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Essays on sovereign default risk in emerging countries

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À mes parents et à toute ma famille.

« All models are wrong, some are useful. »

George Box

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General Introduction

Since the 16^{th} century, France and Spain were the first who used the term "sovereign default" in their financial dictionary, and since then sovereign default event has spread in many emerging and developed countries during the next century (Reinhart and K. S. Rogoff 2011).

Looking back at the economic crises in recent years hitting Asia in the 90s, Latin America in 2000s and the global finance in 2007 until now, all underlined the important role of measuring the sovereign default risk for researchers and policy makers. In this study, the sovereign default is defined as a situation where a country's government loses the ability to pay its debt and choose to default. Based on the default history of emerging countries, the majority of default cases are in the latter because they have borrowed too much in foreign currency and are unable to repay its debt. Hence, we focus on the problem of sovereign default in emerging countries in the thesis.

The debate about the determinant of the sovereign default risk is an interesting question for researchers and economists. In fact, there are three big credit rating agencies such as Moody's, Standard & Poor's and Fitch Ratings who publish the sovereign credit rating of the ability to debt reimbursement and the likelihood of default. However, many researchers and economists do not believe in their rating (scientific point of view) because they do not publish the methodology used in obtaining their rating (Cohen 2013). Hence, the sovereign default risk has become a highly interesting subject.

Consequently, two main questions are addressed in this study, including: how can we determine and evaluate the sovereign default risk in emerging countries? And what type of models and indicators that best express the sovereign default risk?

In order to answer these questions, an article that drew my attention is called the "Contingent Claims Approach to measuring and managing sovereign credit risk" for Gray et al. 2007. This article showed how to calculate the sovereign default probability by transferring the credit risk model to sovereign credit risk. This method was based on the option pricing theory of Black and Scholes 1973 and sovereign balance sheet. An empirical results of Brazil's crisis for the period 2002-2005 highlighted the sovereign credit risk indicator of Brazil is homogeneous with the sovereign credit default swap, which is a proxy of sovereign default risk. Besides, Karmann and Maltritz 2009 focussed on how to calculate directly sovereign's ability-to-pay as the sum of all foreign exchange reserves and the discounted steady state capital flow of balance trade.

In addition, the economic policies are modelled when a government decides to defaults, in several cases such as the role of bargaining power of reducing debt (Yue 2010; Andrade 2009; Jeanneret 2013), the incentive to issue debt (Jeanneret 2013) and the acceptance to pay the default cost in order to choose to default (Panizza 2008; Arellano 2008; Andrade and Chhaochharia 2011).

Furthermore, a number of empirical results study the effect of the fundamental macroeconomics and financial index on the sovereign default risk proxies, such as sovereign CDS spread (Georgievska et al. 2008; IMF-Report 2013), sovereign yield spread (Hernandez-Trillo 1995; Baek et al. 2005; Hilscher and Nosbusch 2010; Ramos-Francia and Rangel 2012), Emerging Market Bond Index Plus (Ferrucci 2003; Petrova et al. 2010; Rowland and Torres 2004; Jaramillo and Tejada 2011). These studies regress the sovereign default proxies and take the following as explanatory variables, namely, government's solvency, government's liquidity and macroeconomic situation. These regressions take into account the influence of these explanatory variables to the sovereign default proxies over a specific period, and do not examine the effect in the long-run and short-run. However, each method has advantages and limitations. Hence, in this study we will fill the gaps in the literature on the determination of sovereign default risk.

The structure of the thesis

Before presenting the research objectives of the thesis, we present briefly the structure of my thesis. This dissertation consists of five chapters. The remainder of the dissertation is organized as follows:

Chapter 1: Literature review of sovereign default.

Chapter 2: A structural sovereign default model: Evidence from Argentina

Chapter 3: A stochastic model of sovereign default risk.

Chapter 4: Long-run determinant of sovereign CDS spread in emerging countries.

Chapter 5: Long-run determinant of sovereign bond in emerging countries: New evidence from asymmetric and nonlinear pass-through

Research Objective and Methodology

The main objective of this thesis is to determine and evaluate the sovereign default risk, and the sovereign risk indicators. The underlying aims of my dissertation are the following:

— To review the determinant of sovereign default risk.

— To transpose the credit risk model in corporate level to the sovereign risk level, and calculate the default probability of Argentina.

— To calculate the sovereign credit spread from two default policies: increase corporate income tax and reduce a part of debt.

— To study the long-run determinant of the Sovereign CDS spread in the following emerging market: Brazil, Malaysia, South Korean, Thailand, Turkey, South Africa, Indonesia and Mexico.

— To study the asymmetric long-run and short-run determinant of sovereign bond index, a proxy of sovereign default, for two typical emerging countries: Turkey and Brazil.

In order to achieve the above stated objectives, chapter 1 describes the related literature of sovereign default risk; Chapter 2 examines the sovereign default probability indicator; Chapter 3 identifies a stochastic model to calculate the Daily Sovereign Credit Spread; Chapter 4 determines the long-run Sovereign Credit Default Swaps spread for eight emerging markets; and the last chapter provides an asymmetric non-linear model to estimate sovereign bond index for Turkey and Brazil.

The first chapter begins by detailing the literature about sovereign default in the panorama, namely, history of sovereign default, how we can understand the sovereign default, and its principal models. These models are: structural model, econometric model through CDS sovereign or yield spread sovereign, and dynamic stochastic model. Hence, this chapter aims to build a theoretical foundation upon which the research is based by reviewing the relevant literature to identify research issues, highlighting those that have not been answered by previous researchers.

The second chapter transposes the credit risk model in corporate level to the sovereign risk level. We base our research on the pricing option of Black & Scholes (1973) and the credit risk model of Merton (1974), and the work of Gray and Malone 2008 by using the sovereign balance sheet. The "central variable" in this chapter is the "sovereign equity" which is the sum of domestic currency debt and monetary base. This variable is determined as a call option. A case study is applied to Argentina for the period 1997 - 2010.

Our result shows that Argentina's default probability in the structural model is very fluctuating in regards to this country's. The limitation in this chapter is the data availability of the domestic-currency debt is only found from the period of 1997 to 2010.

This chapter is presented at 2^{nd} ***Annual Doctoral Workshop JRD 2013 in Paris, France.***

The third chapter presents a dynamic stochastic model, in which we tried to calculate the sovereign credit spread from two default policies that we proposed.

We opt for two policies, the first one is when a country choose to default and its government will negotiate with its lenders to reduce a part of its debt. Paralleled with this policy, the government will increase the corporate income tax. An empirical study is applied for four emerging countries: Brazil, Mexico, Peru and Turkey over the period 2000 - 2011.

Our results can be summarized as follows: *firstly*, the evolution of modelled sovereign credit spread is fairly homogeneous with a benchmarked sovereign credit spread; *secondly*, the sign and Adjusted R-square value explain a strong relationship between the estimated sovereign credit spread and the benchmarked one; *finally*, the existence of co-integration in long-run between the estimated sovereign credit risk and the benchmark. This means that the evolution in the long-run of modelled sovereign credit spread co-integrates with the benchmark.

This chapter is presented at *63rd Annual Congress of the French Economic Association in Lyon, France*; *14th FRAP - Finance, Risk and Accounting Perspectives Conference in Oxford, England*[1].

The fourth chapter carries on the study of the long-run determinant the Sovereign CDS spread in emerging market: Brazil, Malaysia, South Korean, Thailand, Turkey, South Africa, Indonesia and Mexico for the period 2008 -2013. In order to proceed, we present a new econometric approach: Pooled Mean Group (PMG) estimation. By using Autoregressive Distributed Lag (ARDL) model and

1. This conference is in the top conferences in Banking, Economics and Finance 2014

PMG (M Hashem Pesaran et al. 1997, 1999), we find the long-run determinant of Sovereign CDS (a proxy of sovereign risk) from the fundamental macroeconomics variables, namely, the current account balance to GDP, the external debt to GDP and the international reserves to GDP. These three variables represent the government's solvency, liquidity and macroeconomics variables (Georgievska et al., 2008).

Our findings can be summarized as follows: *firstly*, the existence of co-integration between these variables indicated above; *secondly*, the coefficients of the current account, the external debt and international reserves are significant and expected vis-à-vis theoretical economics in the long-run for all countries. From the policy maker's point of view, in order to reduce the country risk, the government should have focused to increase more reserves than focus on solving two factors: the external debt and the current account; *finally*, in the short-run the external debt and the international reserves are significant.

This chapter is presented at *1st Vietnam International Conference in Finance in Hanoi, Vietnam*.

The last chapter studies the asymmetric long-run and short-run determinant of sovereign bond index, a proxy of sovereign default, for two typical emerging countries: Turkey and Brazil for the period 2000 -2011. The determinant of sovereign bond index is estimated from three macroeconomic factors: the current account, the external debt and the international reserves. We use positive and negative partial sum composition of the current account in order to determine asymmetric effect to sovereign bond. Our findings can be summarized as follow: *firstly*, the long-run relationship between the sovereign bond and explanatory variables exists; *secondly*, we detect only asymmetric long-run effect for Turkey and both asymmetric short-run and long-run effect for Brazil; *finally*, the asymmetric long-run effect is greater than symmetric effect for both Turkey and Brazil. The limitation in this chapter is the non-availability of data for a long period of time for the EMBI.

