4 Empirical Findings

Two main topics will be covered in this section. Firstly, the results of the extended Merton model is investigated in a comparative fashion. The outputs of the model and the market rates are compared in terms of the movements in predicted and observed spreads.

In the second part, through a Granger causality test and principal component analysis, the existence of a lead-lag relationship is checked and the significance and direction of price discovery is discussed.

Using the formulas and implementing the extended Merton model, the following tables and graphs are obtained. As for the volatility, different measures are used in order to compare the reliability of the results. First, the standard deviation is used as the implied volatility of the sovereign, followed by the Garch(1,1) as a comparison.

After implementing the extended Merton model, the results have been regressed by using ordinary least squares methodology. The OLS regression result summary tables are displayed below. And the detailed regression statistics are placed in appendix

K. The following tables (4.3-4.4) report the pairwise correlation coefficients for changes in the CDS spreads for the indicated countries using two different methodologies standard deviation and Garch(1,1) respectively. Each pairwise correlation is computed using for all the two series of the model and market CDS rates observations for the four sovereigns.

Table 4.3 Summary Table for the Correlation Matrix of Changes in Sovereign CDS Spreads Using Standard Deviation Methodology for Estimating Implied Country Volatility

Regression Statistics	Multiple R	R Square	Adj. R Square	Standard Error	Observations
Brazil	0,8695	0,7561	0,7550	551,52	237
Mexico	0,8270	0,6840	0,6826	141,59	237
Russia	0,9627	0,9268	0,9265	85,54	237
Turkey	0,8434	0,7113	0,7100	437,80	237

Table 4.4 Summary Table for the Correlation Matrix of Changes in Sovereign CDS Spreads Using GARCH(1,1) Methodology for Estimating Implied Country Volatility

Regression Statistics	Multiple R	R Square	Adj. R Square	Standard Error	Observations
Brazil	0,8309	0,6904	0,6891	490,31	237
Mexico	0,8477	0,7187	0,7175	166,59	237
Russia	0,9093	0,8268	0,8261	126,08	237
Turkey	0,8721	0,7605	0,7595	365,13	237

When comparing the two methods it can be seen that benchmark volatility calculation by the standard deviation method outperforms the Garch(1,1) methodology except for Mexico and Turkey cases. However, both methodologies suggest a significant relationship between the model and market rates. This implies that the model explains most of the variance in the market rates under both volatility calculations and in return the parameters can be considered meaningful. However, more advanced econometric techniques have to be applied before reaching a conclusion about this relationship. The Figures 4.9-4.12 below show the graphs for the model outputs vs market rates for all the sample countries.

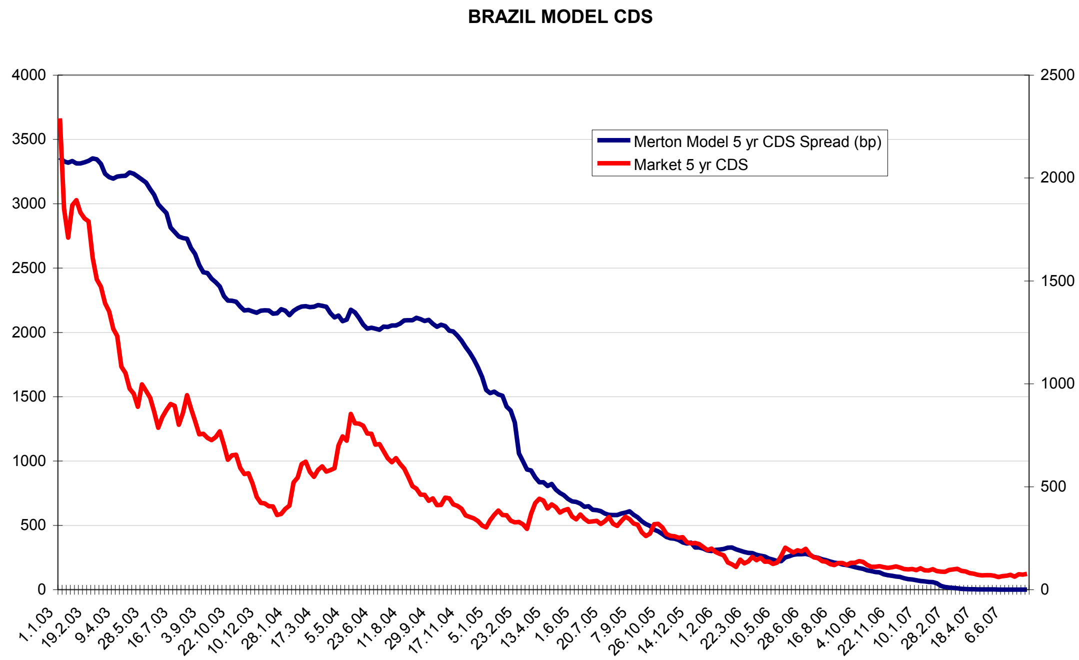


Figure 4.9 Model CDS Spreads Compared to Market Observed Rates : Brazil case

Brazil model rates underperform significantly in the earlier periods rejecting the claims in the literature and have been moving along with the lower volatility in the last periods. Though it seems that the model can not be used as a forecasting tool in the original form, it can be used to give direction whenever the parameters change. So as it shows that relation holds, a sensitivity analysis would be useful for market players and policy makers.

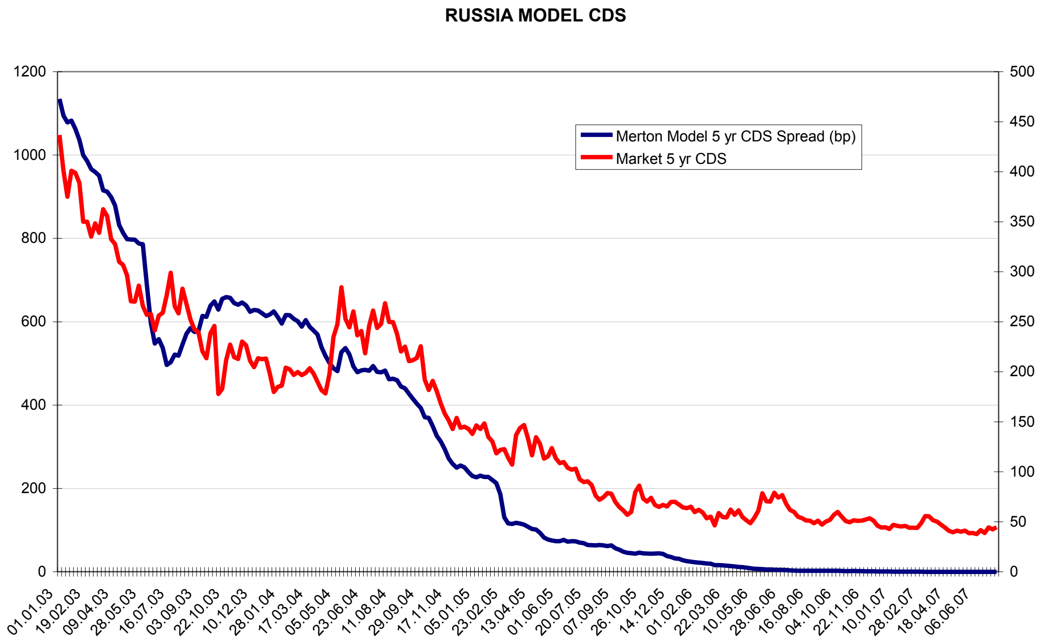


Figure 4.10 Model CDS Spreads Compared to Market Observed Rates : Russia case

The Mexico outputs in Figure 4.11 also display the same results with Brazil model.

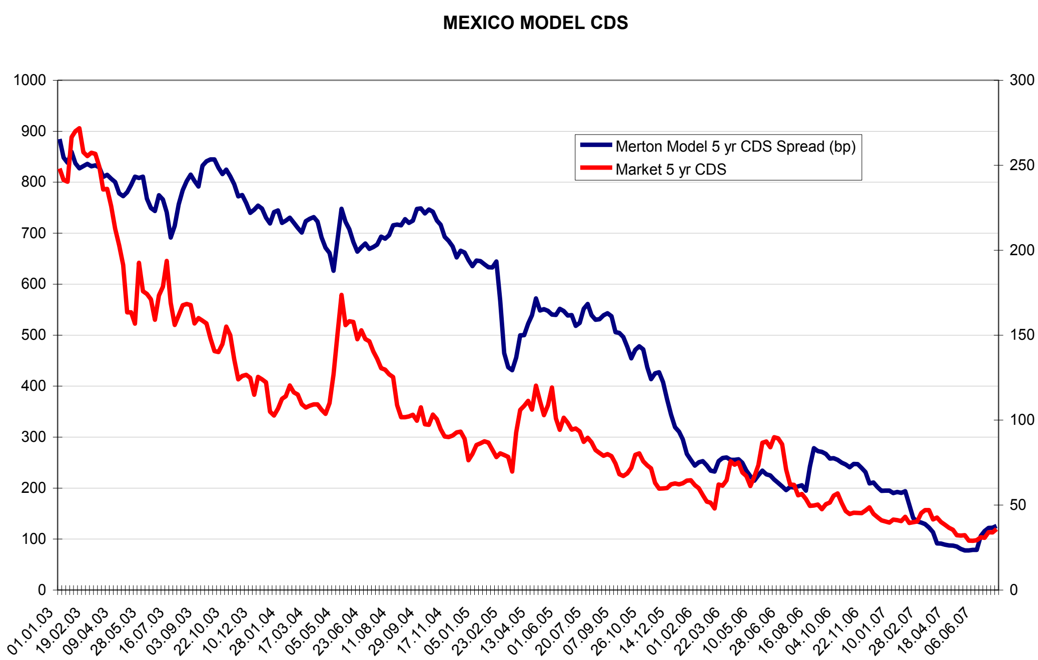


Figure 4.11 Model CDS Spreads Compared to Market Observed Rates : Mexico case

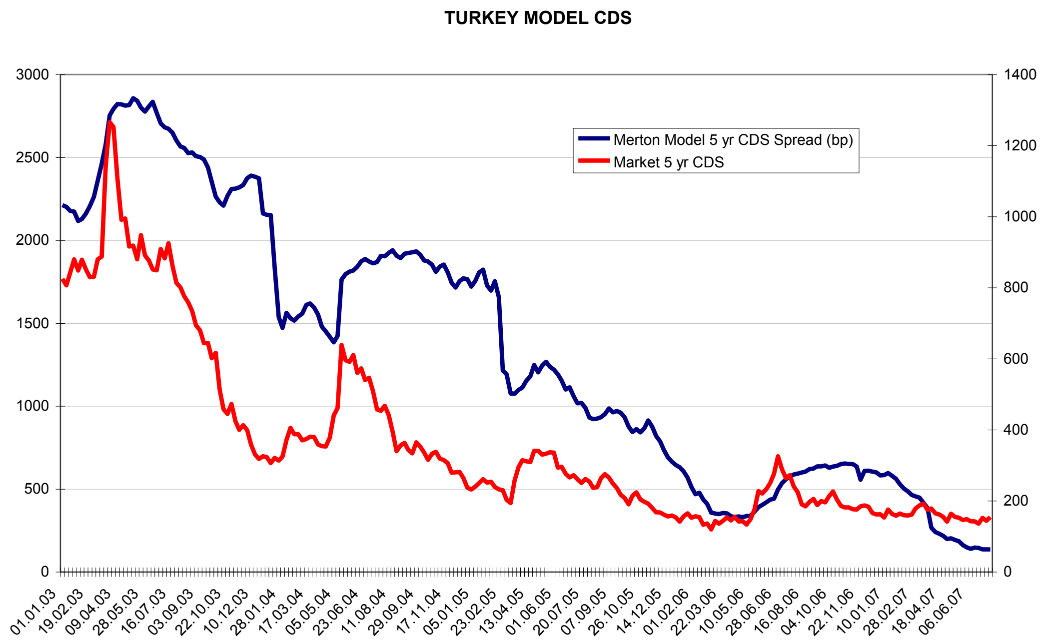


Figure 4.12 Model CDS Spreads Compared to Market Observed Rates : Turkey case

By these evidences it has been empirically proven that the relations between the time series in emerging markets need more complex models rather than just simple econometric methods. These emerging markets have been going through a lower volatility cycle and the extended model though holds pretty strongly, however the main tendency of the model is not to underestimate the spreads as suggested by the studies in literature such as Jones (1984) and Ogden (1987). Though more recently the volatility has faded due to excess leverage and short volatility strategies, this caused the model rates to tighten more rapidly and caused the model to underestimate the market rates.

The need for calibration is still present despite the strong relation of the model and market rates. Some recent research provides evidence that sovereign credit spreads are related to common global factors. In particular, Pan and Singleton (2007) show that the credit spreads for Mexico, Turkey, and Korea share a strong common relation to U.S. stock market volatility as measured by the VIX index. Though the VIX which is the volatility measure of S&P exchanges in US by Chicago Board Options Exchange has been tried to utilize as a calibration technique and used as a multiplication factor of benchmark bond volatility, it has not proven to be a reliable methodology as a result of the calculations, so omitted from the analysis. Also, a global liquidity measure, used by many banks in the global markets, the foreign holdings of US treasuries plus the monetary base index have been used, it produced no better results.

4.4.1 Granger Causality Test

Using the data, the relationship between CDS spreads and the parameters utilized is examined. Firstly, the Granger causality tests are carried out on the relationship between the two series for each entity. The tests are performed using equation above, where X and Y are substituted by the first-order difference of the two credit spreads. In the appendix G the reports are placed displaying the results of Granger causality tests with two lagged periods. The results are checked for %1 significance level, however if %5 or lower level significance is needed, it can also be seen from the table.

According to results obtained by the causality tests at %1 significance level, Turkish Market CDS have one way causality towards the model CDS rates. Mexican CDS results have a little causality effect among each other both ways. For Russia the model CDS has a one way causality towards the market rates. And the model CDS rates seem to be caused by the risk free rates in US. Furthermore, another interesting point is that the external debt level causes Russian central bank reserves to increase. For Brazil case, the volatility causes the debt to increase. Also the CDS levels cause the debt to increase. And also interestingly, the reserves cause the debt level increase.

So as a result, for selected countries Granger causality tests indicate a close dynamic connection between model and market rates, but there is no clear evidence that this connection goes in a certain direction. Moreover, the Granger causality tests does not provide conclusive evidence on economic causality, but nevertheless is able to assess whether there is a consistent pattern of shifts in one series preceding the other. The results therefore provide only grounds for further investigation of the causal mechanisms.

4.4.2 Principal Component Analysis

As it can be seen from the tables in the appendix J, the sum of the scaled variances for the variables is equal to 1.

Principal component analysis of the estimated correlation or covariance matrix of a group of series are computed, and the results are displayed in the appendix J. Also, the table of eigenvalues and eigenvectors, line graphs of the ordered eigenvalues and component scores are displayed.

For Turkish case, the first principal component accounts for 89,7% of the total variance, while the second accounts for 5,4% of the total. The first two components account for over 95,1% of the total variation. This shows that even with the first component most of the variance can be explained.

On the other hand for Mexico case, the first principal component accounts for 73,6% of the total variance, while the second accounts for 19,6% of the total. The first two components account for over 93,2% of the total variation. In Mexico case, most of the variances can be explained with two components.

Brazil's first principal component accounts for 83,6% of the total variance, while the second accounts for 8,8% of the total. The first two components account for over 92,4% of the total variation.

Also for Russia, the first principal component accounts for 91,5% of the total variance, while the second accounts for 4,5% of the total. The first two components account for over 96,0% of the total variation.

In the second section of analysis, the linear combination coefficients can be observed in the tables from the appendix J.

In Turkish case, it can be seen that the first principal component ("PC1") has negative loadings for model and market CDS rates and volatility variables. The second principal component ("PC2") has negative loading for only model CDS rate and positive loadings for the rest of the variables. According to the loadings, CDS rates appear to be affected by the common factor which represents that the model is consistent with the market rates.

In Mexico case, it can be seen that the first principal component has negative loading for only central bank reserves, risk free rate and positive for other variables. The second principal component has negative loading for only market CDS rate and positive loadings for the rest of the variables. According to the loadings, model accounts for less variance of the CDS rates compared to Turkey.

Brazil's first principal component has positive loadings for model and market CDS rates and volatility variables. The second principal component has negative loading for only model external debt and risk free rate and positive loadings for the rest of the variables. According to the loadings, CDS rates appear to be affected by the common factor which represents that the model is consistent with the market rates.