This chapter is presented at 2^{nd} ***Paris Financial Management Conference (PFMC2014)***.

CHAPTER 1

Literature review of sovereign default

This chapter is organized as follows. In the first section, we present the history of sovereign default. In the second section, we briefly show the cost of sovereign default. The important contribution of this chapter is highlighted in the third section that reviews the background of the sovereign default risk, and three principal approaches to evaluate and to determine the sovereign default risk. And finally, the last section covers the conclusion.

1.1 History of sovereign default

In this section, we will answer the following questions:

— What is a sovereign default?

— Why does sovereign default?

— What are the causes and the costs of sovereign default?

There are many different discussions about the definition of sovereign default. In the first hand, from a legal point of view, in the debt contracts, there are two principal points: scheduled and reimbursed amount. According to Hatchondo et al. 2007, a sovereign default occurs when a scheduled debt service is not paid on time specified in the debt contracts. However, sovereign default is defined by Reinhart and K. S. Rogoff 2011 as the failure of a government to meet a principal or interest payment on the due date (or within the specified grace period). Tomz and Wright 2013 show generally that default occurs when the debtor violates the legality of the debt contract. Gray et al. 2007; Gray and Malone 2008 propose that sovereign default occurs when the market value of sovereign asset is below the contractual sovereign liabilities. In the other hand, from credit ratings agencies' view, a sovereign default when the sovereign breaks the contract, or when the sovereign "tenders an exchange offer of new debt with less favorable terms than the original issue" (Beers and Chambers 2006, Standard and Poor's). In addition, Hatchondo et al. 2007 consider a "technical" default as an episode in which the sovereign makes a restructuring offer that contains terms less favorable than the original debt. Further, Kulatilaka and Marcus 1987 state that sovereign default occurs when the present value of consumption under default first exceeds the present value given continuance of debt service. Andrade 2009 argues that sovereign default occurs after bad endowment shocks and has negative implications for subsequent economic growth.

Reinhart and K. Rogoff 2009 summarize four reasons why the government of a country go to sovereign crisis, and tend to default:*(i)* the external and domestic debt of government highly increase; *(ii)* Banking crisis; *(iii)* Hyper-Inflation [1] and *(iiii)* Currency crashes [2].

We will proceed by explaining the two types of debt: domestic and external debt. There are several approaches to determine the external debt and the domestic debt. The first approach is based on currency of issued debt, i.e. foreign-currency debt is considered external debt, and local-currency debt is domestic debt. But, the limitation of this approach is that in reality some countries that issue the foreign-currency debt in the internal market, and issue domestic-currency debt in the international market. The second approach is based on the residence of the creditor, i.e. foreign-currency debt comes from non-residents debt (Panizza

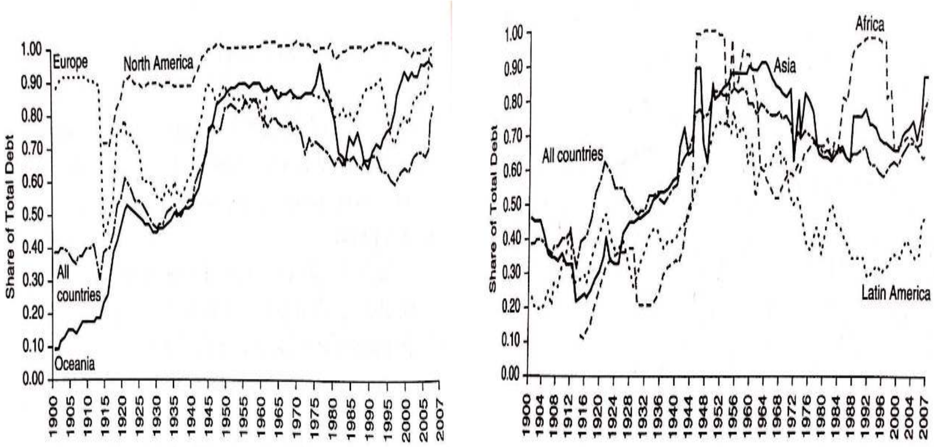
1. Hyper-Inflation is inflation rate of 40% per month.
2. Currency crashes: A currency crash is the final diver of sovereign risk, when a country is in a state of default, the exchange rate has an annual depreciation of 15% and more.

(2008), BIS[3]). Reinhart and K. Rogoff 2009 show that creditors often determine all debt's terms of the debt contracts.

The history of default on the domestic and external debt is rich. Generally speaking, a government can choose to default on external debt or domestic debt. It is noteworthy that not only the external debt is dangerous, because the domestic sovereign debt is enormous, and default on domestic debt is more complex than external debt. In the paper of Reinhart and K. S. Rogoff 2011, the domestic debt accounts two-third of total public debt from the period 1914 to 2010, as Figure 1.1 shows. Government's incentives default on domestic debt will lead to inflation or hyperinflation, i.e. Argentina's default from the year 1824 until 2001, there are two defaults on domestic debt, one in 1824 and the other in 1999, also in 2001 Argentina defaults on external debt. If a government is hesitating to default on domestic debt because of inflationary consequence, then it can default on external debt.

Reinhart et al. 2003[4] showed that during the 16th-19th century, European countries did default many times (e.g. Germany did six defaults, France did eight defaults, Spain did thirteen defaults, Portugal did six defaults and Greece did four defaults). To add, in the 20th-21th century, the world economic situation is always highly volatile, there are eighty-four events of sovereign default from 1975 to 2002

3. Bank for International Settlements
4. Table 2 in their article



(a) (b)

Source : The League of Nation, the United Nations, cite from Reinhart and K. Rogoff 2009

Figure 1.1: Domestic public debt as a share of total debt: Advanced economic (a), Emerging market economies (b), 1900-2007

according to Standard and Poor's. Tomz and Wright 2013 show two-hundred-and-fifty sovereign defaults by 106 countries between 1820 and 2004.

A timeline of sovereign default history presents the following:

— The beginning of the emerging market economies default in 1930s and the debt crisis of the 1980s, 1990s: Mexico's default in 1983 and in 1994, Brazil's financial crisis in 1998 and in 2002, and Uruguay's default in 2002,

— the debt crisis of the 1990s in Eurasia (Thailand's crisis in 1997 and Russian's crisis in 1998),

— the financial crisis in United State in the 2000s,

— the largest default in Argentina in 2002 (defaulted on $82 billions of external debt),

— the sovereign default in European countries in recent years.

1.2 The cost of sovereign default

Defaults are costly both to the creditors and the debtors. Andrade and Chhaochharia 2011 define that the cost of sovereign default is equal to the sum of a long-run increase in the cost of corporate equity capital and a long-run reduction in the average growth rate of corporate earnings following sovereign default. Their results show that the cost of sovereign default is 5.1 % for Greece, Ireland, Italy, Portugal, Spain from the period 2006 to 2010.

Borensztein and Panizza 2008 present four possible costs of sovereign default: loss of reputation, reductions in trade, costs to the domestic economy and political costs. They conclude that the cost of sovereign default is significant, but short-lived (not significant after 1 year).

First cost is the cost of reputation, i.e., a government borrows easily money from international capital markets if it has a good reputation. In addition, the reputation influences credit ratings and also interest rate spread. Borensztein and Panizza 2008 show that a default has a direct negative impact, short-live on credit rating (1 to 3 years): the sovereign spread increases 250 to 400 basis points in 2 years after the default. But these effects are rather short-lived (not statistically significant after two or three years).

Second cost is reductions in trade, i.e., the possibility of trade sanctions (J. Bulow and Rogoff 1989). Borensztein and Panizza 2008 find a essential trade impact on sovereign default caused by a decline in trade credit during the four years following the default by using industry-level data, but these effects are also short lived (only last two to three years). Reinhart et al. (2003) and Sturzenegger and Zettelmeyer (2006) also emphasise that the costs of defaulting on external debt can be significant for a country's trade.

Third cost is costs to the domestic economy: sovereign defaults have a direct impact on growth (Herndon et al. 2013; Borensztein and Panizza 2008). Herndon et al. 2013 [5] find that the economic growth has just reduced by about 2.2 % when a country has the public debt/GDP ratio above 90 %. Borensztein and Panizza 2008 display that the relationship between the output growth and default is negative in the year of default, i.e., the growth rate decreases by 2,5 %. However, they find no significant growth effect in the years that follow the default episode and the economic costs are not large, the reasonable is last cost below.

Last cost is political costs: all sovereign defaults was recovery its economic by using currency devaluation as IMF requests South-east Asian countries to devalue its currency in the financial crisis (1997). This politic has been revived theses South-east Asian country by exports through devaluating own fiat currency by

5. He finds an error of a famous article of Reinhart, Carmen M., and Kenneth S. Rogoff. (2010) "Growth in a Time of Debt" *American Economic Review, 100(2): 573-78.* Two economist find the economic growth has just reduced about 1%

30-50 % (Borensztein and Panizza, 2008).

1.3 Three main approaches of sovereign default

This section reviews three predominant approaches that evaluate the sovereign default risk. The first approach is the structural model based on the pricing option; the second approach is the econometric models which determine the sovereign default risk proxies by the macroeconomic fundamentals; and finally, the dynamic stochastic model.

Before presenting these approaches, Table 1.1 shows the list of sovereign default risk indicators. The definition of each indicator can be seen in the following section.

Sovereign default risk indicator	Authors
Sovereign default probability	Mellios and Paget-Blanc 2006; Gray et al. 2007; Souto et al. 2007; Karmann and Maltritz 2009; François et al. 2011; Jeanneret 2008, 2013
Sovereign CDS spread, Sovereign CDS premia	Chan-Lau 2003, 2006; IMF-Report 2013
Sovereign credit spread, Sovereign yield spread	Hernandez-Trillo 1995; Baek et al. 2005; Hilscher and Nosbusch 2010; Ramos-Francia and Rangel 2012
Sovereign bond, Emerging Market Bond Index	Ferrucci 2003; Petrova et al. 2010; Rowland and Torres 2004; Jaramillo and Tejada 2011
Sovereign credit rating	Rating Agency

Table 1.1: Sovereign default risk indicators list

In this thesis, we propose four methods to determine four indicators of the sovereign default risk: the sovereign default probability, the sovereign CDS spread, the sovereign credit spread and Emerging Market Bond Index Plus (EMBI+).

1.3.1 Sovereign default risk via the structural model

How can sovereign default risk be modelled ? There are many papers about the structure model of sovereign default. Sovereign default model is developed from the corporate credit risk model. The original corporate credit risk model began with Merton's credit risk model (Robert C Merton 1974) based on the option pricing theory of Black and Scholes 1973 under the perfect market assumption [6].

Suppose at time T, a firm has an asset A_T that is financed by equity E_T and zero-coupon debt D_T, represented by the following formula: $A_T = E_T + D_T$. The market value of the firm's asset dynamics A_T follows a Geometric Brownian Motion:

$$\frac{dA}{A} = \mu dt + \sigma_A dW \tag{1.1}$$

where μ, σ are the drift and volatility of the asset.

The Merton's credit risk model proves that corporate debt can be interpreted as a short Put Option on the firm value, and corporate equity interpreted as a Call option. Corporate default occurs when the firm value falls below its contractual debt obligations. The outputs of this model calculate the firm's asset value and

6. This assumption will interpret in chapter 2 of this thesis

asset volatility by using information of firm's liabilities on the firm's balance sheet. This model is also called Contingent Claims Analysis (CCA) model, and this was improved by Black and Scholes 1973, Longstaff & Schwartz (1995), Kealhofer-Merton-Vasicek (KMV,2000) and commercialized by Moody's.

This idea was transposed from firm level to the sovereign level with extension and modification. The sovereign default risk model was developed by Gray et al. 2007; Karmann and Maltritz 2009; Souto et al. 2007; François et al. 2011; Jeanneret 2008, 2013.

Gray et al. 2007 applied sovereign CCA balance sheet which interlinks balance sheet of government and authorities to calculate the value of sovereign asset and sovereign asset volatility. They based on perfect market assumption and added one principal idea that supposed the sum of domestic currency debt plus monetary base as sovereign equity. The goal of this model is to find the sovereign asset that will be used to pay its public debt. Gray et al. 2007 applied this model for Brazil, Turkey, Korean, Mexico, South Africa, Philippines in the period from 2002 to 2005. Their results show risk-neutral default probability that is compared to CDS spread (5-years of CDS spread for Brazil, and 1-year of CDS spread for the other countries) on sovereign foreign-currency debt to valid their model. Gray and Jones 2006; Gapen et al. 2008 show that the sovereign default probability has a high correlation with sovereign spreads 5-year.

Souto et al. 2007 use the CCA method and the implied volatility of forward exchange rate value in order to find the change of loan losses value in the main economic sector for Turkey in the period 2001-2006. Their results reveal that when interest rates and its volatility decrease, the trend of default probability and credit spreads decline.

Instead of indirect calculation of sovereign asset value through sovereign equity, Karmann and Maltritz 2009 focus on how to calculate directly sovereign's ability-to-pay (not "willingness-to-pay"), as sum of all foreign exchange reserves and the discounted steady state capital flow of balance trade, and using implicit volatility technique to find annual default probability. Their model was applied for 17 emerging markets [7] in the 1994-2002 period [8]. The authors used Quadratic Probability Score (QPS) to valid this model.

Default Probability Equation in Structural Model

Under the CCA model, Gray et al. 2007; Karmann and Maltritz 2009; Souto et al. 2007; François et al. 2011 define the default as an event that occurs when

7. Argentina, Brazil, Chile, China, Colombia, Ecuador, Indonesia, Malaysia, Mexico, Peru, Philippines, Poland, Romania, Russia, South Africa, South Korea, Turkey, Venezuela

8. The country sample and time period are determined by the availability of market data: Argentina (missing value in 1996,1997,2002), Brazil (missing value in 1994 to 1996,1999 to 2002), Chile (missing value in 1994 to 1999), Colombia (missing value in 1994 to 1996 and 2000 to 2002), Ecuador (missing value in 1994 to 1997, 2000,2002), Indonesia (missing value in 1995,1996, 1998 to 2002), Mexico (missing value in 1994,1996), Peru(missing value in 1994 to 1999), Philippines(missing value in 1994 to 1996), Poland (missing value in 1994 to 1997), Romania (missing value in 1994 to 1997), Russia (missing value in 1994, 1999 to 2001), South Africa (missing value in 1994 to 1997), South Korea (missing value in 1994 to 2001), Turkey (missing value in 1994 to 1997, 2001,2002), Venezuela (missing value in 1994 to 1997)

$A_t < D_t$, and the neutral-risk default probability[9] $\mathcal{P}$ is computed by:

$$\mathcal{P}(A_t < D_t) = \mathcal{N}(\quad d_{2,r}) = \mathcal{N}(\quad \frac{Ln(\frac{A_0}{D_t}) + (r \quad 0,5\sigma^2)T}{\sigma\sqrt{T}}) \tag{1.2}$$

There are various definitions of the variables in equation (1.2), e.g: A_t is called sovereign asset (Gray et al. 2007) or it is called ability-to-pay (Karmann and Maltritz 2009); D_t is distress barrier, or total public debt or external debt or obligation government debt; r risk-free interest rate; σ is volatility of the A_t process; T is maturity.

Default point

For the structural model, there must exist a default point/default threshold to calculate default probability. Borensztein and Panizza 2008 show "default point" should be the point at which cost of servicing debt is higher than cost of incurred restructure in the contractual terms. Kulatilaka and Marcus 1987 assume nation output (GDP) as continuous-time stochastic to find timing decision of strategic default. They called a critical value as a default point at which *"the present value of consumption under default first exceeds the present value given continuance of debt service"*. Gray et al. 2007 use the definition of the default barrier of De Servigny and Renault (2007) who used the ratio between long term foreign currency debt and short term foreign currency debt to define the default barrier. Default barrier

9. We can see the proof more detail in the chapter 2 of this thesis

is equal to foreign currency debt in short term plus a half of foreign currency debt in long term. But Karmann and Maltritz 2009 use total public debt as default point.

Model's Limitations

Because of the Merton's model based on perfect market assumptions, the Merton's model has four main restrictions as follows:

— The default can occur only at maturity date of debt.

— There is a constant risk-free rate during tested period.

— The asset volatility is constant during tested period.

— There is fixed default point that is equal to total debt.

There are some papers that try to improve theses limitations in corporate level: *The first extension* is presented by Black and Cox (1976) relating the default time. Precisely, the default may occur at any time before maturity if the firm's asset value in this moment goes bellow a deterministic barrier, called *"safety convenants"*, depending on time. In this model, the shareholders receive continuous dividend payments (κ is payout ratio) which are proportional to the value of firm's assets (A):

$$\frac{dA}{A} = (\mu \quad \kappa)dt + \sigma_A dW \tag{1.3}$$

The "safety convenants" give the firm's bondholders a right to force the firm to bankruptcy or reorganization if the firm's asset value bellows a standard deterministic barrier which is computed by: $K(t) = Ke^{\;\vartheta(T\;\; t)}, t \in [0, T]$.

The default probability in the Black & Cox's model is calculated by:

$$\mathcal{P} = \mathcal{N}(h_1) + e^{\theta}\mathcal{N}(h_2) \tag{1.4}$$

where $\theta = 2\{(\mu \quad \frac{\sigma_v^2}{2})ln\frac{K}{V_0}(\frac{1}{\sigma_v^2})\}$;
$\mathcal{N}(h_1) = \dfrac{ln\frac{K}{e^{\mu}TV_0} + 0.5\sigma_v^2 T}{\sigma_v\sqrt{T}}$ and $h_2 = \mathcal{N}(h1) \quad \sigma_v\sqrt{T}$.

Although the Black& Cox's model corrects a strong hypothesis of the Merton's model. In deed, the default can occur at any time before maturity. Nevertheless, this model reminds not realistic since it is based on strong hypotheses of the Merton's model.

The second extension is presented by Vasicek's model. This model describes the evolution of interest rate (r_t) that follows a process: $dr_t = a(b \quad r_t)dt + \sigma dW$, where a is the speed of reversion and b is the long term mean level.