For Russia, it can be seen that the first principal component has positive loadings for model and market CDS rates and volatility variables. The second principal component has negative loading for only model volatility variable and positive loadings for the rest of the variables. According to the loadings, model and market CDS rates appears to be affected by the common factor which represents that the model is consistent with the market rates.

Another method for determining the number of factors to interpret is to construct the scree plots. Specifically, the successive eigenvalues are shown in appendix J shown in a simple line plot. In the scree plots it can be seen that the point where the smooth decrease of eigenvalues appears is the second factor which levels off to the right of the plot. In all country cases, the scree plots show the sharp decline between the first and second eigenvalues. Also depicted in the graph is a horizontal line marking the mean value of the eigenvalues which is always 1 for eigenvalue analysis conducted on correlation matrices.

And the final thing to be interpreted in this analysis is the variable loadings plot which shows the scores vs loadings. The variable loadings plots produce component-wise plots of the eigenvectors, and show the composition of the components in terms of the variables. The component scores are displayed as circles and the variable loadings are displayed as lines from the origin with variable labels.

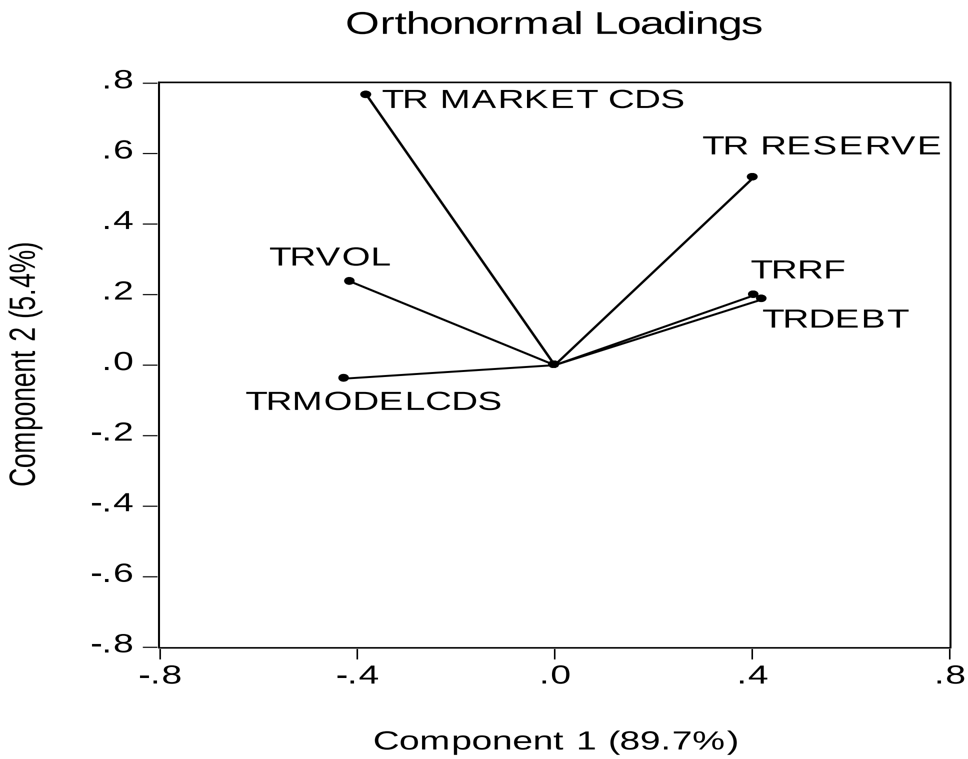


Figure 4.13 PCA result graph: Turkey case

The notations used in these graphs are the parameters used in this model and the output of the model vs. the market rates. These notations are used similarly for all the countries in the tests. Namely;

TR MARKET CDS : Turkish Market CDS rates

TR MODEL CDS : Turkish Model CDS rates

TRRESERVE : Turkish central bank reserves

TRDEBT : Turkish gross external debt

TRRF: US Treasury 5 yr rates

TRVOL : Turkish benchmark bond volatility

For Turkish case, it can be seen from Figure 4.13 that the first component has negative loadings for market and model CDS results which indicate that there is a common component which explains the common variance. However on the second component which explains only %5.4 of the variance, the variable loadings differ slightly.

The Figure 4.13 also suggests that the volatility and model and market CDS are affected by the component 1 in the same manner, however the increase in volatility is being affected by the component 1 in a different way than reserves, risk free rates or the debt. So the volatility changes are an important parameter and related to model and market CDS rates.

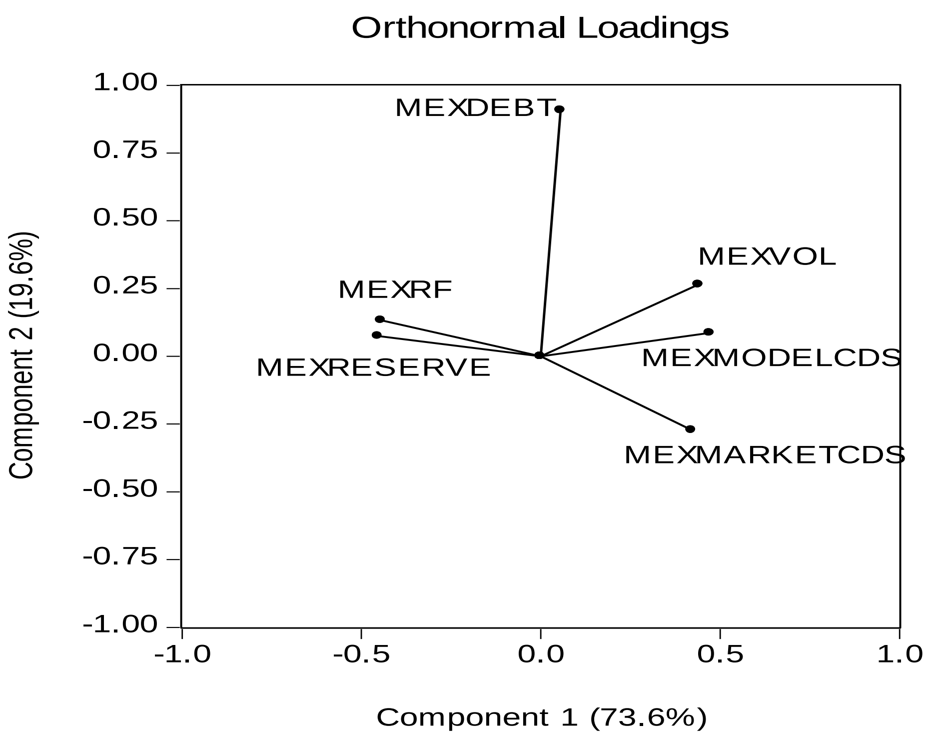


Figure 4.14 PCA result graph: Mexico case

Mexican PCA analysis, which can be seen from Figure 4.14, reveals that the first component has positive loadings for CDS results which indicate that there is a common component which explains the variance. Also on the second component the difference is so slight that it can be ignored. So the model seems to be holding well for this country as well though the total variance explained is a slightly less than Turkey.

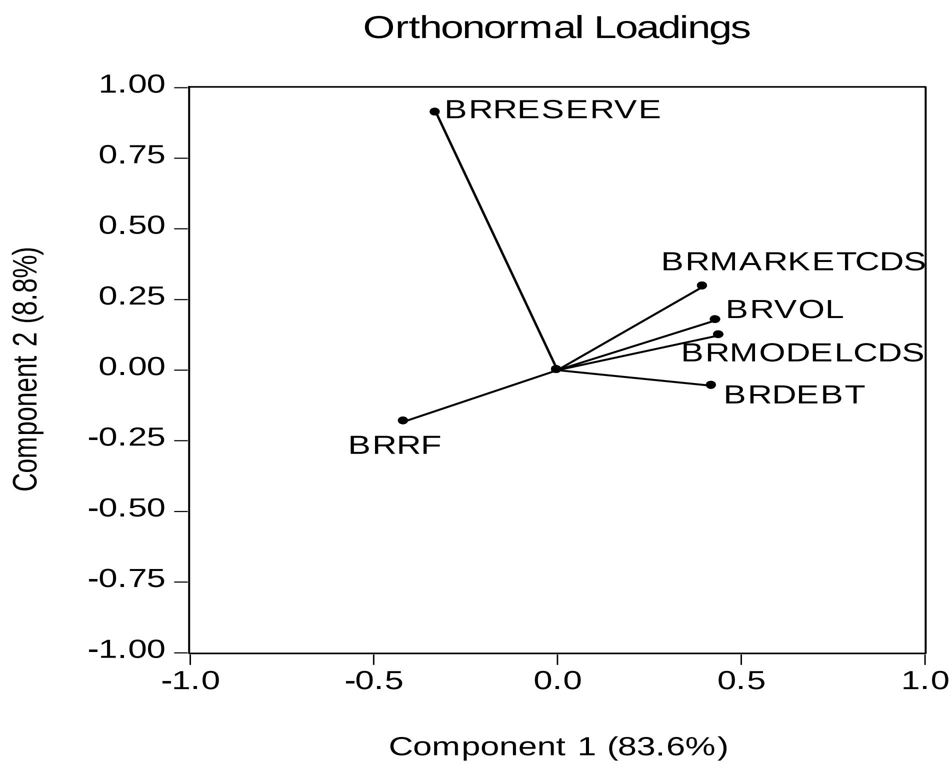


Figure 4.15 PCA result graph: Brazil case

Brazilian PCA analysis can be seen in Figure 4.15. The results indicate that the first component has CDS results are closely related and score similarly on both axis.

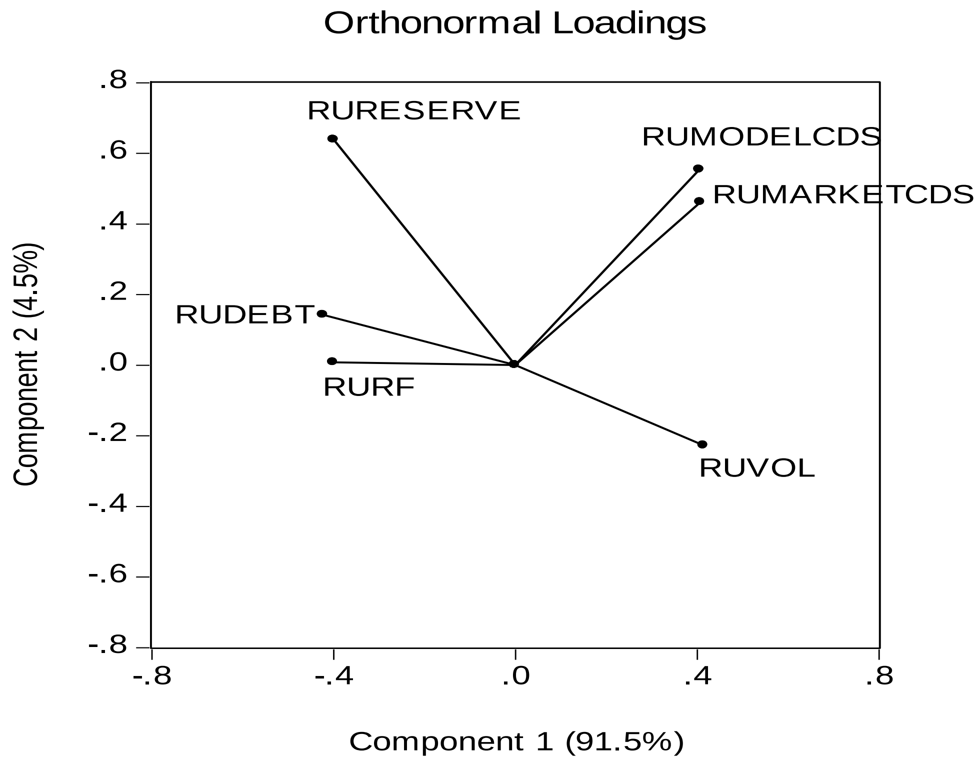


Figure 4.16 PCA result graph: Russia case

Russian PCA analysis can be seen in Figure 4.16. The Russian model and market CDS results are closely related on the first and second components.

To this end, the reports in the appendix J summarize results from a principal components decomposition of the correlation matrix of CDS spread changes. The table in the appendix J reports results based on the correlation matrix formed from the pairwise correlations between the parameters used.

The results when only the overlapping observations are used imply an even greater level of commonality in the movements of CDS spreads.

Chapter 5
Conclusion

In this dissertation the possibility of extending Merton model to sovereigns is elaborated. The main objective in this thesis was to figure out if there is a significant econometric relation with the extended Merton model and the market CDS rates under certain assumptions. As an indication of the model's strength, the consistency of the model outputs with the market pricing is to be considered as the desired outcome. So, if the spreads can be predicted by this methodology, then the components resulting in the credit risk spread variation will be better understood. The variables used for this purpose is comprised of the central bank international reserves, gross external debt, historical volatility of sovereign benchmark bond, risk free rates as US treasury rates, besides the average duration of the debt. Four emerging market countries are selected for this dissertation, namely Turkey, Brazil, Mexico and Russia.

Also, credit derivatives market is explained in detail and the basis which causes the credit spreads to diverge from sovereign spreads is evaluated. Furthermore, standard CDS pricing models are introduced and formulated to calculate the sovereign risk. Besides these, the implementation of the Merton model is shown, assumptions are listed and the results are analyzed.

The empirical findings from this dissertation suggest that the CDS rates from the model output are highly correlated with the market CDS rates for all the selected country cases. Furthermore, the series are found to be cointegrated and principal component analysis suggests that the variance of these series is dependent on mostly a single factor which might be presence of excess liquidity in global markets or such. The results have been tested for different volatility methods for the benchmark bonds such as Garch(1,1) besides the historical variance. Further, the Hodrick-Prescott filter is applied to Garch(1,1) outputs. Though smoothing by the filter did not increase the explanatory power of the relation, Garch(1,1) produced high correlation as well, which supports the idea that the extended Merton model holds even under different assumptions.

As the results indicate, extended Merton model is a tool to help understand credit risk, however a dynamic analysis have to be carried out to make certain that the relations presented herein do not break. Also it has to be calibrated with some global factors in order to explain more of the variation in estimating the credit default swap spreads. The sovereign credit spreads are related to common global factors such as US stock market volatility index (VIX), liquidity factors and investment flows. To this end I have made some attempts regarding calibration with VIX and liquidity factors, however the explanatory power was not any better. In the calibration attempts, the assumption was that the affect of global factors were mainly seen on volatility parameters. So only the volatility was adjusted with these factors. As a result of these attempts, it was observed that the simple standard deviation or GARCH models returned stronger results.

It is almost a common knowledge that the models which use market information sometimes reflects overestimates or underestimates the market rates. However in our case, though we utilized a different methodology, the main tendency is not to underestimate the real market CDS spreads. According to the evidence from this dissertation, the outputs still suggest that the model overestimates the spreads for all the countries for most of the covered period, and with the volatility fading in recent periods, the model started underestimating the spreads.

One of the caveats in this thesis is that some simplifying assumptions are made to cope with certain difficulties; such as obtaining specific data which are not accessible by the general public. So whenever possible, those assumptions can be relaxed and also other modern techniques to calibrate the model can be adopted. However even working with the naïve Merton model shows that the hypothesized relations hold under these assumptions.

The results obtained in this dissertation will have two important achievements. The first achievement is the theoretical contribution; the second is the empirical and practical contribution.

In terms of the theoretical framework, this dissertation makes two important contributions to the literature on sovereign risk and sovereign debt pricing.

First, it provides evidence that variations in country balance sheet explain a large proportion of the variation in emerging markets' sovereign credit risk spreads. 4 emerging market economies are considered over the period 2003-2007 and these countries are the highest weighted members of J.P. Morgan's Emerging Markets Bond Index. In order to explain spread variation, assets and liabilities of a sovereign balance sheet is used as a measure. Some recent strategies by Gray *et al*. (2003) and Gapen *et al*. (2004), suggest that the Merton model can be considered as a contingent claims analysis and can be extended to sovereigns in this manner. Though the existing empirical literature on sovereign debt puts emphasis on the volatility of assets, departing from this thesis would have placed emphasis on the volatility of liabilities as these are already traded in the market. The standard bond and option pricing theory suggests that the volatility of parameters should be a function of the price. Verifying this fact, this thesis has utilized volatility of liabilities which has been proven to be an important determinant of a country's spread. In particular the volatility of liabilities is both statistically and economically significant in explaining spread variation. The principal component analysis results show that the first component explains most of the variation in model and market CDS rates. Also, they are affected in the same manner by this common factor.

Second, the model of sovereign spreads is presented to formalize the insight that a country's spread is higher if its fundamentals are lower or if the volatility of fundamentals is higher. Using historical data the spreads are predicted. This extended Merton model helps to explain 69-83% of the variation in observed spreads. Furthermore, according to the results, sovereign credit spreads are highly correlated, with just first two principal components accounting for more than 90 percent of their variation. This level of explanatory power is surprisingly large given the model's specific assumptions and the fact that our model estimation only uses the foreign currency balance sheet and implied volatility to calculate predicted spreads.

The practical applicability of the model used is another achievement of this dissertation. In terms of practical application, the benefits will be numerous. In practice, the empirical evidence found by this research will assist market participants in determining if Merton's model is useful in determining the components from which the credit risk premium is made of. The applicability of the model will enable the practitioners and market players to measure the sensitivity of the risk premium to the input parameters which are derived from the foreign currency denominated balance sheet of the sovereign. For the policymakers it might be a useful tool to understand what affects the credibility of the country and how to reduce the credibility gap in that sense, and for the market players it is almost a fair value analysis to see if the dynamics of the asset-liability structure of the country is reflected correctly in the credit default swap spreads. The two important implications of this thesis extend to the central bank reserve management and debt management. On the highly debated central bank's reserves issue, extended Merton model can be used to determine an optimum level or if the relationship between credit spreads and reserves is determined as an outcome, then the desired credit spread can be targeted through the central bank reserve accumulation to the specified degree. Given this evidence, it is possible to suggest that the sovereigns can use international reserves or gross external debt to manage their risk premium. On the debt management side, extended Merton model can be used by treasury departments to decide on debt buybacks or targeting a debt level for sustainability. Some of the methods that can be suggested to manage the external debt would be to issue debt buyback programs whenever possible or to increase the foreign currency reserves by issuing more local currency debt and buying foreign currency from the markets against local currency. These policies would help governments and treasuries to bring down the credit risk premiums and borrowing rates in return. The classical methods suggested that debt to GDP ratio is the indicator to watch for sustainability; however relating the debt level with a specific credit spread seems to be more realistic.

These are significant findings since the issue has been highly debated in the literature and has been controversial among many leading economists. Though some have suggested that holding a lower carry return hard currency instead of the high yielding local currency is a costly strategy, the analysis and the strong relation by the application of extended Merton model suggests otherwise.

For future research, the market CDS spreads on emerging market sovereigns with the breakeven spreads implied by their ratings can be investigated building on our findings. The model CDS rates imply an implicit rating level. So as a result of this calculation, the breakeven spread vs. the market rate will be used to measure the risk premium with which investors are being rewarded for holding these instruments.

Furthermore, as for the future research, stochastic volatility models can be adopted for the calculation of volatility. Furthermore, for estimating the sovereign volatility, instead of using conventional volatility calculation methods used in this thesis, models which will enable to capture high volatility and news affect should be tested. By using such methodologies the econometric tests might yield even more reliable results.

In order to evaluate how the credit risk spread changes with these parameters, a sensitivity analysis in depth would be helpful. This will enable the policy makers and investors fully understand how the relations affect each other in the markets. The scenario analysis would clearly depict that the capital outflows that might result in a certain credit spread increase, or the volatility increase in the markets, would also cause a variation in the credit risk spreads. A more comprehensive analysis would include value at risk calculations and risk migration tables. The sovereign balance sheet risks can be better managed through these scenario analyses and through the use of more rigorous quantitative methodologies.

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APPENDIX

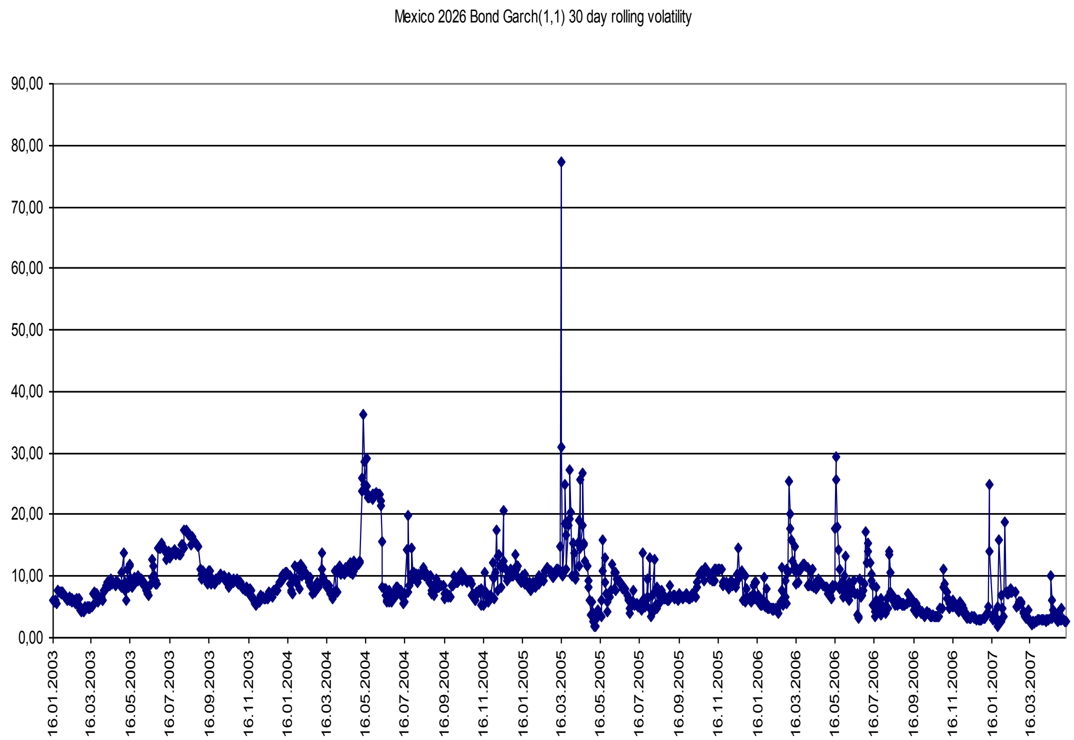
APPENDIX A

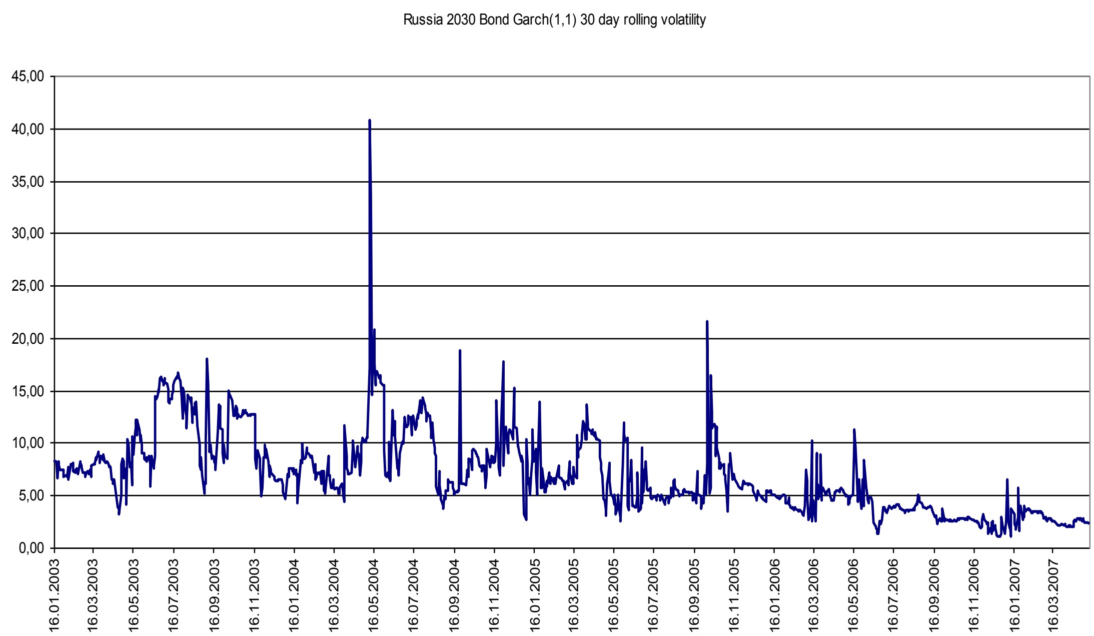
Default Statistics for the Sovereigns

Table 2 Sovereign Debt in Default							
	(Number of issuers)					(Bil. $)	
	All issuers	New issuers	Local currency debt	Foreign currency debt*	Foreign currency bonds	Total debt	Avg. debt per issuer
1975	4	2	2	2	1	2.4	0.6
1976	5	2	2	4	1	1.6	0.3
1977	4	0	1	3	1	1.6	0.4
1978	8	4	1	7	1	4.5	0.6
1979	11	4	3	10	1	7.7	0.7
1980	12	4	2	10	1	5.6	0.5
1981	19	12	2	17	0	9.4	0.5
1982	29	11	4	27	0	43.6	1.5
1983	44	17	2	42	0	93.0	2.1
1984	44	2	3	42	1	90.7	2.1
1985	44	5	2	43	1	120.7	2.7
1986	51	10	3	50	1	199.1	3.9
1987	55	6	4	52	2	288.2	5.2
1988	54	3	2	53	2	229.0	4.2
1989	54	3	3	52	4	244.4	4.5
1990	55	4	5	53	2	335.4	6.1
1991	54	6	4	52	2	227.5	4.2
1992	58	7	3	57	4	220.7	3.8
1993	55	1	4	54	3	188.2	3.4
1994	51	1	4	50	3	161.5	3.2
1995	48	4	7	44	3	101.7	2.1
1996	45	2	7	41	3	83.3	1.9
1997	37	3	6	32	3	76.9	2.1
1998	34	3	8	29	5	103.8	3.1
1999	30	3	7	27	5	104.6	3.5
2000	30	4	5	26	5	72.1	2.4
2001	26	1	3	24	3	75.5	2.9
2002	28	5	4	27	5	134.2	4.8
2003 ¶	26	3	3	25	3	126.4	4.9
Source: Standard & Poor's. *Bank debt and bonds. ¶Through third quarter.							

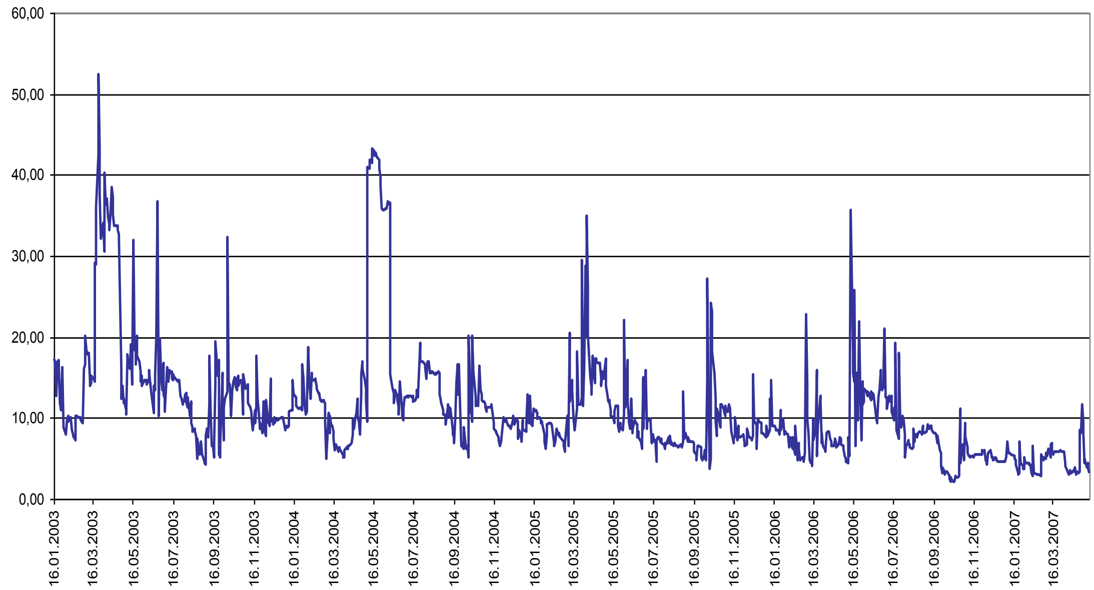
APPENDIX B

Benchmark Bond Garch(1,1) Volatility Graphs

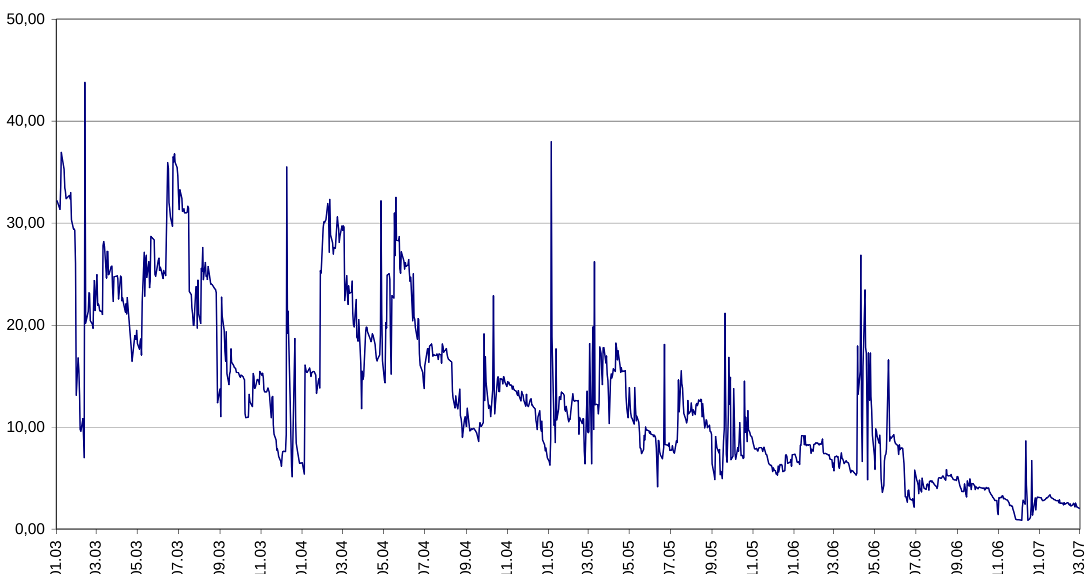




Turkey 2030 Bond Garch(1,1) 30 day rolling volatility



Brazil 2030 Bond Garch(1,1) 30day rolling volatility



APPENDIX C

Software Code for Garch(1,1) Calculation

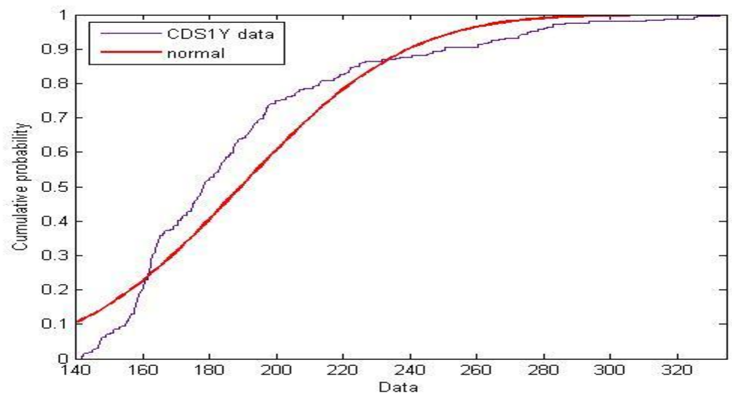
Garch(1,1) Benchmark Bond Price Volatility Calculation Matlab Code to Calculate 30 days

```
gunsayisi=30;
l=length(TURK);
sonuc=zeros(1,1);
for n=1:l-gunsayisi;
data=TURK(n:n+gunsayisi,:);
r_data=log(data./((lagmatrix(data,1))));
r_data=r_data(2:end,:);
[coeff_data,errors_data,LLF_data,innovations_data,...
   sigmas_data,summary_data]=garchfit(r_data);
[sigmaForecast_data,meanForecast_data,...
   sigmaTotal_data]=garchpred(coeff_data,r_data,10);
[sigmaForecast_data,meanForecast_data];
longvar_data = 100*sqrt(250*coeff_data.K/...
   (1 - sum([coeff_data.GARCH(:);...
   coeff_data.ARCH(:)])));
vol_data=sqrt(250)*sigmas_data;
sonvar_data=100*sqrt(250)*sigmaTotal_data(1);
sonuc=[sonuc ; sonvar_data];
end
xlswrite('sonuc',sonuc)
```