The third extension is presented firstly by Heston 1993; Heston and Nandi 2000 who show a stochastic volatility process by using GARCH model. In this model, he assumes a asset followed:

$$\frac{dA(t)}{A} = \mu dt + \sqrt{\sigma(t)}dW_1(t) \tag{1.5}$$

and the volatility follows an Ornstein-Uhlenbeck process:

$$d\sqrt{\sigma(t)} = \quad \beta\sqrt{\sigma(t)}dt + \delta dW_2(t),\ W_1(t) \text{ has correlation } \rho \text{ with } W_2(t).$$

Based on the Heston 1993; Heston and Nandi 2000 model, Fouque et al. 2008 develop a model of multi-factor stochastic volatility. The stochastic volatility models of Heston 1993; Heston and Nandi 2000; Fouque et al. 2008 solve a strong hypothesis of constant volatility in the Merton's model.

The detailed calculation of asset value and the default probability can be seen in the original article of Vasicek (1977); Heston 1993; Heston and Nandi 2000; Fouque et al. 2008.

But theses extended models are difficult to apply in the sovereign level because we cannot aggregate asset value of all components in the economy.

1.3.2 Sovereign default risk via econometric models

The second approach of sovereign default is the econometric models. This section aims at providing an overview of the determinants of sovereign CDS spread, sovereign credit spread and the EMBI+ by the macroeconomic fundamentals.

Sovereign CDS spread

Before defining the sovereign CDS spread, we present briefly the CDS contract, the relationship between the CDS and the default probability, and its application to evaluate the sovereign default probability.

Credit Default Swap (CDS) is a credit derivative contract: a buyer of CDS, or protection buyer (e.g. a bank), purchases a CDS contract against the event of default and will pay a premium, that is called *CDS spread*. If an event of default occurs, an investor has to compensate the protection buyer for the loss. In other words, CDS is a form of insurance to protect what the borrowers are unable to repay. In general, CDS is used to insure the bonds issued by a firm or a government. Maturity for corporate issuers is 5-year, and its is from 1 to 10 years for sovereign issuers. The CDS spread is expressed in base point, 100 basis points represent 1%. For example: in 26/9/2008, the sovereign CDS spread in 5-year of Brazil is 167.06 basic point (source: Reuters). If the protection buyer wants to insure 10 millions dollars, he must pay 835300 dollars in total, or 41765 dollar in quarterly during five years. Thus, a greater CDS spread is associated with increasing bond risk.

Chan-Lau 2003, 2006 explains the relationship between the CDS spread and the sovereign default probability. The default probability can be recovered directly and can be predicted from the CDS spread. In fact, we assume a 1-year of CDS contract. The protection seller has an *expected loss*, EL, equal to: $EL = p(1 \quad RR)$; where p is the default probability, and RR is the expected recovery rate at default. The recovery and default rate are assumed to be independent. The CDS spread, S should be equal to the present value of the expected loss because it is a premium against default:

$$S = \frac{\mathcal{P}(1 \quad RR)}{1 + r} \tag{1.6}$$

where r is the risk-free rate. If we known the CDS spread, the recovery rate and the discount factor, we can calculate directly the default probability $\mathcal{P}$.

Sovereign credit spread (SCS)

We must distinguish between the *sovereign credit spread* and the *sovereign CDS spread*. The sovereign credit spread (or called sovereign yield spread) is the differentials between yields on risky debt and those on what might be considered risk-free government bonds (Remolona et al. 2007). The yield of risk-free government bond is usually the yield of US bond, and the yield on risky debt is usually a emerging country's bond issued by the government. The sovereign credit spread is computed in equation (1.7):

$$SCS = y \quad r \tag{1.7}$$

where y is the yield to maturity on the risky debt and r is the risk-free interest rate. If yield spread increases, the market is forecasting a greater risk of default which implies a slowing economy (Simkovic and Kaminetzky 2011).

The relationship between the yield spread (YS) and default probability is given by: $YS = \dfrac{EDF * LGD}{1 \quad EDF}$, where EDF is the Expected Default Frequency, LGD is the Loss-Given-Default. As this equation indices, an increase in the Yield Spread suggests either an increase in the Expected Default Frequency or an increase in the Loss-Given-Default.

Emerging Market Bond Index Plus

The final indicator that is presented in this section is the *Emerging Market Bond Index Plus (EMBI+).* According to JP-Morgan 2004, the EMBI+ is a JPMorgan's index indicating total return for liquid sovereign debt in emerging markets as an indicator of measure for sovereign default risk.

Determinants of sovereign risk proxies by the macroeconomic fundamentals

We begin by reviewing the literature on the determinants of sovereign risk proxies by the macroeconomic fundamentals.

Hernandez-Trillo 1995 assumes that a government tries to maximize national product that is used to repay its loan, and the government decides to default on its loan. This model emphasizes on factors affecting the sovereign default probability: the degree of openness, international reserves and the risk-free interest rate. Further, he creates a spread index over LIBOR[10] and debt service ratio to determine the sovereign default probability. The sovereign default probability is

10. London Interbank Offered Rate is short term interest rates, as the primary benchmark around the world

explained by a function of the degree of openness; the ratio between the official exchange rate and the black market exchange rate and international reserves. His result explains for 33 debtor countries where liberalization policies decrease the default probability by both raising the GDP and increasing openness. This model displays a negative effect of international reserves on the default decision. This paper present only a theoretical model of default probability without empirical results.

Cantor and Packer 1996 use a country's ability and willingness-to-service its debt as the explained variables for a panel of developing countries. They find six variables affecting the sovereign credit rating which are per capita income, GDP growth, inflation rate, external debt, default history and an economic development indicator.

More recently, Ramos-Francia and Rangel 2012 estimate the relationship between the sovereign yield spread (explained variable) and the macroeconomic fundamentals in the period from January 2000 to December 2009. They create a sovereign yield spread index as the difference between the yields on long term government bonds and the yield on 10-year US Treasuries for the developed markets [11], and EMBI spreads is for the emerging markets [12]. The macroeconomic fundamentals variables are represented by inflation rate, economic growth, fiscal,

11. Canada, England, France, Germany, Greece, Ireland, Italy, Japan, Portugal, Spain, Sweden, and Switzerland

12. Brazil, Chile,Colombia, Czech Republic, Hungary, Indonesia, Korea, Malaysia, Mexico, Peru, Philippines,Poland, Thailand, and Turkey

current account deficits, international reserves and nominal exchange rate variations. These results explain that international reserves and exchange rate appreciations are associated with lower default risk in emerging markets. In addition, the inflation rate increase come with higher sovereign spreads, real growth rate has negative effect on sovereign default risk. The impact of exchange rate variations on the sovereign default is also found in J. I. Bulow and Rogoff 1988; Mellios and Paget-Blanc 2006. They argue that the exchange rate variations have a direct impact on a country's terms of trade, which may affect the ability of the country to generate dollar revenue and make payments on its external debt.

Baek et al. 2005 show the link between sovereign risk represented by Brandy bond yield spread, and three principal explanatory variables: *solvency variables* represented by real GDP growth rate, total external debt to GDP ratio and government budget balance to GDP ratio, *liquidity variables* represented by international reserves to import ratio and current account balance to GDP ratio, and *economic stability variables* represented by inflation rate and changes in the real exchange rate by using time-series cross-sectional equation with fixed effect. An empirical studies for Argentina, Brazil, Mexico, the Philippines and Venezuela for the period from 1992 to 1997 found that liquidity, solvency and economic stability variables are significantly affecting the market premium of country risk.

Georgievska et al. 2008 provide the Bayesian approach to study the link between the sovereign rescheduling probability and three classified variables explaining sovereign default: total debt to GDP ratio and Export to GDP ratio represented solvency variables; international reserves to GDP ratio expressed liquidity variable; currency account balance to GDP ratio and imports to GDP ratio variables represented macroeconomic variables for a panel of 124 emerging countries during the 1981-2002 period.

Pan and Singleton 2008 focus on the term structure of sovereign CDS spreads, and pricing sovereign CDS contracts. An empirical result for Mexico, Turkey, and Korea in March 2001 until the beginning of August 2006 period show that risk neutral intensities and loss rate describe the best CDS data. Longstaff et al. 2011 analyse the sovereign CDS spread into default risk and risk premium by using the intensity model. They find that the sovereign CDS spread are driven by global macroeconomics. In addition, Hilscher and Nosbusch 2010 examine the effect of macroeconomic variables on probability through yield spread by using a linear regression. He detects the volatility of term of trade that is significant with yield spread.

IMF-Report 2013 introduces the determinants of the CDS spread by regressing this latter on various economics and financial explanatory variables. The debt-to-GDP ratio and GDP growth rate would be expected to increase the spread, whereas international reserve would reduce it. This report suggests global or region-specific explanatory variables such as VIX (S&P 500 index), global equity return (1-month US Treasury) and Funding cost (3-month LIBOR-OIS) that have impact on the CDS spread.