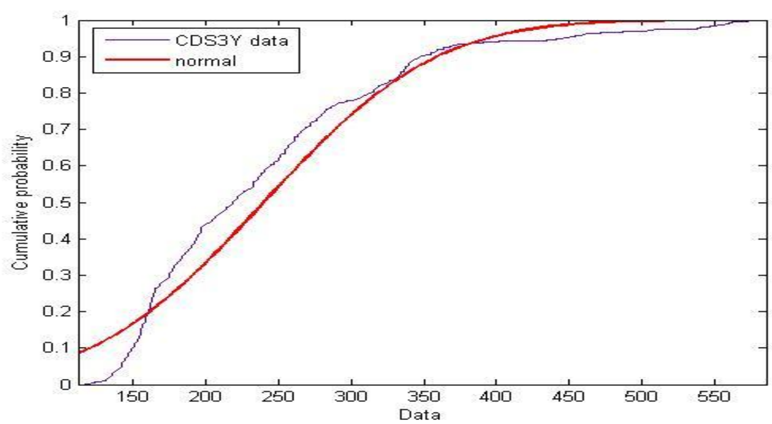
APPENDIX D

CDS Cumulative Distribution Graphs For Turkey in Different Maturities

1 year CDS Cumulative Distribution Graph



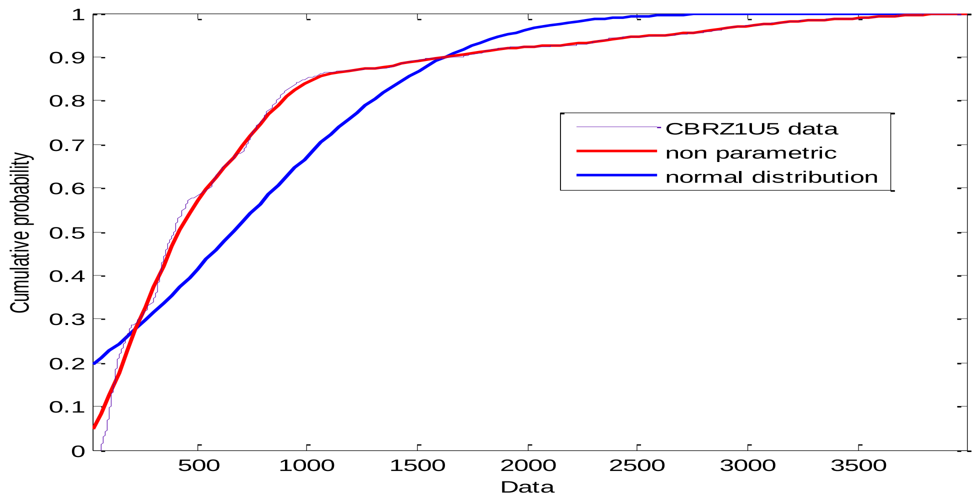
3 year CDS Cumulative Distribution Graph



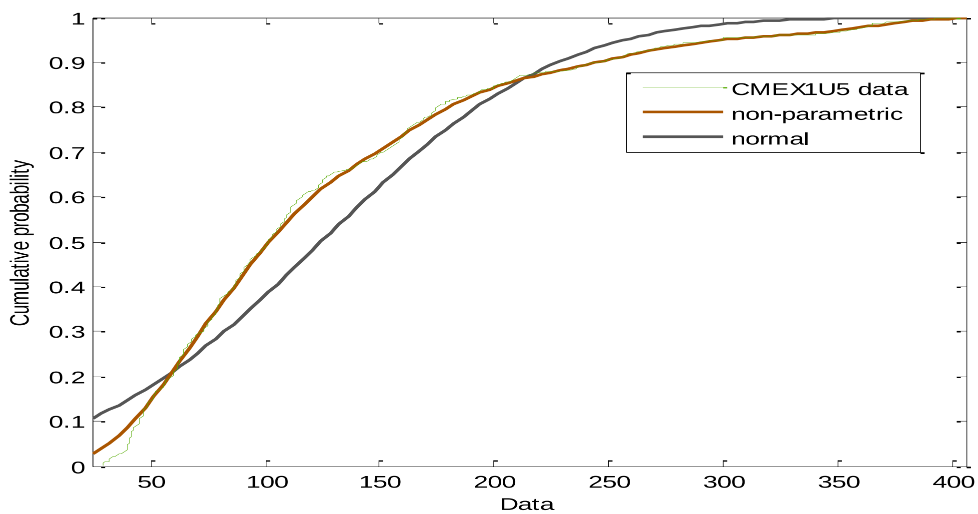
APPENDIX E

5 year CDS Cumulative Distribution Graphs For the Selected Countries

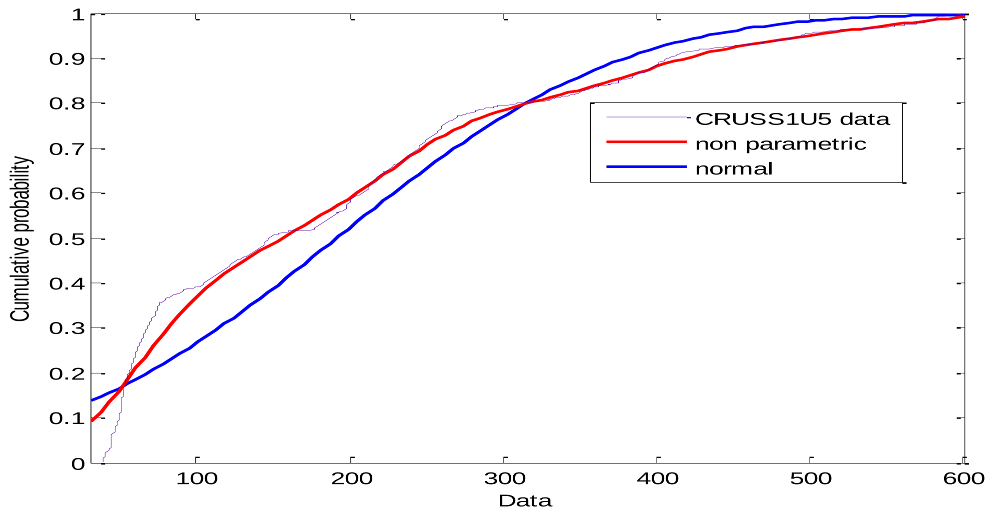
Brazil CDS Cumulative Distribution Graph



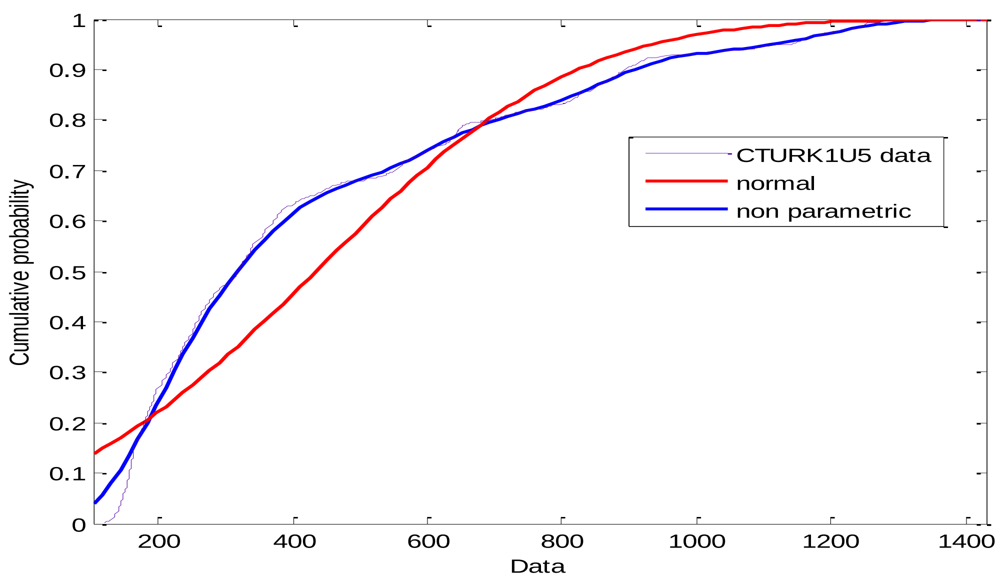
Mexico CDS Cumulative Distribution Graph



Russia CDS Cumulative Distribution Graph



Turkey CDS Cumulative Distribution Graph



APPENDIX F

Standard Merton Model Calculation Spreadsheet Example

Standart Merton Model

Using Merton

Data
Consider the following data:
Value of firm
Face value of debt
Maturity (year)
Interest rate
Volatility

Mkt risk premium
Beta asset

Characteristic of risky debt
Market value of debt
Yield to maturity
Spread (bp)

Decomposition of risky debt
Riskless debt
Put

Another decomposition
Face value
Default probability
Loss if no recovery
Expected recovery
Exp.Loss|Default
Exp Recovery Rate
Value of risky debt

Cost of capital (using CAPM)
Beta equity
Expected return on equity rE
Beta debt
Expected return on debt rD
WACC
rA

Using Merton Model

Data

Value of firm	100
Face value of debt	60
Maturity (year)	10
Interest rate	5,00%
Volatility	30,00%
Mkt risk premium	6,00%
Beta asset	1

Solution

Using Black Scholes:

Step 1: Calculate d1 and d2

d1 =	1,538
d2 =	0,589

Step 2: Find N(d1) and N(d2)

N(d1) = Delta =	0,9380
N(d2) = Proba NoDefault = (in a risk-neutral world)	0,7221

Step 3: Find E using Black-Scholes

Market value of equity =	67,52

Characteristic of risky debt	
Market value of debt	32,48
Yield to maturity	6,14%
Spread (bp)	114

Decomposition of risky debt	
Riskless debt	36,39
Put	3,91

Another decomposition	
Face value	60
Default probability	27,79%
Loss if no recovery	60
Expected recovery	36,81
Exp.Loss|Default	23,19
Exp Recovery Rate	61,35%
Value of risky debt	32,48

Cost of capital (using CAPM)	
Beta equity	1,389
Expected return on equity rE	13,34%
Beta debt	0,191
Expected return on debt rD	6,15%
WACC	11,00%
rA	11,00%

APPENDIX G

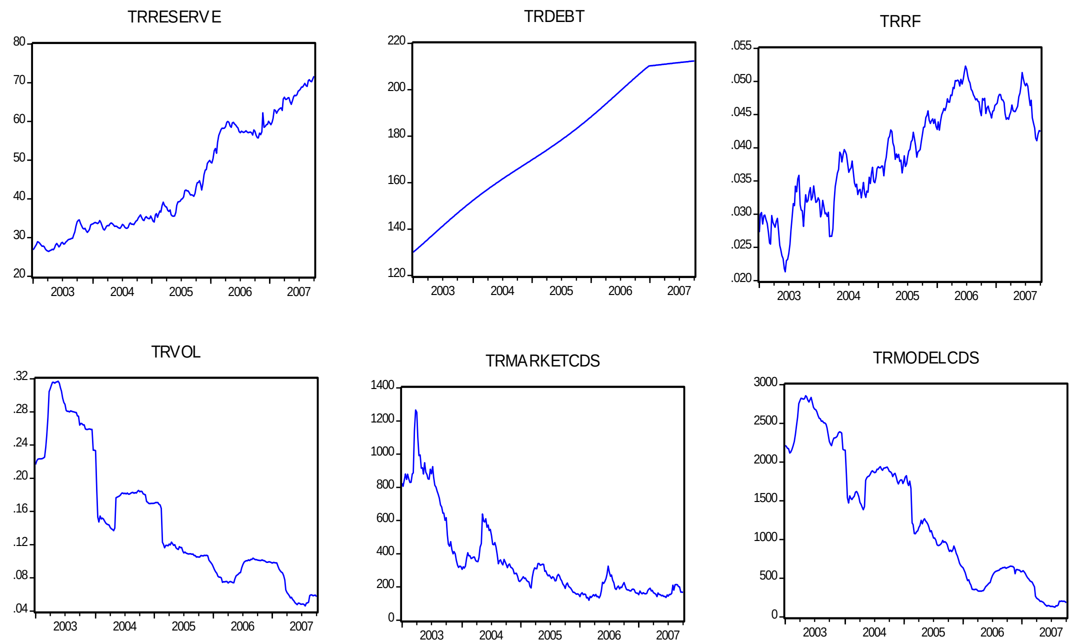
Granger Causality Test Results

Granger Causality Test Results : Turkey Case

Turkey Pairwise Granger Causality Tests
Date: 02/19/08
Sample: 1/01/2003 10/09/2007
Lags: 2

Null Hypothesis:	F-Statistic	Probability	%1 Significance Level
TRMARKETCDS does not Granger Cause TRVOL	13,2841	0,00000	CAUSALITY EXISTS
TRMARKETCDS does not Granger Cause TRMODELCDS	8,02434	0,00042	CAUSALITY EXISTS
TRMODELCDS does not Granger Cause TRRF	7,13371	0,00098	CAUSALITY EXISTS
TRVOL does not Granger Cause TRRF	6,04163	0,00275	CAUSALITY EXISTS
TRDEBT does not Granger Cause TRRF	5,59729	0,00420	CAUSALITY EXISTS
TRDEBT does not Granger Cause TRMODELCDS	3,92693	0,02097	...
TRDEBT does not Granger Cause TRVOL	2,97237	0,05305	...
TRMARKETCDS does not Granger Cause TRRF	2,91333	0,05620	...
TRMODELCDS does not Granger Cause TRDEBT	2,36323	0,09628	...
TRRF does not Granger Cause TRDEBT	1,94901	0,14464	...
TRMARKETCDS does not Granger Cause TRRESERVE	1,90167	0,15154	...
TRRF does not Granger Cause TRMARKETCDS	1,87890	0,15498	...
TRDEBT does not Granger Cause TRRESERVE	1,80335	0,16695	...
TRRESERVE does not Granger Cause TRRF	1,74020	0,17767	...
TRVOL does not Granger Cause TRDEBT	1,68660	0,18732	...
TRVOL does not Granger Cause TRMARKETCDS	1,46689	0,23269	...
TRRESERVE does not Granger Cause TRVOL	1,30867	0,27208	...
TRDEBT does not Granger Cause TRMARKETCDS	1,20999	0,30000	...
TRRF does not Granger Cause TRMODELCDS	1,13945	0,32171	...
TRMODELCDS does not Granger Cause TRRESERVE	0,99007	0,37305	...
TRRF does not Granger Cause TRVOL	0,49007	0,61319	...
TRVOL does not Granger Cause TRMODELCDS	0,47877	0,62013	...
TRVOL does not Granger Cause TRRESERVE	0,43872	0,64538	...
TRMODELCDS does not Granger Cause TRVOL	0,36594	0,69393	...
TRMARKETCDS does not Granger Cause TRDEBT	0,33150	0,71817	...
TRRESERVE does not Granger Cause TRMODELCDS	0,31030	0,73352	...
TRRF does not Granger Cause TRRESERVE	0,23306	0,79229	...
TRMODELCDS does not Granger Cause	0,21664	0,80538	...

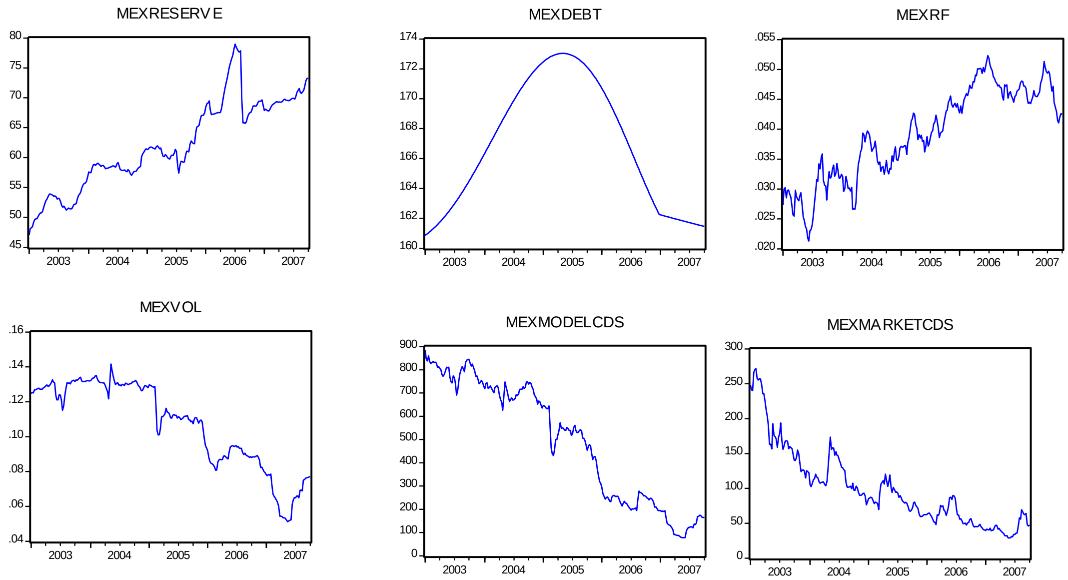
TRMARKETCDS			
TRRESERVE does not Granger Cause TRMARKETCDS	0,15558	0,85600	...
TRRESERVE does not Granger Cause TRDEBT	0,13586	0,87303	...



Granger Causality Test Results : Mexico Case

Mexico Pairwise Granger Causality Tests
Date: 02/19/08
Sample: 1/01/2003 10/09/2007
Lags: 2

Null Hypothesis:	F-Statistic	Probability	**%1 Significance Level**
MEXMARKETCDS does not Granger Cause MEXRF	6,58992	0,00163	CAUSALITY EXISTS
MEXRF does not Granger Cause MEXRESERVE	4,90104	0,00819	CAUSALITY EXISTS
MEXMODELCDS does not Granger Cause MEXRF	3,41235	0,03456	...
MEXMODELCDS does not Granger Cause MEXRESERVE	3,28050	0,03929	...
MEXRESERVE does not Granger Cause MEXVOL	2,52278	0,08234	...
MEXDEBT does not Granger Cause MEXRF	2,40188	0,0927	...
MEXRF does not Granger Cause MEXMODELCDS	2,33739	0,09876	...
MEXMODELCDS does not Granger Cause MEXVOL	2,27807	0,10468	...
MEXRESERVE does not Granger Cause MEXRF	2,26537	0,10599	...
MEXVOL does not Granger Cause MEXRF	2,23330	0,10938	...
MEXVOL does not Granger Cause MEXRESERVE	2,02783	0,13385	...
MEXMODELCDS does not Granger Cause MEXMARKETCDS	1,96402	0,14252	...
MEXMARKETCDS does not Granger Cause MEXMODELCDS	1,92139	0,14863	...
MEXMARKETCDS does not Granger Cause MEXRESERVE	1,91618	0,14939	...
MEXRESERVE does not Granger Cause MEXMARKETCDS	1,84764	0,15983	...
MEXMARKETCDS does not Granger Cause MEXVOL	1,61193	0,20164	...
MEXDEBT does not Granger Cause MEXVOL	1,57088	0,20997	...
MEXRESERVE does not Granger Cause MEXDEBT	1,56652	0,21088	...
MEXDEBT does not Granger Cause MEXMODELCDS	1,39691	0,24935	...
MEXVOL does not Granger Cause MEXDEBT	1,36694	0,25685	...
MEXDEBT does not Granger Cause MEXRESERVE	1,10609	0,33252	...
MEXRESERVE does not Granger Cause MEXMODELCDS	1,07108	0,34426	...
MEXVOL does not Granger Cause MEXMARKETCDS	1,04395	0,35364	...
MEXVOL does not Granger Cause MEXMODELCDS	1,03445	0,35699	...
MEXMODELCDS does not Granger Cause MEXDEBT	0,89928	0,40822	...
MEXRF does not Granger Cause MEXDEBT	0,79401	0,4532	...
MEXDEBT does not Granger Cause MEXMARKETCDS	0,67841	0,50839	...
MEXRF does not Granger Cause MEXVOL	0,57906	0,5612	...
MEXRF does not Granger Cause MEXMARKETCDS	0,52609	0,59158	...
MEXMARKETCDS does not Granger Cause MEXDEBT	0,01161	0,98846	...

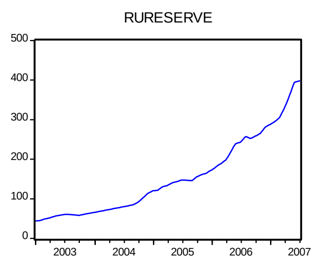

MEXRESERVE
80
75
70
65
60
55
50
45
2003
2004
2005
2006
2007
MEXDEBT
174
172
170
168
166
164
162
160
2003
2004
2005
2006
2007
MEXRF
.055
.050
.045
.040
.035
.030
.025
.020
2003
2004
2005
2006
2007
MEXVOL
.16
.14
.12
.10
.08
.06
.04
2003
2004
2005
2006
2007
MEXMODELCDS
900
800
700
600
500
400
300
200
100
0
2003
2004
2005
2006
2007
MEXMARKETCDS
300
250
200
150
100
50
0
2003
2004
2005
2006
2007

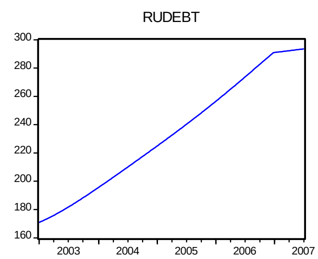
Granger Causality Test Results : Russia Case

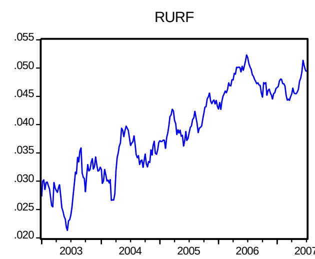
Russia Pairwise Granger Causality Tests
Date: 02/19/08
Sample: 1/01/2003 10/09/2007
Lags: 2

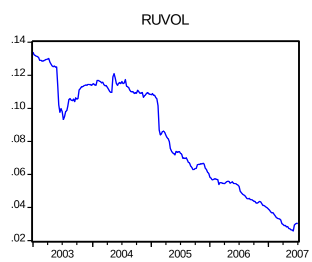
Null Hypothesis:	F-Statistic	Probability	**%1 Significance Level**
RURF does not Granger Cause RUMODELCDS	8,92689	0,00018	CAUSALITY EXISTS
RUDEBT does not Granger Cause RURESERVE	7,66469	0,0006	CAUSALITY EXISTS
RUMODELCDS does not Granger Cause RURF	7,08017	0,00104	CAUSALITY EXISTS
RUVOL does not Granger Cause RURF	6,28331	0,00221	CAUSALITY EXISTS
RUDEBT does not Granger Cause RURF	6,23150	0,00232	CAUSALITY EXISTS
RUMARKETCDS does not Granger Cause RURF	6,01883	0,00283	CAUSALITY EXISTS
RUMODELCDS does not Granger Cause RUMARKETCDS	4,54853	0,01156	...
RUDEBT does not Granger Cause RUMARKETCDS	3,76564	0,0246	...
RUDEBT does not Granger Cause RUVOL	2,87716	0,05833	...
RURESERVE does not Granger Cause RURF	2,37988	0,09485	...
RUMODELCDS does not Granger Cause RUDEBT	1,82525	0,16351	...
RURF does not Granger Cause RUDEBT	1,55506	0,2134	...
RURF does not Granger Cause RURESERVE	1,52001	0,22091	...
RUVOL does not Granger Cause RUMARKETCDS	1,44661	0,23751	...
RURESERVE does not Granger Cause RUVOL	1,38604	0,25215	...
RUMARKETCDS does not Granger Cause RUVOL	1,33168	0,26607	...
RURESERVE does not Granger Cause RUDEBT	1,27337	0,28186	...
RURF does not Granger Cause RUMARKETCDS	1,17276	0,31136	...
RURESERVE does not Granger Cause RUMARKETCDS	1,13823	0,32219	...
RUVOL does not Granger Cause RUMODELCDS	1,06667	0,34586	...
RURF does not Granger Cause RUVOL	1,03818	0,35576	...
RUMARKETCDS does not Granger Cause RUDEBT	0,91521	0,40189	...
RUMODELCDS does not Granger Cause	0,74150	0,47754	...

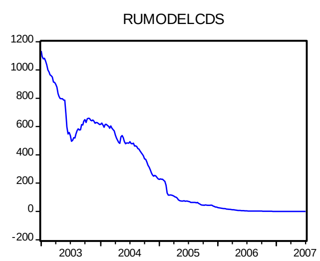
RUVOL			
RURESERVE does not Granger Cause RUMODELCDS	0,49360	0,61108	...
RUDEBT does not Granger Cause RUMODELCDS	0,46582	0,62822	...
RUVOL does not Granger Cause RURESERVE	0,38877	0,67834	...
RUMARKETCDS does not Granger Cause RUMODELCDS	0,26484	0,76756	...
RUMARKETCDS does not Granger Cause RURESERVE	0,12307	0,88426	...
RUMODELCDS does not Granger Cause RURESERVE	0,10657	0,89895	...
RUVOL does not Granger Cause RUDEBT	0,05197	0,94937	...

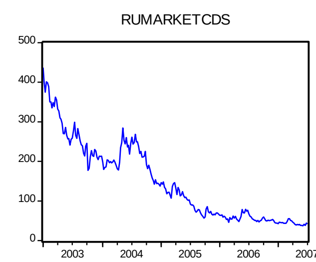










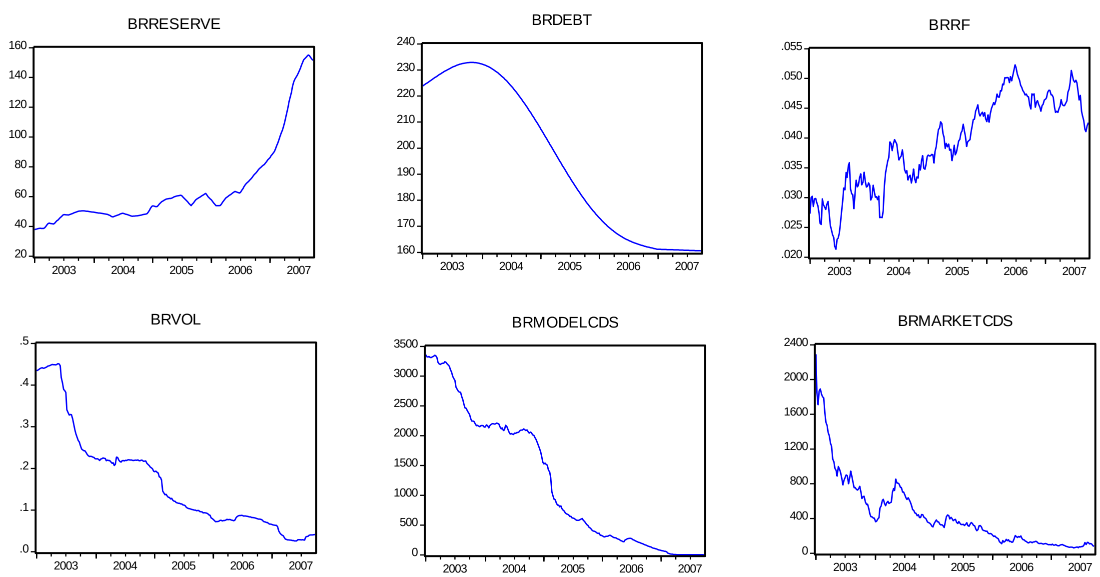


Granger Causality Test Results : Brazil Case

Brazil Pairwise Granger Causality Tests
Date: 02/19/08
Sample: 1/01/2003 10/09/2007
Lags: 2

Null Hypothesis:	F-Statistic	Probability	**%1 Significance Level**
BRVOL does not Granger Cause BRDEBT	42,0146	2,20E-16	CAUSALITY EXISTS
BRRESERVE does not Granger Cause BRDEBT	38,3994	3,30E-15	CAUSALITY EXISTS
BRMARKETCDS does not Granger Cause BRDEBT	33,5538	1,40E-13	CAUSALITY EXISTS
BRMODELCDS does not Granger Cause BRDEBT	22,6076	1,00E-09	CAUSALITY EXISTS
BRMARKETCDS does not Granger Cause BRVOL	8,00205	0,00043	CAUSALITY EXISTS
BRMODELCDS does not Granger Cause BRRF	6,39085	0,00198	CAUSALITY EXISTS
BRVOL does not Granger Cause BRRF	6,07126	0,00268	CAUSALITY EXISTS
BRRF does not Granger Cause BRMODELCDS	4,92868	0,00798	CAUSALITY EXISTS
BRDEBT does not Granger Cause BRRF	4,89542	0,00824	CAUSALITY EXISTS
BRRF does not Granger Cause BRDEBT	4,66574	0,01028	...
BRMARKETCDS does not Granger Cause BRRF	3,48762	0,03213	...
BRMARKETCDS does not Granger Cause BRMODELCDS	3,17041	0,04374	...
BRDEBT does not Granger Cause BRRESERVE	2,89261	0,05736	...
BRDEBT does not Granger Cause BRMODELCDS	2,49158	0,08491	...
BRRF does not Granger Cause BRMARKETCDS	2,11013	0,12346	...
BRRF does not Granger Cause BRRESERVE	1,91720	0,14925	...
BRMODELCDS does not Granger Cause BRRESERVE	1,90980	0,15035	...
BRDEBT does not Granger Cause BRMARKETCDS	1,86927	0,15647	...
BRMARKETCDS does not Granger Cause BRRESERVE	1,80521	0,16666	...

BRRESERVE does not Granger Cause BRMODELCDS	1,76770	0,17293	...
BRMODELCDS does not Granger Cause BRMARKETCDS	1,40047	0,24848	...
BRRF does not Granger Cause BRVOL	1,23228	0,29346	...
BRVOL does not Granger Cause BRRESERVE	1,03375	0,35724	...
BRRESERVE does not Granger Cause BRVOL	0,66088	0,51733	...
BRVOL does not Granger Cause BRMARKETCDS	0,61556	0,54119	...
BRMODELCDS does not Granger Cause BRVOL	0,59136	0,55437	...
BRVOL does not Granger Cause BRMODELCDS	0,47496	0,62249	...
BRRESERVE does not Granger Cause BRMARKETCDS	0,36341	0,69568	...
BRRESERVE does not Granger Cause BRRF	0,23874	0,78781	...
BRDEBT does not Granger Cause BRVOL	0,00300	0,997	...



APPENDIX H

Unit Root Test Results

Merton CDS Model vs Market CDS Rates Unit Root Test : Turkey Case

Group unit root test: Summary
Series: TRMODELCDS, TRMARKETCDS
Date: 03/24/08 Time: 17:25
Sample: 1/01/2003 10/09/2007
Exogenous variables: None
Automatic selection of maximum lags
Automatic selection of lags based on SIC: 0 to 1
Newey-West bandwidth selection using Bartlett kernel

Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes unit root process)				
ADF - Fisher Chi-square	10.8692	0.0281	2	495
PP - Fisher Chi-square	10.5857	0.0316	2	496

** Probabilities for Fisher tests are computed using an asymptotic Chi -square distribution. All other tests assume asymptotic normality.

Unit Root Test Results

Merton CDS Model vs Market CDS Rates Unit Root Test : Brazil Case

Group unit root test: Summary
Series: BRMARKETCDS, BRMODELCDS
Date: 03/24/08 Time: 17:27
Sample: 1/01/2003 10/02/2007
Exogenous variables: None
Automatic selection of maximum lags
Automatic selection of lags based on SIC: 0 to 7
Newey-West bandwidth selection using Bartlett kernel

Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes unit root process)				
ADF - Fisher Chi-square	61.0019	0.0000	2	487
PP - Fisher Chi-square	66.3393	0.0000	2	494

** Probabilities for Fisher tests are computed using an asymptotic Chi -square distribution. All other tests assume asymptotic normality.

Unit Root Test Results

Merton CDS Model vs Market CDS Rates Unit Root Test : Mexico Case

Group unit root test: Summary
Series: MEXMARKETCDS, MEXMODELCDS
Date: 03/24/08 Time: 17:28
Sample: 1/01/2003 10/09/2007
Exogenous variables: None
Automatic selection of maximum lags
Automatic selection of lags based on SIC: 0 to 2
Newey-West bandwidth selection using Bartlett kernel

Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes unit root process)				
ADF - Fisher Chi-square	17.5185	0.0015	2	494
PP - Fisher Chi-square	18.5037	0.0010	2	496

** Probabilities for Fisher tests are computed using an asymptotic Chi -square distribution. All other tests assume asymptotic normality.