These regressions take into account the influence of these explanatory variables to the sovereign default proxies over a specific period, and do not examine the effect in the long-run and short-run. In order to improve these gaps, some papers use the panel cointegration technique by Pooled Mean Group to estimate the long-run effect of the macroeconomic fundamentals on the EMBI+ (Ferrucci 2003; Petrova et al. 2010; Poghosyan 2012). The Pooled Mean Group model is based on Autoregressive Distributed Lag (ARDL) model by assuming the existence of long-run equilibrium. The error correction coefficient must be negative and significant. More detailed, Ferrucci 2003 tests 11 emerging countries from the period 1997 to 2002 in order to determine the short and long-run effects of the EMBI+, EMBI Global. His work finds the external liquidity conditions that are important factor of spreads market. Moreover, Petrova et al. 2010 try this method and fixed effect for a panel of 14 emerging markets in a long period from 1997.Q1-2009.Q2. They use two groups of explanatory variables: Macroeconomic variables referring to the external debt/GDP [13], interest payments on external debt/reserves, short-term debt/reserves, external debt amortization/reserves, fiscal balance/GDP, current

13. They use an interpolation technique in order to convert the annual external debt to quarterly data

account balance/GDP, trade openness; Financial variables concerning the financial stress index, risk-free rate, U.S. 3-month Treasury bill rate, 10-year government bond yield, and volatility index VIX (see also Min 1998).

Rowland and Torres 2004 use the random-effects Generalized Least Squares regression for a panel of 16 emerging markets from 1998 to 2002. They find out that economic growth rate, debt-to-GDP ratio, reserves-to-GDP ratio and debt-to-exports ratio are significant to explain the EMBI+ of the studied entities. Furthermore, Gupta et al. 2008 explain the sovereign bond spreads by opting to two-stage least squares and Generalized Method of Moments (GMM) for a panel of 30 emerging market economies from 1997 to 2007. Their paper highlights the fiscal variables that are more essential and have a larger impact on EMBI. Jaramillo and Tejada 2011 study the fixed effect for a panel of 35 emerging markets in the period 1997 to 2010 indicating the investment grade status reduces spreads by 36 percent of bond spread.

In summary, the macroeconomic fundamentals long-run and short-run effects on EMBI+ in these previous papers, are done without examining the asymmetric effects (which effects are more important). Therefore, these gaps will open a path of research in this dissertation.

We can see the summary of the principal empirical studies of the sovereign default risk by using the technical econometric in Table 1.2:

Explained variable	Explanatory variable	Method	Country	Source
Sovereign rescheduling probability	solvency variables(1), liquidity variable(2); macroeconomic variables (3) [a]	Panel logit + Bayesian approach	124 emerging countries	Georgievska et al. 2008
Brandy bond yield spread	solvency variables(1), liquidity variables(2), economic stability variables(3) [b]	cross-sectional with fixed effect	Argentina, Brazil, Mexico, the Philippines and Venezuela	Baek et al. 2005
CDS spread	various economics(1) and financial explanatory variables (2) [c]	linear regression	many countries	IMF-Report 2013
Sovereign yield spread, EMBI	inflation, economic growth, fiscal and current account deficits, international reserves, and nominal exchange rate variations	country specific fixed effect	26 countries of emerging, developed countries,	Ramos-Francia and Rangel 2012
country's ability, willingness-to-service its debt	per capita income, GDP growth, inflation rate, external debt, default history and an economic development indicator	linear regression	developing countries	Cantor and Packer 1996
default probability	per capita income, government income, real exchange rate changes, inflation rate and default history	Logistic regression + Wald test	10 emerging countries	Mellios and Paget-Blanc 2006
yield spread	volatility of term of trade	linear regression	Latin America, Africa, Eastern Europe, Southeast/Middle East Asia	Hilscher and Nosbusch 2010

Table 1.2: Summery of empirical econometric studies on the sovereign default risk

a. (1):total debt/GDP; Export/GDP; (2): international reserves/GDP; (3): currency account balance/GDP; imports/GDP

b. (1):real GDP growth rate, total external debt/GDP, government budget balance/GDP;(2):international reserves/imports and current account balance/GDP ;(3):inflation rate and the change in the real exchange rate

c. (1):GDP growth rate, debt/GDP and international reserves; (2):S&P 500 index,1-month US Treasury,3-month LIBOR-OIS

1.3.3 Sovereign default risk via the dynamic stochastic model

The last approach of sovereign default is shown by the dynamic stochastic model & equilibrium model. This section focuses on reviewing some stochastic models and equilibrium model on measuring and analysing the sovereign credit spread with default policies.

There are several papers studying a small open economy under incomplete market and microeconomics theory with relationship of sovereign income, sovereign consumption and sovereign utility function. Alfaro and Kanczuk 2005 assume that a representative borrowing sovereign being a function of sovereign's preferences function is[14]: $U = \mathbb{E}\sum_{t=0}^{\infty}\beta^t u(c_t)$, where c_t is consumption, $u(c) = \dfrac{c^{1-\sigma}-1}{(1-\sigma)}, \sigma > 0$, and this sovereign has two assets, one is stock of each type of debt and income of the economy. Alfaro and Kanczuk 2005 present two types of country: "good[15]" and "bad"[16], and suppose that the capital and debt are fixed, country cannot save or dis-save. They show that the existence of Markov perfect equilibrium when "good sovereign" does not default after a bad shock. They also find that the welfare is higher in equilibrium for which there is never default.

Alfaro and Kanczuk 2009 extend their model in 2005. They present a dynamic

14. See also in Arellano and Ramanarayanan 2012
15. *"Good sovereign may or may not choose optimally to default on their international commitmments"*
16. *"Bad sovereign are extremely impatient and choose to default at any time independently of the state of the economy"*

equilibrium model to optimal reserve, and the role of exchange rate. They clarify that the reserve accumulation does not play an important role, and the optimal policy does not hold reverse at all. In addition, the interaction between fiscal policy and sovereign risk appears in Cuadra et al. 2010; Hatchondo et al. 2012.

Yue 2010 creates a model with country's preference to study sovereign default, debt renegotiation, interest rates and debt recovery rates. Arellano 2008 studies the interaction between GDP, consumption, foreign debt and interest spread. Yue 2010; Arellano 2008 prove the existence of default and debt reduction in equilibrium of incomplete market. Arellano 2008 assumes that the government chooses to default and accepts to pay a default cost, and he demonstrates that the cost of sovereign default is significant with default and hight interest rate. His results illustrate that default probability and interest rate depend on the incentive for repayment,i.e., default incentive. Eaton and Gersovitz 1981 show that the government chooses to repay its debt because the default reputation would make it lose the access to credit in the international market. Developing this idea, J. Bulow and Rogoff 1989 study the default reputation that excludes from the international market.

More specifically, Yue 2010 focuses on the debt recovery rate when a country goes to default. In fact, when a country gets a bad shock, the government negotiates and bargains with its lender to reduce its debt. She finds that the expected recovery rate is smaller according to debt renegotiation and decreases with indebtedness. Another important & interesting result: a lowly-indebted country may choose not to default even when there is a debt renegotiation because the cost of financial exclusion will be higher than the benefit of getting a debt reduction.

Arellano and Ramanarayanan 2012 show that a sovereign default occurs in low-income, high-debt times, on the total outstanding debt in long term and short term. The country will decide to optimize debt, maximize utility and focus on maturity composition of debt. In their empirical analysis for Argentina, Brazil, Mexico, and Russia in the period March 1996 and May 2004, the authors conclude that maturity of debt shortens in times of high spreads and downward-sloping spread curves. They indicate that when spreads are initially low, governments will issue long-term bonds more heavily and thus long-term spreads will be higher than short-term spreads. When the spread rise, maturity of bond issuances shortens and short-term spreads are higher than long-term spreads.

Several papers are based on the stochastic calculus, the Brownian movement and American pricing option in order to improve some limitations in the structural model.

Jeanneret 2008, 2013 generates *daily* sovereign credit spreads from endogenous sovereign debt and default policies. The government receives income taxes from the firms and uses them to repay its sovereign debt by assuming that the fiscal revenues of the government follow a stochastic process. The government defines the optimal debt level and default policy, which maximize the sovereign wealth that composes the present value of future fiscal revenue net of debt service plus incentive for debt issuance. Default policy maximizes the value of the economy minus the outstanding debt value. Sovereign default occurs when the sovereign fiscal revenues fall below an endogenous default boundary that depends on economic, optimal debt level. When default occurs, government and lenders will restructure the terms in the debt contracts and agree to reduce a fraction of debt and reduce a fraction of firm income level. His model explains the substantial daily variation in sovereign credit spread while the availability of economic data is in quarter and annual frequency.

Andrade 2009 uses also yield spreads on sovereign bonds, but the function of yield spread on sovereign bond is different with other papers, because he uses stock Price-Earnings (P/E) ratio and expected return as yield spread on sovereign bond. In this model, he supposed an emerging country whose an endowment as stochastic process and using specifies a *kernel-pricing* showed a measure of "country risk" as a negative regime change that is with a hostile renegotiation of the country's foreign debt. The empirical result is calibrated on Brazilian data from January 1998 to December 2007 based on EMBI+. He finds that when the sovereign yield spread increases, "the emerging market stocks tend to become more volatile in absolute terms, less volatile relative to sovereign bonds, and more correlated with sovereign bonds" by validating the consistence between the model's quantitative and qualitative predictions.

1.4 Conclusion

This chapter aims at presenting an overview of the sovereign default history, the causes of sovereign default, the default's costs, and the different approaches of sovereign default risk determinants.