Unit Root Test Results

Merton CDS Model vs Market CDS Rates Unit Root Test : Russia Case

Group unit root test: Summary
Series: RUMARKETCDS, RUMODELCDS
Date: 03/24/08 Time: 17:29
Sample: 1/01/2003 7/10/2007
Exogenous variables: None
Automatic selection of maximum lags
Automatic selection of lags based on SIC: 1 to 2
Newey-West bandwidth selection using Bartlett kernel

Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes unit root process)				
ADF - Fisher Chi-square	36.2734	0.0000	2	467
PP - Fisher Chi-square	50.0247	0.0000	2	470

** Probabilities for Fisher tests are computed using an asymptotic Chi -square distribution. All other tests assume asymptotic normality.

APPENDIX I

Cointegration Test Results

Merton CDS Model vs Market CDS Rates Cointegration Test : Turkey Case

Null Hypothesis: TRMARKETCDS has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic based on SIC, MAXLAG=15)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.744225	0.4077
Test critical values:	1% level	-3.456622	
	5% level	-2.872998	
	10% level	-2.572951	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(TRMARKETCDS)
Method: Least Squares
Date: 05/04/08 Time: 18:24
Sample (adjusted): 1/08/2003 10/03/2007
Included observations: 237 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
TRMARKETCDS(-1)	-0.014867	0.008523	-1.744225	0.0824
C	2.700400	3.737678	0.722371	0.4707

R-squared	0.012216	Mean dependent var	-2.648516
Adjusted R-squared	0.008201	S.D. dependent var	33.78925
S.E. of regression	33.65042	Akaike info criterion	9.877960
Sum squared resid	278558.3	Schwarz criterion	9.906294
Log likelihood	-1222.867	F-statistic	3.042319
Durbin-Watson stat	1.615428	Prob(F-statistic)	0.082369

Null Hypothesis: TRMODELCDS has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic based on SIC, MAXLAG=15)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-0.668053	0.8513
Test critical values:	1% level	-3.456730	
	5% level	-2.873045	
	10% level	-2.572976	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(TRMODELCDS)
Method: Least Squares
Date: 05/04/08 Time: 18:25
Sample (adjusted): 1/15/2003 10/03/2007
Included observations: 237 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
TRMODELCDS(-1)	-0.002831	0.004238	-0.668053	0.5047
D(TRMODELCDS(-1))	0.366071	0.059638	6.138204	0.0000
C	-1.568494	6.481095	-0.242011	0.8090

R-squared	0.134190	Mean dependent var	-8.166978
Adjusted R-squared	0.127093	S.D. dependent var	58.93785
S.E. of regression	55.06533	Akaike info criterion	10.86699
Sum squared resid	739854.6	Schwarz criterion	10.90961
Log likelihood	-1339.073	F-statistic	18.90851
Durbin-Watson stat	1.974419	Prob(F-statistic)	0.000000

Merton CDS Model vs Market CDS Rates Cointegration Test : Brazil Case

Null Hypothesis: BRMARKETCDS has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic based on SIC, MAXLAG=15)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-7.135199	0.0000
Test critical values:	1% level	-3.456730	
	5% level	-2.873045	
	10% level	-2.572976	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(BRMARKETCDS)
Method: Least Squares
Date: 05/04/08 Time: 18:27
Sample (adjusted): 1/08/2003 9/26/2007
Included observations: 237 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
BRMARKETCDS(-1)	-0.047216	0.006617	-7.135199	0.0000
C	12.02726	3.975953	3.025002	0.0028

R-squared	0.172049	Mean dependent var	-8.945344
Adjusted R-squared	0.168669	S.D. dependent var	46.15080
S.E. of regression	42.07907	Akaike info criterion	10.32504
Sum squared resid	433808.9	Schwarz criterion	10.35346
Log likelihood	-1273.143	F-statistic	50.91106
Durbin-Watson stat	1.421446	Prob(F-statistic)	0.000000

Null Hypothesis: BRMODELCDS has a unit root
Exogenous: Constant
Lag Length: 7 (Automatic based on SIC, MAXLAG=15)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.109399	0.2412
Test critical values:	1% level	-3.457515	
	5% level	-2.873390	
	10% level	-2.573160	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(BRMODELCDS)
Method: Least Squares
Date: 05/04/08 Time: 18:29
Sample (adjusted): 2/26/2003 9/26/2007
Included observations: 240 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
BRMODELCDS(-1)	-0.003033	0.001438	-2.109399	0.0360
D(BRMODELCDS(-1))	0.454317	0.064112	7.086260	0.0000
D(BRMODELCDS(-2))	-0.051055	0.069291	-0.736818	0.4620
D(BRMODELCDS(-3))	0.220901	0.067617	3.266956	0.0013
D(BRMODELCDS(-4))	-0.180335	0.068095	-2.648291	0.0086
D(BRMODELCDS(-5))	0.234739	0.067272	3.489414	0.0006
D(BRMODELCDS(-6))	-0.211522	0.068949	-3.067805	0.0024
D(BRMODELCDS(-7))	0.200299	0.063450	3.156816	0.0018
C	-1.060843	2.343566	-0.452662	0.6512

R-squared	0.347123	Mean dependent var	-13.88061
Adjusted R-squared	0.324513	S.D. dependent var	28.17010
S.E. of regression	23.15245	Akaike info criterion	9.158857
Sum squared resid	123824.3	Schwarz criterion	9.289381
Log likelihood	-1090.063	F-statistic	15.35233
Durbin-Watson stat	2.032066	Prob(F-statistic)	0.000000

Merton CDS Model vs Market CDS Rates Cointegration Test : Mexico Case

Null Hypothesis: MEXMARKETCDS has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic based on SIC, MAXLAG=15)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.567262	0.1012
Test critical values:	1% level	-3.456622	
	5% level	-2.872998	
	10% level	-2.572951	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(MEXMARKETCDS)
Method: Least Squares
Date: 05/04/08 Time: 18:30
Sample (adjusted): 1/08/2003 10/03/2007
Included observations: 237 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
MEXMARKETCDS(-1)	-0.021853	0.008512	-2.567262	0.0108
C	1.376008	0.972807	1.414471	0.1585

R-squared	0.026093	Mean dependent var	-0.808887
Adjusted R-squared	0.022134	S.D. dependent var	7.504325
S.E. of regression	7.420811	Akaike info criterion	6.854485
Sum squared resid	13546.83	Schwarz criterion	6.882820
Log likelihood	-847.9562	F-statistic	6.590835
Durbin-Watson stat	1.831213	Prob(F-statistic)	0.010843

Null Hypothesis: MEXMODELCDS has a unit root
Exogenous: Constant
Lag Length: 2 (Automatic based on SIC, MAXLAG=15)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-0.745378	0.8319
Test critical values:	1% level	-3.456840	
	5% level	-2.873093	
	10% level	-2.573002	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(MEXMODELCDS)
Method: Least Squares
Date: 05/04/08 Time: 18:30
Sample (adjusted): 1/22/2003 10/03/2007
Included observations: 246 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
MEXMODELCDS(-1)	-0.003079	0.004131	-0.745378	0.4568
D(MEXMODELCDS(-1))	0.394715	0.062667	6.298621	0.0000
D(MEXMODELCDS(-2))	-0.215251	0.062239	-3.458473	0.0006
C	-0.753711	2.301522	-0.327484	0.7436

R-squared	0.149191	Mean dependent var	-2.733827
Adjusted R-squared	0.138644	S.D. dependent var	17.77630
S.E. of regression	16.49806	Akaike info criterion	8.460489
Sum squared resid	65868.98	Schwarz criterion	8.517486
Log likelihood	-1036.640	F-statistic	14.14506
Durbin-Watson stat	1.990162	Prob(F-statistic)	0.000000

Merton CDS Model vs Market CDS Rates Cointegration Test : Russia Case

Null Hypothesis: RUMARKETCDS has a unit root
Exogenous: Constant
Lag Length: 2 (Automatic based on SIC, MAXLAG=14)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.566288	0.1015
Test critical values:	1% level	-3.458347	
	5% level	-2.873755	
	10% level	-2.573355	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(RUMARKETCDS)
Method: Least Squares
Date: 05/04/08 Time: 18:26
Sample (adjusted): 1/22/2003 7/04/2007
Included observations: 233 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
RUMARKETCDS(-1)	-0.020659	0.008050	-2.566288	0.0109
D(RUMARKETCDS(-1))	-0.083334	0.062788	-1.327237	0.1858
D(RUMARKETCDS(-2))	-0.237201	0.061919	-3.830834	0.0002
C	1.046708	1.396991	0.749260	0.4545

R-squared	0.084362	Mean dependent var	-1.427768
Adjusted R-squared	0.072367	S.D. dependent var	12.10912
S.E. of regression	11.66275	Akaike info criterion	7.767695
Sum squared resid	31148.50	Schwarz criterion	7.826940
Log likelihood	-900.9364	F-statistic	7.032961
Durbin-Watson stat	1.968526	Prob(F-statistic)	0.000152

Null Hypothesis: RUMODELCDS has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic based on SIC, MAXLAG=14)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-3.158241	0.0238
Test critical values:	1% level	-3.458225	
	5% level	-2.873701	
	10% level	-2.573327	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(RUMODELCDS)
Method: Least Squares
Date: 05/04/08 Time: 18:27
Sample (adjusted): 1/15/2003 7/04/2007
Included observations: 234 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
RUMODELCDS(-1)	-0.008665	0.002743	-3.158241	0.0018
D(RUMODELCDS(-1))	0.397970	0.058942	6.751886	0.0000
C	-0.267296	1.116432	-0.239420	0.8110

R-squared	0.240018	Mean dependent var	-4.679619
Adjusted R-squared	0.233438	S.D. dependent var	14.31697
S.E. of regression	12.53501	Akaike info criterion	7.907667
Sum squared resid	36296.24	Schwarz criterion	7.951966
Log likelihood	-922.1970	F-statistic	36.47727
Durbin-Watson stat	1.917448	Prob(F-statistic)	0.000000

APPENDIX J

Principal Components Analysis Results

Principal Components Analysis : Turkey Case

Principal Components Analysis
Date: 03/21/08 Time: 15:29
Sample: 1/01/2003 10/03/2007
Included observations: 249
Computed using: Ordinary correlations
Extracting 6 of 6 possible components

Eigenvalues: (Sum = 6, Average = 1)

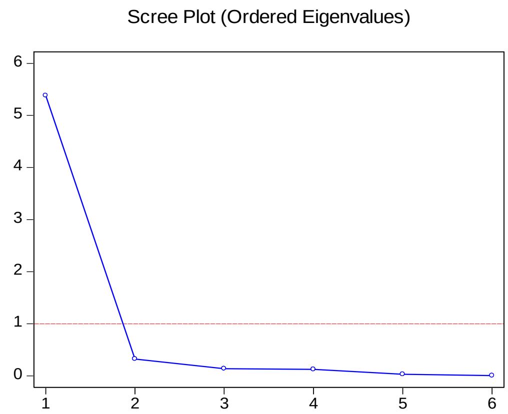
Number	Value	Difference	Proportion	Cumulative Value	Cumulative Proportion
1	5.382672	5.058910	0.8971	5.382672	0.8971
2	0.323762	0.188389	0.0540	5.706434	0.9511
3	0.135373	0.011510	0.0226	5.841807	0.9736
4	0.123862	0.094186	0.0206	5.965669	0.9943
5	0.029676	0.025021	0.0049	5.995345	0.9992
6	0.004655	---	0.0008	6.000000	1.0000

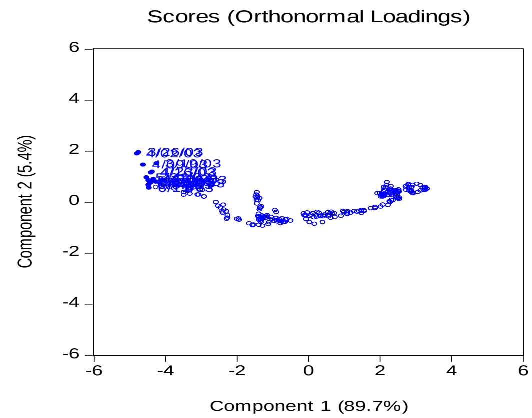
Eigenvectors (loadings):

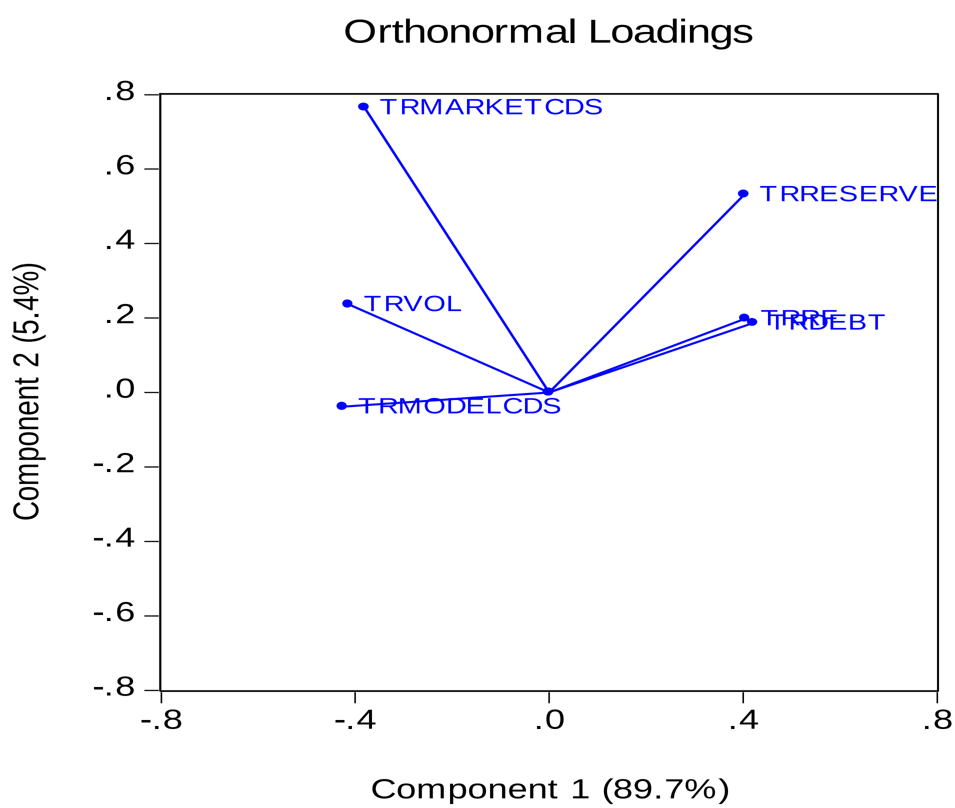
Variable	PC 1	PC 2	PC 3	PC 4	PC 5	PC 6
TRDEBT	0.421102	0.186955	0.018853	0.346501	0.803847	-0.1453
TRMODELCDS	-0.425202	-0.037936	0.299132	0.280631	0.242579	0.7685
TRMARKETCDS	-0.380877	0.765291	-0.189157	-0.434249	0.211783	-0.0076
TRRESERVE	0.402324	0.531659	-0.210073	0.443852	-0.463854	0.3149
TRRF	0.405098	0.198521	0.789434	-0.394459	-0.089002	0.0987
TRVOL	-0.413328	0.236363	0.455024	0.509910	-0.164474	-0.5283

Ordinary correlations:

	TRDEBT	TR MODEL CDS	TR MARKET CDS	TR RESERVE	TR RF	TR VOL
TRDEBT	1.000000					
TRMODELCDS	-0.948007	1.000000				
TRMARKETCDS	-0.831056	0.841066	1.000000			
TRRESERVE	0.951343	-0.922629	-0.714509	1.000000		
TRRF	0.913128	-0.911628	-0.780880	0.868677	1.000000	
TRVOL	-0.903084	0.976167	0.865850	-0.837826	-0.862169	1.00000


Scree Plot (Ordered Eigenvalues)
0
1
2
3
4
5
6
1
2
3
4
5
6


Scores (Orthonormal Loadings)
Component 2 (5.4%)
Component 1 (89.7%)
6
4
2
0
-2
-4
-6
-6
-4
-2
0
2
4
6


Orthonormal Loadings
TRMARKETCDS
TRRESERVE
TRVOL
TRRF
TRDEBT
TRMODELCDS
Component 2 (5.4%)
Component 1 (89.7%)
.8
.6
.4
.2
.0
-.2
-.4
-.6
-.8
-.8
-.4
.0
.4
.8

Principal Components Analysis : Mexico Case

Principal Components Analysis
Date: 03/21/08 Time: 15:34
Sample: 1/01/2003 10/03/2007
Included observations: 249
Computed using: Ordinary correlations
Extracting 6 of 6 possible components

Eigenvalues: (Sum = 6, Average = 1)

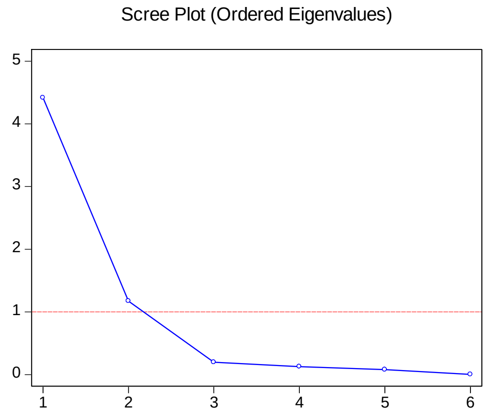
Number	Value	Difference	Proportion	Cumulative Value	Cumulative Proportion
1	4.416792	3.243599	0.7361	4.416792	0.7361
2	1.173193	0.974510	0.1955	5.589985	0.9317
3	0.198683	0.070806	0.0331	5.788668	0.9648
4	0.127877	0.047322	0.0213	5.916546	0.9861
5	0.080555	0.077656	0.0134	5.997101	0.9995
6	0.002899	---	0.0005	6.000000	1.0000

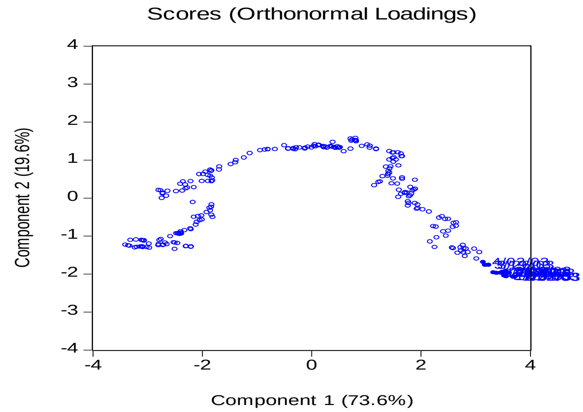
Eigenvectors (loadings):

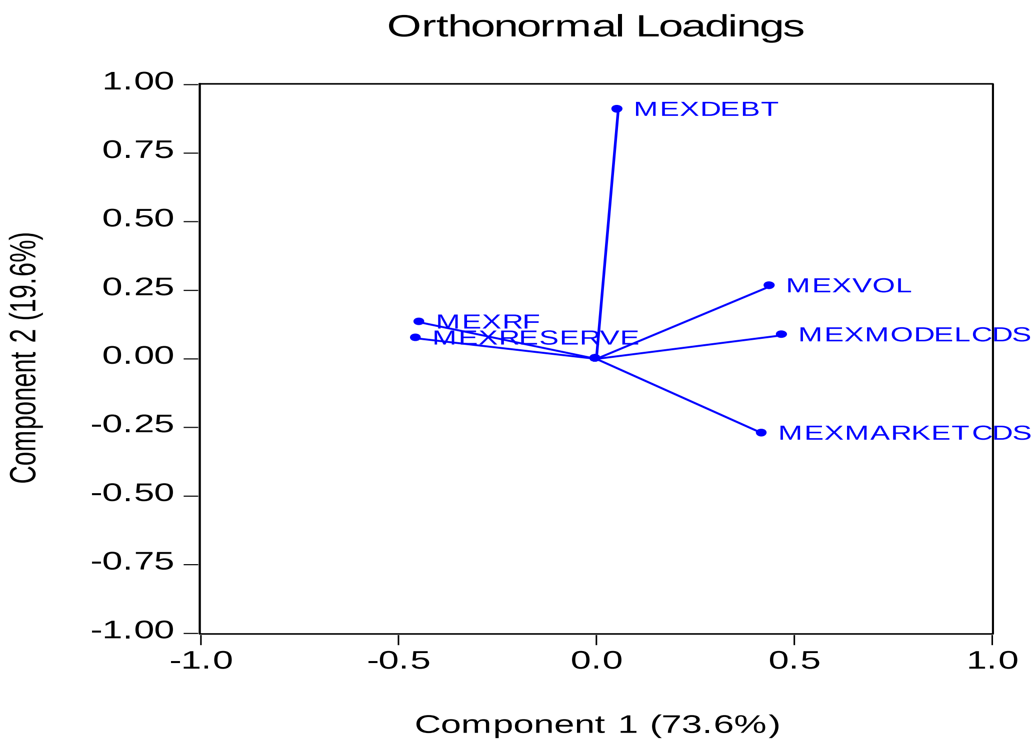
Variable	PC 1	PC 2	PC 3	PC 4	PC 5	PC 6
MEXDEBT	0.055488	0.908009	0.102371	-0.291027	-0.277723	0.0115
MEXMARKETCDS	0.420710	-0.272247	0.769431	-0.151641	-0.364733	-0.0288
MEXMODELCDS	0.471341	0.086759	-0.054242	0.148273	0.237107	0.8301
MEXRESERVE	-0.453855	0.074917	0.195831	0.674109	-0.468435	0.2760
MEXRF	-0.445285	0.133559	0.587352	-0.077164	0.649470	0.1055
MEXVOL	0.439884	0.265374	0.105929	0.640271	0.303937	-0.4717

Ordinary correlations:

	MEX DEBT	MEX MARKET CDS	MEX MODEL CDS	MEX RESERVE	MEX RF	MEX VOL
MEXDEBT	1.000000					
MEXMARKETCDS	-0.157458	1.000000				
MEXMODELCDS	0.196039	0.829928	1.000000			
MEXRESERVE	-0.042038	-0.836671	-0.934828	1.000000		
MEXRF	0.033438	-0.797888	-0.908543	0.896127	1.000000	
MEXVOL	0.362012	0.727516	0.958438	-0.810991	-0.801752	1.000000


Scree Plot (Ordered Eigenvalues)
5
4
3
2
1
0
1 2 3 4 5 6


Scores (Orthonormal Loadings)
Component 2 (19.6%)
4
3
2
1
0
-1
-2
-3
-4
-4 -2 0 2 4
Component 1 (73.6%)


Orthonormal Loadings
Component 2 (19.6%)
1.00
0.75
0.50
0.25
0.00
-0.25
-0.50
-0.75
-1.00
MEXDEBT
MEXVOL
MEXRF
MEXRESERVE
MEXMODELCDS
MEXMARKETCDS
-1.0 -0.5 0.0 0.5 1.0
Component 1 (73.6%)

Principal Components Analysis : Brazil Case

Principal Components Analysis
Date: 03/21/08 Time: 15:39
Sample: 1/01/2003 9/26/2007
Included observations: 248
Computed using: Ordinary correlations
Extracting 6 of 6 possible components

Eigenvalues: (Sum = 6, Average = 1)

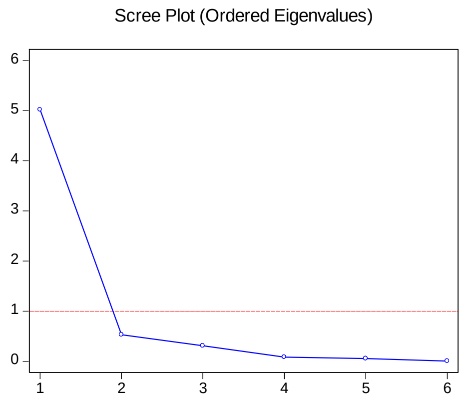
Number	Value	Difference	Proportion	Cumulative Value	Cumulative Proportion
1	5.017601	4.487796	0.8363	5.017601	0.8363
2	0.529804	0.221090	0.0883	5.547405	0.9246
3	0.308715	0.224752	0.0515	5.856120	0.9760
4	0.083963	0.028399	0.0140	5.940083	0.9900
5	0.055565	0.051212	0.0093	5.995648	0.9993
6	0.004352	---	0.0007	6.000000	1.0000

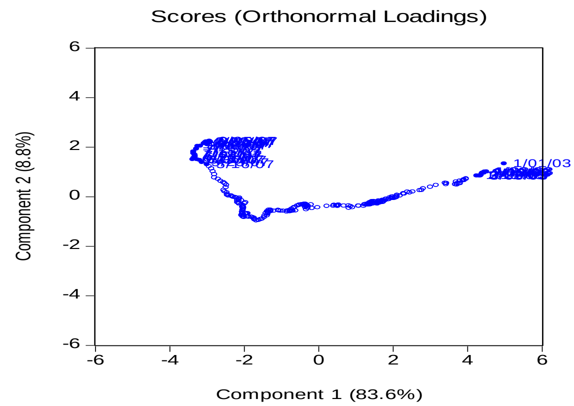
Eigenvectors (loadings):

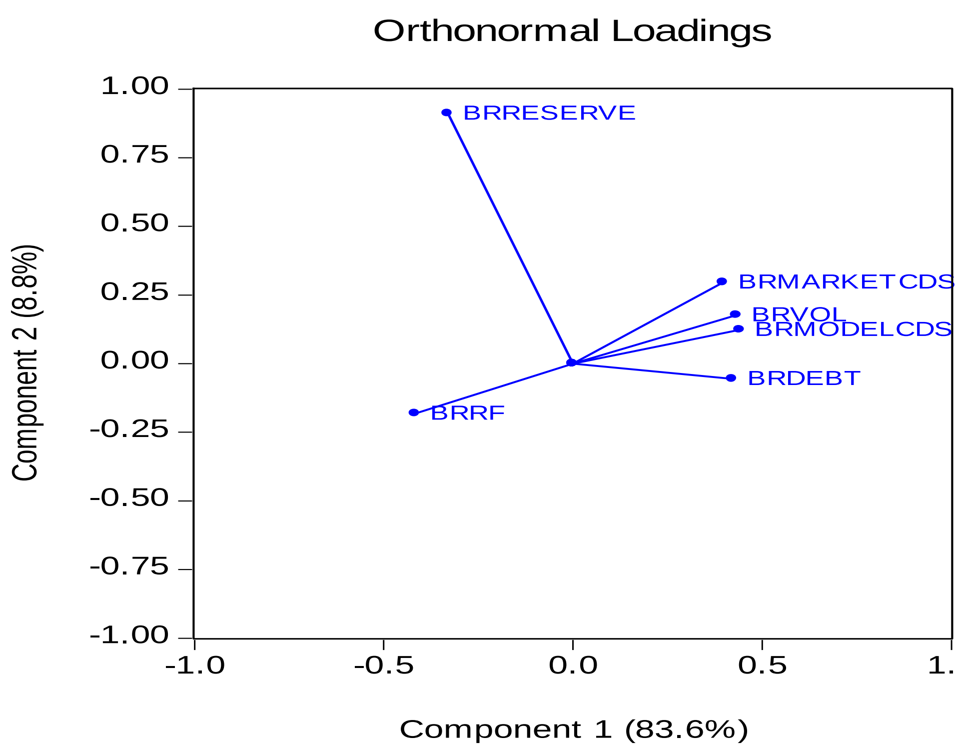
Variable	PC 1	PC 2	PC 3	PC 4	PC 5	PC 6
BRDEBT	0.421985	-0.055358	-0.470235	0.636666	-0.184917	0.397750
BRMARKETCDS	0.397650	0.295813	0.682561	0.114489	-0.524758	-0.000983
BRMODELCDS	0.440905	0.123365	-0.083299	0.243258	0.349827	-0.775817
BRRESERVE	-0.330312	0.910946	-0.188780	0.144877	0.049185	0.045006
BRRF	-0.416356	-0.181802	0.469352	0.674939	0.339667	0.048866
BRVOL	0.432375	0.177022	0.223880	-0.214107	0.671016	0.485272

Ordinary correlations:

	BR DEBT	BR MARKET CDS	BR MODEL CDS	BR RESERVE	BR RF	BR VOL
BRDEBT	1.000000					
BRMARKETCDS	0.745713	1.000000				
BRMODELCDS	0.950091	0.873638	1.000000			
BRRESERVE	-0.691381	-0.556108	-0.662587	1.000000		
BRRF	-0.911700	-0.763742	-0.924827	0.584109	1.000000	
BRVOL	0.860298	0.915989	0.969381	-0.644894	-0.887255	1.000000


Scree Plot (Ordered Eigenvalues)


Scores (Orthonormal Loadings)
Component 2 (8.8%)
Component 1 (83.6%)
1/01/03


Orthonormal Loadings
Component 2 (8.8%)
Component 1 (83.6%)
BRRESERVE
BRMARKETCDS
BRVOL
BRMODELCDS
BRDEBT
BRRF

Principal Components Analysis : Russia Case

Principal Components Analysis
Date: 03/21/08 Time: 15:45
Sample: 1/01/2003 7/04/2007
Included observations: 236
Computed using: Ordinary correlations
Extracting 6 of 6 possible components

Eigenvalues: (Sum = 6, Average = 1)

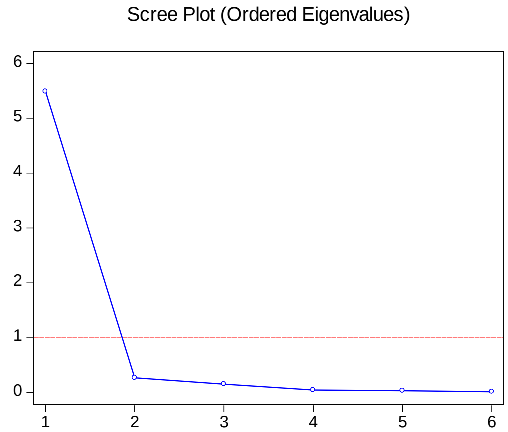
Number	Value	Difference	Proportion	Cumulative Value	Cumulative Proportion
1	5.490169	5.222613	0.9150	5.490169	0.9150
2	0.267556	0.115609	0.0446	5.757726	0.9596
3	0.151947	0.107602	0.0253	5.909673	0.9849
4	0.044346	0.010995	0.0074	5.954018	0.9923
5	0.033351	0.020720	0.0056	5.987369	0.9979
6	0.012631	---	0.0021	6.000000	1.0000

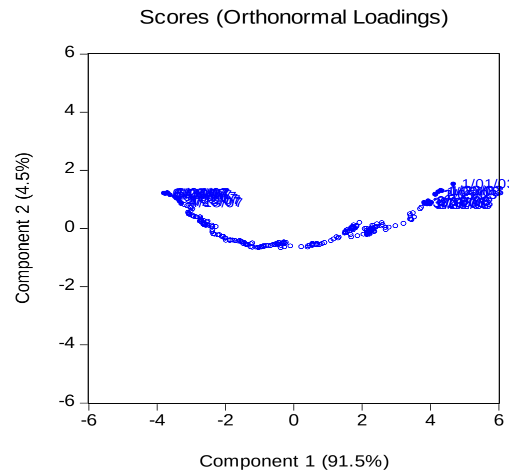
Eigenvectors (loadings):

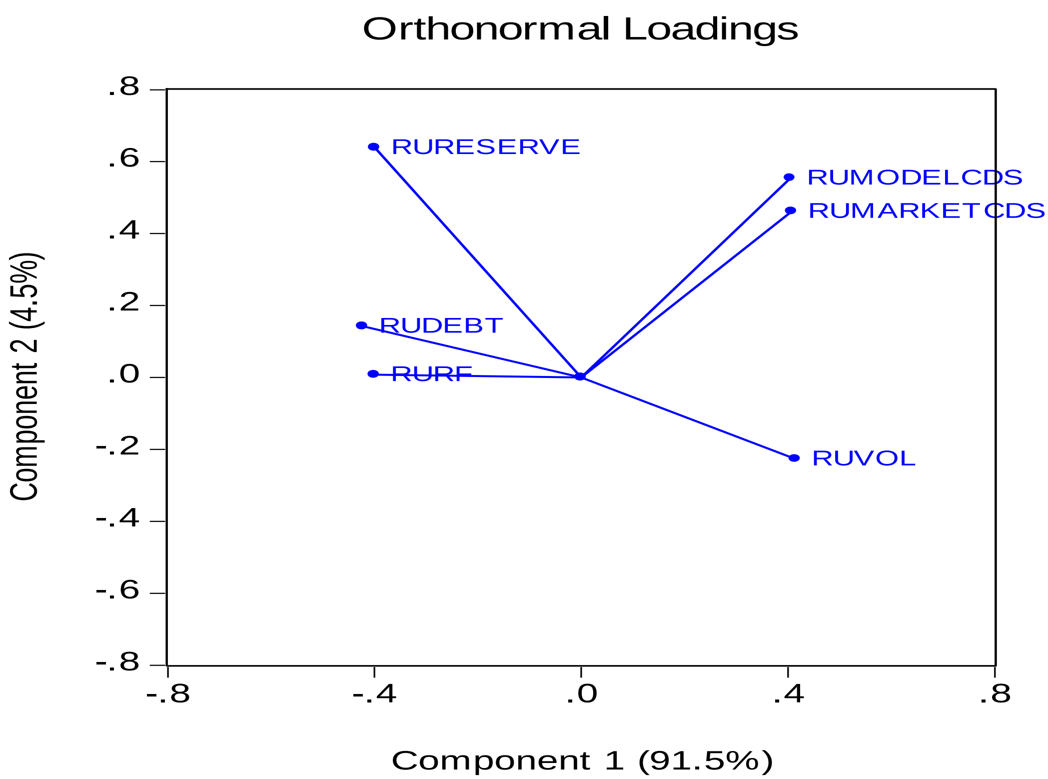
Variable	PC 1	PC 2	PC 3	PC 4	PC 5	PC 6
RUDEBT	-0.422531	0.142239	0.001926	0.332018	0.196342	0.807741
RUMARKETCDS	0.407417	0.461473	0.293615	-0.293620	0.663653	0.090530
RUMODELCDS	0.405002	0.554232	0.085588	0.071365	-0.674222	0.248608
RURESERVE	-0.399378	0.638849	-0.192219	0.364829	0.115474	-0.498985
RURF	-0.400266	0.008098	0.883621	-0.103460	-0.179318	-0.126798
RUVOL	0.414412	-0.226811	0.297872	0.809107	0.144738	-0.111752