We provided the knowledge of the sovereign default risk indicators and its proxies; such as the sovereign default probability, sovereign CDS spread, sovereign yield spread and Emerging Market Bond Index Plus. We highlighted theoretically the three main models of sovereign default with empirical evidences: the structure model, the dynamic stochastic model and the econometric models. We analysed the advantages and limitations of each approach.

To start, the structure sovereign default model is based on the pricing option and the sovereign balance sheet. The sovereign default risk is expressed by the sovereign default probability indicator. However, one of the limitations of this model is data availability, i.e., the data is only available on annual basis and for a short period of time. Consequently, it is difficult to test statistically the significance of the model. Hence, the structure model is only applied for Brazil and Turkey.

Secondly, the dynamic stochastic model is used to modelling the economic policies based on the stochastic calculus and the Brownian movement. Accordingly, researchers model the sovereign credit spread or the sovereign yield spread based on these policies, i.e., when the government encourages the trade to generate higher revenues in order to reimburse their debt; or when the government decides to issue the money, or when it negotiates to reduce debt. The aim of these models is compare the estimated indicator with observed one in order to confirm the consistency of the model.

Thirdly, the econometric models are most widely used in economic research field in recent years. Among these models, we can disclose the following: Generalized Method of Moments (GMM), Pooled Mean Group (PMG), Mean Group (MG) and cointegration tests. In these models, we focused on reviewing the determinants of sovereign CDS spread and EMBI+ by macroeconomic fundamentals which are represented by government's solvency, government's liquidity and macroeconomic situation.

Finally, this rich literatures suggest four propositions that will be explored in the next chapters.

CHAPTER 2

A structural model of sovereign default risk: Evidence from Argentina

2.1 Introduction

The volatility of the world economy is more complex and more difficult to forecast. The collapse and chained bankruptcy of the financial system caused the sovereign default of many countries that depends on *strong currencies*, like the U.S. Dollar. In fact, the financial crisis in Thailand (1997) derived from the default of large financial institutions and loss of its liquidity, together with the withdrawal of foreign investment in the country. In addition, globalization is one of the causes that lead to contagion crisis in Southeast Asian countries, such as Indonesia and Malaysia, followed by Russia and Latin American countries, for example, Brazil (2002) and Argentina (2001). Consequently, public debt management has become the first priority to stabilize the economy.

Credit risk models have been used in the lending activities of commercial banks. The original structural models began with Merton's credit risk model (Robert C Merton 1974) based on the option pricing theory of Black and Scholes 1973. The model allows calculating the value of a firm's asset and asset volatility by using information of firm's liabilities on the firm's balance sheet. This model is also called Contingent Claims Analysis (CCA) model, and this was improved by Black and Scholes 1973, Longstaff & Schwartz (1995), Kealhofer-Merton-Vasicek (KMV,2000) and commercialized by Moody's. This idea was transposed from firm level to country level to calculate the sovereign asset value and sovereign asset volatility. The sovereign default risk model was developed by Gray and Malone 2008 who use macroeconomic and the option pricing theory. More precisely, they applied sovereign CCA balance sheet which interlinks balance sheet of government and authorities. The sovereign default risk model has successfully been applied to some emerging countries, such as Brazil (Gray et al. 2007; Gray and Malone 2008) and Turkey (Souto et al. 2007).

This chapter is organized as follows. In the second section of this chapter, we review the Black & Scholes formula. In section 3, we present the Merton credit risk model; in section 4, we explain how to transpose from credit risk to sovereign default risk, and how to apply a sovereign CCA balance sheet model for emerging countries. In the next section, we show an empirical result for the case of Argentina for the period 1997-2009. We conclude in the last section.

2.2 The Black & Scholes Formula

In the trend of investment boom and globalization, the development of financial instruments is considered as one of the five pillars of stable growth in the U.S. economy. The new financial instruments on the financial market are derivative financial instruments that not only allow banks to prevent risks but also make a profit following arbitrage.

A derivative instrument is a contract between two parties that specifies conditions (especially the dates, resulting values of the underlying variables, and notional amounts) under which payments are to be made between the parties (Hull 2008).

One of those derivatives contracts is the option contract. This is a financial contract between two parties, the buyer and the seller, that gives the buyer the right, but not the obligation to buy/sell an underlying asset from the seller at a pre-determined price K, on or before pre-determined future time T. If the right is valid on the date T, but not before is called a European option, otherwise if the right is valid before the time T it is called an American option. In this chapter, we will only use European options contracts. There are two types of option contract: Call option and Put option.

The Black & Schole model is one of the fundamental concepts of modern financial theory. Developed in 1973 by Black and Scholes 1973, it is considered as a benchmark to determine the option price that has been used widely today. In 1997, Merton and Schole received the Nobel Prize in economics. This model includes the formula of Black & Scholes which gives the price of the European option.

Merton analyzed security price dynamics and asset dynamics by using a stochastic process where the stochastic process is a random process indexed by time. He used continuous time to price the security price/asset dynamic. There are two principal stochastic processes in continuous time that we use in this chapter: Brownian motion and Itô's process. Brownian motion is a stochastic process where the value of the stock may be positive or negative. Indeed, we have a variable X that follows a Brownian motion with expected rate of return (drift) μ and volatility σ given by: $dX = \mu dt + \sigma dW$

The second one is an Itô's process of X variable given by : $dX = \mu(t, X)dt +$

$\sigma(t, X)dW$. We have Itô's lemma of a function f(t,X)[1] by:

$$df(t,X) = [\frac{\partial f}{\partial t} + \frac{\partial f}{\partial X}\mu(t,X) + \frac{\partial^2 f}{\partial X^2}\sigma^2(t,X)]dt + \frac{\partial f}{\partial X}\sigma(t,X)dW \tag{2.1}$$

where dW is a Brownian process.

If $\mu(t, X) = \mu X$ and $\sigma(t, X) = \sigma X$ then the function $df(t, X)$ in equation (2.1) becomes $dX/X = \mu dt + \sigma dW$, this new function is named Geometric Brownian Motion (GBM). Therefore, the value of the underlying asset dynamics describes a GBM.

The Call option is one of three assets dynamics with risk-free interest rate and underlying risky asset in the continuous-time market, and the Call option follows an Ito's lemma process.

For an option pricing contract, R. C. Merton 1990 used several assumptions:

— There is a perfect market

  — There is no transaction cost, tax.

  — All participants in the market can lend and borrow at the same risk-free rate; This risk-free rate is exogenous and constant during the life cycle of the option.

  — There exists a sufficient number of investors; each investor believes that he can buy and sell assets at the desired amount.

1. $f(t, X)$ is at least twice differentiable in X and one differentiable in t

— It allows short-selling[2] of all assets

— There is no arbitrage opportunities (without risk).

— With an instantaneous risk-free rate r at any period, the price of a risk-free discount bond paying one dollar at time T in the future is $p(T) = exp(\quad rT)$.

— The trading of the securities is continuous.

— The value of the underlying asset follows a GBM written by: $dA = \mu A dt + \sigma A dW$; where: A is value of the underlying asset; μ is a drift; σ is volatility of the underlying asset; dW is a standard Gauss-Wiener process.

Under these assumptions, we review the Call, Put formula:

The Call option is a financial contract which gives the buyer the right, not the obligation, to purchase a security at a pre-determined price (strike price) K on the future date T. In return, the buyer is required to pay the seller a fee that is called call premium (p). The buyer of the Call option hopes that the price of underlying asset will rise in the future. If the stock price rises as expected, then the buyer will exercise this contract, since he has invested only a small fee. Otherwise, if the stock price is below the price K, we do not exercise the Call option contract because the pay-off is negative. The pay-off of a Call option is: $max(0, A \quad K)$ where A is the value of the underlying asset at the time T.

2. short-selling is the practice of selling borrowed securities when securities price down, hope that the price will down so that borrower can buy it back at a lower price to return the borrower to the lender.

We have the equation for the Call option price:

$$C = A\mathcal{N}(d_1) \quad Ke^{\ rT} * \mathcal{N}(d_2)$$

where $d_1 = \dfrac{Ln(\frac{A}{K}) + (r + 0,5\sigma^2)T}{\sigma\sqrt{T}}$ and $d_2 = d_1 \quad \sigma\sqrt{T}$; $\mathcal{N}$ is the cumulative standard normal distribution, r is a continuous risk-free interest rate, σ is volatility of the underlying asset, T is time.

We can see in Figure 2.1 below that: when the stock price fluctuates from 0 to K, the buyer does not exercise the Call option contract. The graph is represented by a line that is parallel with the horizontal axis from 0 to K. When the price is greater than K, the buyer will exercise a Call option contract. In this case, the graph is represented by the 45 degree line.

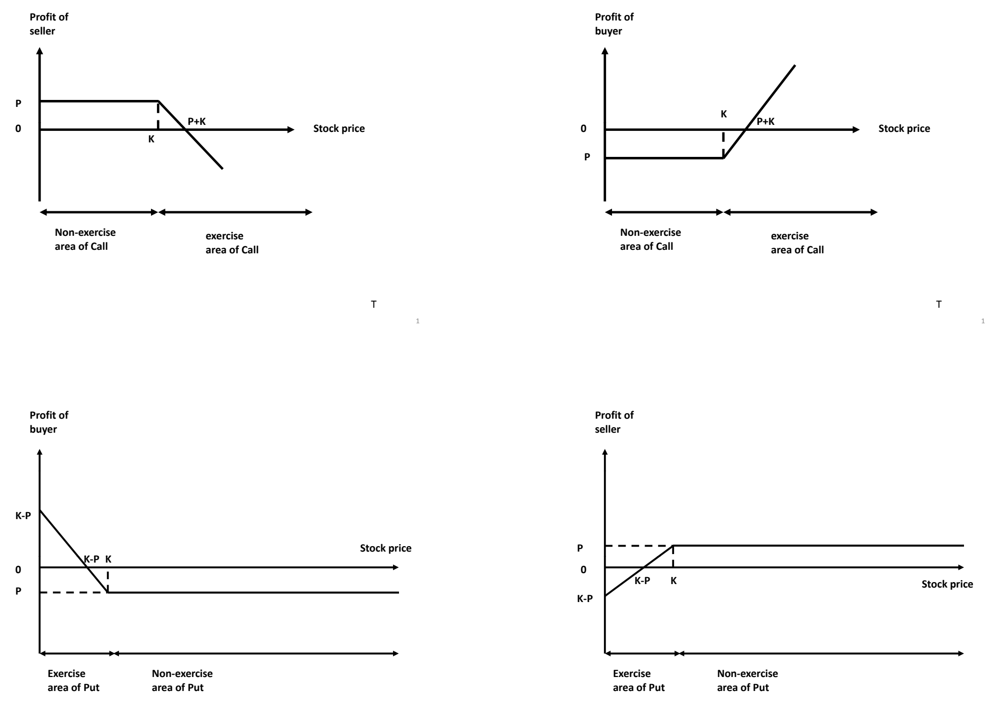
The put option is a financial contract that gives the buyer the right, not the obligation to sell a security at a pre-determined price (strike price) K on the future date T. In return, the buyer is required to pay the seller a fee that is called put premium (p). The buyer of the put option hopes that the price of the underlying asset will fall in the future. If the stock price falls as expected, then the buyer will exercise this contract, the buyer will benefit as he has to invest a small fee. Otherwise, if the stock price is greater than the prices K, we don't exercise the put option contract because the pay-off is negative. The pay-off of a put option is: $max(0, K \quad A)$ where A is the value of underlying asset at the time T.

We have the equation for the put option price:

$$P = \quad A\mathcal{N}(d_1) + Ke \ ^{rT} * \mathcal{N}(d_2)$$

where $d_1 = \dfrac{Ln(\frac{A}{K}) + (r + 0,5\sigma^2)T}{\sigma\sqrt{T}}$ and $d_2 = d_1 \quad \sigma\sqrt{T}$; $\mathcal{N}$ is cumulative standard normal distribution, r is continuous risk-free interest rate, μ is volatility of underlying asset, T is time.

In Figure 2.1 below: when the stock price fluctuates from 0 to K, the buyer exercises the put option contract, the graph line is represented by the 45 degree line. When the price is greater than K, then the buyer will not exercise put option contract, the graph is represented by the parallel line with the horizontal axis from 0 to K.



Source: Hull 2008

Figure 2.1: Profit of buyer/seller for Call/Put option

2.3 The credit risk model

Credit risk is a popular term which is used in the banking and finance sector. In fact, one of the main activities of commercial banks is lending activities which have always a credit risk. Credit risk is a risk in which a borrower will have no capacity to pay-off his debt at maturity. Default occurs when a debtor does not pay his debt at maturity. Or we can understand that debt default occurs when the borrower has not made a scheduled payment of interest or principal. Hence, the banks want to protect themselves against credit risk, so that they require generally that the borrower has a collateral asset (housing, stocks...) in order to access the credit market. At maturity, if the borrower does not pay-off its debt, the banks will process collateral assets for payment of debts. Thus, credit risk is an important factor we have to understand strongly. Simultaneously, banks might analyse, evaluate, manage this type of risk to avoid loss of liquidity and its default.

A powerful model to evaluate default risk is Merton's structural model (Robert C Merton 1974). This model was developed from assumptions of option pricing of Black and Schole (1973) described in the first section. Merton's model is based on the option pricing theory of Black and Scholes 1973 to explain the relationship between equity value and derivative option (Put, Call). The purpose of Merton's model is to quantify the asset value and asset volatility by using information on debt and equity, so that we can determine the probability of default of loans.

The Merton model for credit risk has two steps:

— Firstly, the Black & Scholes' equation for an European Call option is applied to estimate the value of equity.

— Secondly, the firm's equity is to estimate asset value and asset volatility.

Firstly: the Black & Scholes' equation for an European Call option is applied to estimate the value of equity.

This model is based on corporate balance sheet and structural capital. Suppose at time T, a firm has an asset A_T that is financed by equity E_T and zero-coupon debt D_T. The capital structure represents by the following formula: $A_T = E_T + D_T$

Asset	**Liabilities**
A_T	Equity E_T
	Zero-coupon debt D_T

Table 2.1: Firm's balance sheet

In the Merton model, he supposed that the market value of the firm's asset dynamics A_T follows the GBM:

$$dA = rAdt + \sigma_A AdW \tag{2.2}$$

or $\dfrac{dA}{A} = rdt + \sigma_A dW$

where: A, dA are respectively the firm's asset value and the change of asset value; μ_A, σ_A are the expected rate of return of the firm's asset value and its volatility; dW is a Wiener process.

In the original Merton's model, the default risk appears when the asset value (A_T) falls below the face value of all debt (D_T) at maturity ($T = 1$). A strong assumption of this model is that default only occurs at maturity. This assumption is like as a characteristic of zero-coupon bond where the investor receives one payment at maturity. The face value of all debt represents the promised payments of the debt. At maturity T, the firm will pay-off its debt, and there are 2 situations:

— If $A_T < D_T$, the asset of this firm is not sufficient to payoff its debt, so this firm will default at time T.

— If $A_T \geq D_T$, the firm will pay-off its debt to creditors at time T. The value of equity equals to assets minus debt, otherwise the equity value is equal to zero. The value of equity can be written as $E_T = max(A_T \quad D_T, 0)$.

This formula is related to the European Call option contracts and is the first step of Merton model. Indeed, we can explain this as follows: creditors hold a bond issued by a firm, we can assume that creditors have the right, not the obligation, to receive the bond of this firm. Applying option pricing theory, we exercise a Call option if the value of the firm's asset is greater than value of total debt (total debt is the strike price), otherwise if the value of a firm's asset is below the value of total debt, we will not exercise a Call option. So, the equity value (E) can be interpreted exactly as a Call option.

The value of Call price for equity is computed as:

$$E = A\mathcal{N}(d_1) \quad De^{\;rT} * \mathcal{N}(d_2) \tag{2.3}$$

Where $d_1 = \dfrac{Ln(\frac{A}{D}) + (r + 0,5\sigma^2)(T)}{\sigma\sqrt{T}}$; $d_2 = d_1 \quad \sigma\sqrt{T}$; A is the firm's asset value, D is total debt, r risk-free interest rate, σ is the firm's asset volatility, T is maturity.

Secondly: the firm's equity is to estimate the asset value and asset volatility.

We can apply the Itô's lemma for the Call price dynamics $C(t, A)$ on the value of firm's asset A:

$$dC(t, A) = [\frac{\partial C}{\partial t} + \frac{\partial C}{\partial A}\mu_A A + \frac{\partial^2 C}{\partial A^2}\sigma_A^2 A]dt + \frac{\partial C}{\partial A}\sigma_A A dW \tag{2.4}$$

The dynamics for equity follows a GBM process:

$$dE = \mu_E E dt + \sigma_E E dW \tag{2.5}$$

According to Black & Scholes equation, the delta for a Call is given by:

$$\Delta = \frac{\partial C}{\partial A} = \mathcal{N}(d_1) \tag{2.6}$$

where $d_1 = \dfrac{Ln(\frac{A}{D}) + (r + 0,5\sigma^2)T}{\sigma\sqrt{T}}$

Because we can consider the equity as a Call option, we combine formulas (2.4),(2.5),(2.6) for the standard Gauss-Wiener process dW factor to obtain:

$$\sigma_E E = \mathcal{N}(d_1)\sigma_A A \tag{2.7}$$

The outputs of this model find the implicit firm's asset value A and the firm's asset volatility σ_A by using 2 equation (2.3),(2.7). In these two equations, we know the equity value E, equity volatility σ_E , debt value D, interest rate r and maturity T.

$$\begin{cases} E = A\mathcal{N}(d_1) \quad De^{\ rT} * \mathcal{N}(d_2) \\ \sigma_E E = \mathcal{N}(d_1)\sigma_A A \end{cases}$$

Default Probability

From equation (2.2), the process of asset A_T at the time T can be calculated from the asset value at time 0, is written by:

$$A_T = A_0 \exp[(r \quad 0,5\sigma_A^2)T + \sigma_A \varepsilon \sqrt{T}] \tag{2.8}$$

where ε is the random component of a normal random variable $\mathcal{N}(0,1)$.