Ordinary correlations:

	RUDEBT	RUMARKET CDS	RUMODEL CDS	RURESERVE	RURF	RUVOL
RUDEBT	1.000000					
RUMARKETCDS	-0.926518	1.000000				
RUMODELCDS	-0.919219	0.962586	1.000000			
RURESERVE	0.951756	-0.825786	-0.798803	1.000000		
RURF	0.925097	-0.857655	-0.874004	0.851654	1.000000	
RUVOL	-0.958162	0.904778	0.890653	-0.941778	-0.875578	1.000000


Scree Plot (Ordered Eigenvalues)


Scores (Orthonormal Loadings)
Component 2 (4.5%)
Component 1 (91.5%)
1/01/03


Orthonormal Loadings
RURESERVE
RUMODELCDS
RUMARKETCDS
RUDEBT
RURF
RUVOL
Component 2 (4.5%)
Component 1 (91.5%)

APPENDIX K

OLS Regression Results between the Market Rates and Model Rates for the Selected Countries

OLS Regression Market and Model Rates: Brazil Case

Summary Output

Regression Statistics	
Multiple R	0,8695
R Square	0,7561
Adjusted R Square	0,755
Standard Error	551,52
Observations	237

ANOVA

	df	SS	MS	F	Sign. F
Regression	1	2,22E+08	2,22E+08	728,37	6E-74
Residual	235	71480078	304170,5		
Total	236	2,93E+08			

	Coef	Standard Error	t Stat	P-value	Lower %95	Upper %95	Lower 95,0%	Upper 95,0%
Intercept	203,15	53,97262	3,764012	0,0002	96,822	309,486	96,822	309,4856
X Variable 1	2,3762	0,088047	26,98831	6E-74	2,2028	2,54969	2,2028	2,549692

OLS Regression Market and Model Rates: Mexico Case

Summary Output

Regression Statistics	
Multiple R	0,82701
R Square	0,68395
Adjusted R Square	0,68261
Standard Error	141,586
Observations	237

ANOVA

	df	*SS*	*MS*	*F*	*Sign. F*
Regression	1	1E+07	1E+07	508,557	1,04E-60
Residual	235	4710964	20046,7		
Total	236	1,5E+07			

	Coef	*Standard Error*	*t Stat*	*P-value*	*Lower %95*	*Upper %95*	*Lower 95,0%*	*Upper 95,0%*
Intercept	130,292	19,1819	6,79244	9E-11	92,50131	168,082	92,5	168,082
X Variable 1	3,72063	0,16499	22,5512	1E-60	3,395587	4,04567	3,396	4,04567

OLS Regression Market and Model Rates: Russia Case

Summary Output

Regression Statistics	
Multiple R	0,9627
R Square	0,9268
Adjusted R Square	0,92649
Standard Error	85,5424
Observations	237

ANOVA

	df	*SS*	*MS*	*F*	*Sign. F*
Regression	1	2,2E+07	2E+07	2975,29	2,1E-135
Residual	235	1719612	7317,5		
Total	236	2,3E+07			

	Coef.	*Standard Error*	*t Stat*	*P-value*	*Lower %95*	*Upper %95*	*Lower 95,0%*	*Upper 95,0%*
Intercept	-166,39	10,0075	-16,63	1,5E-41	-186,108	-146,68	-186,11	-146,677
X Variable 1	3,08811	0,05661	54,546	2E-135	2,976571	3,19964	2,97657	3,199645

OLS Regression Market and Model Rates: Turkey Case

Summary Output

Regression Statistics	
Multiple R	0,84336
R Square	0,71126
Adjusted R Square	0,71003
Standard Error	437,802
Observations	237

ANOVA

	df	*SS*	*MS*	*F*	*Sign. F*
Regression	1	1,1E+08	1,1E+08	578,868	2,5E-65
Residual	235	4,5E+07	191671		
Total	236	1,6E+08			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower %95*	*Upper %95*	*Lower 95,0%*	*Upper 95,0%*
Intercept	339,342	50,0817	6,77577	9,9E-11	240,676	438,009	240,676	438,009
X Variable 1	2,69752	0,11212	24,0597	2,5E-65	2,47663	2,9184	2,47663	2,9184

APPENDIX 14

Cumulative Probabilities of the Standard Normal Distribution Function N(.)

	0,000	0,005	0,010	0,015	0,020	0,025	0,030	0,035	0,040	0,045	0,050	0,055	0,060	0,065	0,070	0,075	0,080	0,085	0,090	0,095
0,0	0,5000	0,5020	0,5040	0,5060	0,5080	0,5100	0,5120	0,5140	0,5160	0,5179	0,5199	0,5219	0,5239	0,5259	0,5279	0,5299	0,5319	0,5339	0,5359	0,5378
0,1	0,5398	0,5418	0,5438	0,5458	0,5478	0,5497	0,5517	0,5537	0,5557	0,5576	0,5596	0,5616	0,5636	0,5655	0,5675	0,5695	0,5714	0,5734	0,5753	0,5773
0,2	0,5793	0,5812	0,5832	0,5851	0,5871	0,5890	0,5910	0,5929	0,5948	0,5968	0,5987	0,6006	0,6026	0,6045	0,6064	0,6083	0,6103	0,6122	0,6141	0,6160
0,3	0,6179	0,6198	0,6217	0,6236	0,6255	0,6274	0,6293	0,6312	0,6331	0,6350	0,6368	0,6387	0,6406	0,6424	0,6443	0,6462	0,6480	0,6499	0,6517	0,6536
0,4	0,6554	0,6573	0,6591	0,6609	0,6628	0,6646	0,6664	0,6682	0,6700	0,6718	0,6736	0,6754	0,6772	0,6790	0,6808	0,6826	0,6844	0,6862	0,6879	0,6897
0,5	0,6915	0,6932	0,6950	0,6967	0,6985	0,7002	0,7019	0,7037	0,7054	0,7071	0,7088	0,7106	0,7123	0,7140	0,7157	0,7174	0,7190	0,7207	0,7224	0,7241
0,6	0,7257	0,7274	0,7291	0,7307	0,7324	0,7340	0,7357	0,7373	0,7389	0,7405	0,7422	0,7438	0,7454	0,7470	0,7486	0,7502	0,7517	0,7533	0,7549	0,7565
0,7	0,7580	0,7596	0,7611	0,7627	0,7642	0,7658	0,7673	0,7688	0,7704	0,7719	0,7734	0,7749	0,7764	0,7779	0,7794	0,7808	0,7823	0,7838	0,7852	0,7867
0,8	0,7881	0,7896	0,7910	0,7925	0,7939	0,7953	0,7967	0,7981	0,7995	0,8009	0,8023	0,8037	0,8051	0,8065	0,8078	0,8092	0,8106	0,8119	0,8133	0,8146
0,9	0,8159	0,8173	0,8186	0,8199	0,8212	0,8225	0,8238	0,8251	0,8264	0,8277	0,8289	0,8302	0,8315	0,8327	0,8340	0,8352	0,8365	0,8377	0,8389	0,8401
1,0	0,8413	0,8426	0,8438	0,8449	0,8461	0,8473	0,8485	0,8497	0,8508	0,8520	0,8531	0,8543	0,8554	0,8566	0,8577	0,8588	0,8599	0,8610	0,8621	0,8632
1,1	0,8643	0,8654	0,8665	0,8676	0,8686	0,8697	0,8708	0,8718	0,8729	0,8739	0,8749	0,8760	0,8770	0,8780	0,8790	0,8800	0,8810	0,8820	0,8830	0,8840
1,2	0,8849	0,8859	0,8869	0,8878	0,8888	0,8897	0,8907	0,8916	0,8925	0,8934	0,8944	0,8953	0,8962	0,8971	0,8980	0,8988	0,8997	0,9006	0,9015	0,9023
1,3	0,9032	0,9041	0,9049	0,9057	0,9066	0,9074	0,9082	0,9091	0,9099	0,9107	0,9115	0,9123	0,9131	0,9139	0,9147	0,9154	0,9162	0,9170	0,9177	0,9185
1,4	0,9192	0,9200	0,9207	0,9215	0,9222	0,9229	0,9236	0,9244	0,9251	0,9258	0,9265	0,9272	0,9279	0,9285	0,9292	0,9299	0,9306	0,9312	0,9319	0,9325
1,5	0,9332	0,9338	0,9345	0,9351	0,9357	0,9364	0,9370	0,9376	0,9382	0,9388	0,9394	0,9400	0,9406	0,9412	0,9418	0,9424	0,9429	0,9435	0,9441	0,9446
1,6	0,9452	0,9458	0,9463	0,9468	0,9474	0,9479	0,9484	0,9490	0,9495	0,9500	0,9505	0,9510	0,9515	0,9520	0,9525	0,9530	0,9535	0,9540	0,9545	0,9550
1,7	0,9554	0,9559	0,9564	0,9568	0,9573	0,9577	0,9582	0,9586	0,9591	0,9595	0,9599	0,9604	0,9608	0,9612	0,9616	0,9621	0,9625	0,9629	0,9633	0,9637
1,8	0,9641	0,9645	0,9649	0,9652	0,9656	0,9660	0,9664	0,9667	0,9671	0,9675	0,9678	0,9682	0,9686	0,9689	0,9693	0,9696	0,9699	0,9703	0,9706	0,9710
1,9	0,9713	0,9716	0,9719	0,9723	0,9726	0,9729	0,9732	0,9735	0,9738	0,9741	0,9744	0,9747	0,9750	0,9753	0,9756	0,9759	0,9761	0,9764	0,9767	0,9770
2,0	0,9772	0,9775	0,9778	0,9780	0,9783	0,9786	0,9788	0,9791	0,9793	0,9796	0,9798	0,9801	0,9803	0,9805	0,9808	0,9810	0,9812	0,9815	0,9817	0,9819
2,1	0,9821	0,9824	0,9826	0,9828	0,9830	0,9832	0,9834	0,9836	0,9838	0,9840	0,9842	0,9844	0,9846	0,9848	0,9850	0,9852	0,9854	0,9856	0,9857	0,9859
2,2	0,9861	0,9863	0,9864	0,9866	0,9868	0,9870	0,9871	0,9873	0,9875	0,9876	0,9878	0,9879	0,9881	0,9882	0,9884	0,9885	0,9887	0,9888	0,9890	0,9891
2,3	0,9893	0,9894	0,9896	0,9897	0,9898	0,9900	0,9901	0,9902	0,9904	0,9905	0,9906	0,9907	0,9909	0,9910	0,9911	0,9912	0,9913	0,9915	0,9916	0,9917
2,4	0,9918	0,9919	0,9920	0,9921	0,9922	0,9923	0,9925	0,9926	0,9927	0,9928	0,9929	0,9930	0,9931	0,9931	0,9932	0,9933	0,9934	0,9935	0,9936	0,9937
2,5	0,9938	0,9939	0,9940	0,9940	0,9941	0,9942	0,9943	0,9944	0,9945	0,9945	0,9946	0,9947	0,9948	0,9948	0,9949	0,9950	0,9951	0,9951	0,9952	0,9953
2,6	0,9953	0,9954	0,9955	0,9955	0,9956	0,9957	0,9957	0,9958	0,9959	0,9959	0,9960	0,9960	0,9961	0,9962	0,9962	0,9963	0,9963	0,9964	0,9964	0,9965
2,7	0,9965	0,9966	0,9966	0,9967	0,9967	0,9968	0,9968	0,9969	0,9969	0,9970	0,9970	0,9971	0,9971	0,9972	0,9972	0,9972	0,9973	0,9973	0,9974	0,9974
2,8	0,9974	0,9975	0,9975	0,9976	0,9976	0,9976	0,9977	0,9977	0,9977	0,9978	0,9978	0,9978	0,9979	0,9979	0,9979	0,9980	0,9980	0,9980	0,9981	0,9981
2,9	0,9981	0,9982	0,9982	0,9982	0,9982	0,9983	0,9983	0,9983	0,9984	0,9984	0,9984	0,9984	0,9985	0,9985	0,9985	0,9985	0,9986	0,9986	0,9986	0,9986
3,0	0,9987	0,9987	0,9987	0,9987	0,9987	0,9988	0,9988	0,9988	0,9988	0,9988	0,9989	0,9989	0,9989	0,9989	0,9989	0,9989	0,9990	0,9990	0,9990	0,9990
3,1	0,9990	0,9990	0,9991	0,9991	0,9991	0,9991	0,9991	0,9991	0,9992	0,9992	0,9992	0,9992	0,9992	0,9992	0,9992	0,9993	0,9993	0,9993	0,9993	0,9993
3,2	0,9993	0,9993	0,9993	0,9993	0,9994	0,9994	0,9994	0,9994	0,9994	0,9994	0,9994	0,9994	0,9994	0,9995	0,9995	0,9995	0,9995	0,9995	0,9995	0,9995
3,3	0,9995	0,9995	0,9995	0,9995	0,9995	0,9996	0,9996	0,9996	0,9996	0,9996	0,9996	0,9996	0,9996	0,9996	0,9996	0,9996	0,9996	0,9996	0,9997	0,9997
3,4	0,9997	0,9997	0,9997	0,9997	0,9997	0,9997	0,9997	0,9997	0,9997	0,9997	0,9997	0,9997	0,9997	0,9997	0,9997	0,9997	0,9997	0,9998	0,9998	0,9998
3,5	0,9998	0,9998	0,9998	0,9998	0,9998	0,9998	0,9998	0,9998	0,9998	0,9998	0,9998	0,9998	0,9998	0,9998	0,9998	0,9998	0,9998	0,9998	0,9998	0,9998
3,6	0,9998	0,9998	0,9998	0,9998	0,9999	0,9999	0,9999	0,9999	0,9999	0,9999	0,9999	0,9999	0,9999	0,9999	0,9999	0,9999	0,9999	0,9999	0,9999	0,9999
3,7	0,9999	0,9999	0,9999	0,9999	0,9999	0,9999	0,9999	0,9999	0,9999	0,9999	0,9999	0,9999	0,9999	0,9999	0,9999	0,9999	0,9999	0,9999	0,9999	0,9999
3,8	0,9999	0,9999	0,9999	0,9999	0,9999	0,9999	0,9999	0,9999	0,9999	0,9999	0,9999	0,9999	0,9999	0,9999	0,9999	0,9999	0,9999	0,9999	0,9999	1,0000
3,9	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000
4,0	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000	1,0000

CURRICULUM VITAE

Mehmet Türk was born on 26 October 1975, in Ankara. He received his BS degree in Civil Engineering in 1997 from Middle East Technical University and MBA degree in 1999 in Business Administration from Virginia Polytechnic Institute and State University. He has been working as a specialist at the Treasury department of Turkiye Is Bankasi A.S. since year 2000. During this time he has been affiliated with the international capital markets and derivatives and more recently with the asset and liability management of the bank. His research interests include volatility modeling, credit derivatives and financial modeling. Since 2005 he has been a chief dealer at the treasury department and heading the asset and liability management desk for a year.

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