The probability of default occurs when the firm's asset value A_T is less than debt value D_T at maturity T. The debt value is the promised payments value that are the present value of the debts discounted at the risk-free rate.

The probability of default under the neutral-risk P is given by:

$$\mathcal{P}(A_T < D_T) \equiv P(lnA_T < lnD_T)$$

we have:

$$\begin{aligned} ln(A_T) &= ln(A_0) + (r \quad 0,5\sigma_A^2)T + \sigma_A \varepsilon \sqrt{T} \\ \mathcal{P}(lnA_T < lnD_T) &= Pr(ln(A_0) + (r \quad 0,5\sigma_A^2)T + \sigma_A \varepsilon \sqrt{T} < lnD_T) \\ &= \mathcal{P}(\quad \frac{Ln(\frac{A_0}{D_T}) + (r \quad 0,5\sigma^2)T}{\sigma\sqrt{T}} > \varepsilon) \\ &= \mathcal{P}(\quad d_{2,r} > \varepsilon) \end{aligned}$$

where $d_{2,r} = \dfrac{Ln(\frac{A_0}{D_t}) + (r \quad 0,5\sigma^2)T}{\sigma\sqrt{T}}$

Because the random component is normally distributed, $\varepsilon \sim \mathcal{N}(0,1)$, comparing with the above result, we can define the probability of default equal to value of $\mathcal{N}(\quad d_{2r})$.

For example:

Assuming that if we know the firm's equity value E=27.140 \$; D=393.835 \$; $\sigma_E = 0.254$ risk-free rate $r = 5$ %, $T = 1$. So we have four equations:

$$\begin{cases} 27.140 = A\mathcal{N}(d_1) \quad 393.835e^{\ \ 0.05} * \mathcal{N}(d_2) \\ 27.140 * 0.254 = \mathcal{N}(d_1)\sigma_A A \\ d_1 = \dfrac{Ln(\frac{A}{393.835}) + (0.05 + 0.5\sigma_A^2)}{\sigma_A} \\ d_2 = d_1 \quad \sigma_A \end{cases}$$

We find the firm's asset value A= 401.7674 \$, $\sigma_A = 0.2565$ and $d_2 = 0.573$; The default probability of this firm: $\mathcal{N}(\ \ d_{2r}) = 44.2582$ %.

2.3.1 The variation of default probability

In this section, we present the variation of default probability (DP) when distress barrier, risk-free rate, maturity vary.

We can see in Table (2.2), (2.3),(2.4): I set a fixed asset value equal to 100 \$; the distress barrier fluctuates from a very low value (9 \$) to a very high value (99 \$); risk-free risk varies from 5 % to 20 %; maturity varies from 1 year to 10 year.

V	D	r	σ_V	T	d_2	DP
100	75	0.05	0.4	1	0.6442	25.9721 %
100	75	0.05	0.4	5	0.1539	43.8831 %
100	75	0.05	0.4	10	-0.0097	50.3884 %
100	75	0.1	0.4	1	0.7692	22.0885 %
100	75	0.2	0.4	1	1.0192	15.4059 %

Table 2.2: Case 1: increasing r and T

The variation of default probability depends on the variation of the variable

V	D	r	σ_V	T	d_2	DP
100	99	0.05	0.4	1	-0.0498	51.9888 %
100	99	0.05	0.4	5	-0.1564	56.2168 %
100	99	0.05	0.4	10	-0.2292	59.0653 %

Table 2.3: Case 2: increasing D and T

V	D	r	σ_V	T	d_2	DP
100	9	0.05	0.4	1	5.9448	1.38343E-07 ($\approx$ 0) %
100	9	0.05	0.4	5	2.5244	0.5793 %
100	9	0.05	0.4	10	1.6664	4.7809 %
100	9	0.05	0.4	20	1.0106	15.609 %

Table 2.4: Case 3: decreasing D and increasing T

d_2.

We can resume the variation default probability in below:

— If D_T increases/decreases then DP will increase/decrease respectively.

— If A_0 increases/decreases then DP will decrease/increase respectively.

— If σ_A increases/decreases then DP will increase/decrease respectively.

— If T increases/decreases then DP will increase/decrease respectively.

— If r increases/decreases then DP will decrease/increase respectively.

2.3.2 Risk-neutral default probability and Actual default probability

In order to obtain the default probability under the actual risk Q, we replace the neutral-risk interest rate value r by actual interest rate value μ.

$$\mathcal{Q}(A_T < D_T) = \mathcal{N}(\quad d_{2\mu}) = \mathcal{N}(\quad d_2 \quad \rho_{A,M} S\sqrt{T}) \tag{2.9}$$

where: $\rho_{A,M}$ is correlation of implicit asset return and stock market return, S is Sharpe ratio.

The risk-neutral and actual default probability have concern with the risk-neutral expected return and actual expected return respectively. The risk-neutral expected return is a world where all investor/assets been risk-neutral. On the other side, the actual expected return is a real world. Evidently, the actual expected return is greater than the risk-neutral expected return, i.e., we argue that the investor does not want to invest for a risky asset if the expected return of this asset is less than the risk-neutral expected return.

The Girsanov 1960's theorem presented how to measure and to compare the risk-neutral default probability and actual default probability. According to this theorem, the risk-neutral default probability is greater than actual DP because the expected return μ greater than r (Gray and Malone 2008).

2.4 The structural sovereign default risk model

2.4.1 Motivation

From the financial crisis in Thailand (1997) with the collapse of the Baht [3], especially many credit institutions went bankrupt. This collapse led to depreciation of the value of local currency of Korea, Indonesia. Through oil, Russia was the next victim of the financial crisis: Russian currency was devalued and Russia announced its default and denied to pay its government debt to creditors. Facing with this situation, Brazil raised interest rates to 40 % in order to keep capital flow, but this scenario could not save Brazil out of the crisis [4]. Because these countries held a very large amount of U.S. government bonds, the sovereign default of emerging countries led to the decline of the world economic system. Therefore, measuring the sovereign default probability is very essential.

The idea of transposing Merton's model from the firm to the sovereign is to consider that the sovereign has two types of debts: a debt in local currency (for example, bills emitted by the central bank) and a debt in foreign currency. The government will always pay-off at first the debt in foreign currency, and the debt in local currency will only be paid-off if there is enough money.

Theoretically, the central bank will be able to create money to pay its govern-

3. Baht is the currency of Thailand
4. see Friedman 1999

ment debts in local currency. However, this way would stimulate inflation and is opposed to the goal of stabilizing the economy. As a consequence, harmonizing between the debt repayment schedule and economic stability is a difficult task for macroeconomic policy-makers.

The inputs data in Gray et al. 2007; Gray and Malone 2008 were 5-year US Swap rates as the risk-free rate, 5-year maturity, monetary base, local currency debt and foreign currency debt for an empirical case of Brazil. The output of their model showed that the Brazil's sovereign asset value arrives the default point in the Brazil's crisis period 2002-2003, and the Brazil's risk indicator had a high correlation with its sovereign spread. This result illustrated clearly the real Brazilian economy.

Souto et al. 2007 used the volatility value of forward exchange rate as implied volatility from FX-option. The principal objective is to find the loan losses value of the main economic sectors for Turkey by means of using the CCA model. They created some scenarios to find the change of sovereign asset value and its volatility on condition that economic indicators shift, such as the change of exchange rate, risk-free interest rate or stock market index.

The purpose of this section, is to bring some extensions of the Merton model, advanced by Gray and Malone 2008. That is a framework to compute the sovereign asset value and the sovereign asset volatility of emerging countries based on the option pricing theory by using information on sovereign liabilities.

2.4.2 Assumptions of the model

We consider an economy as a set of three interrelated sectors: the financial sector (banks), the non-financial (household and firms) and the sovereign sector (the combination between the government and monetary authority, also called the public sector). The extension of the Merton model is how to calculate the implicit sovereign asset value and its volatility.

The sovereign asset value is an unobservable variable because we cannot aggregate asset value of all components in the economy. In the actual market, only a few components can be observed; therefore, the aggregate value of all assets is not really easy to work with. The extension of Gray and Malone 2008 determined implicit sovereign asset and sovereign asset volatility by using the observed sovereign liabilities based on sovereign balance sheet.

There are three main assumptions in the extension of the Merton model:

— Assets follow a stochastic GBM process.

— The values of liabilities are derived from assets.

— Liabilities have a priority of debt: senior and junior. Foreign-currency debt is senior debt and this debt will be priority pay-off to creditors. Domestic-currency debt is junior debt that will be payed-off to creditors after the finishing payment of foreign-currency debt. For European countries (who use a common currency, the Euro), the debt is also usually in Euros, or strong currencies like the US Dollar, so it does not have a priority of debt. Therefore, this assumption imposes a limitation to the model when applied to European countries.

The sovereign balance sheet has two sides: assets and liabilities. The asset of monetary authorities include foreign reserves, credit to the government and others. The liabilities of monetary authorities are the monetary base, financial guarantees to the government, including guarantees to supply foreign currency to service the sovereign foreign-currency-denominated debt. The assets of the government are: net fiscal assets (including the seigniorage-tax inflation) and others. The liabilities of government are: credit to monetary authorities (including local currency debt held by the monetary authorities) and local currency debt held outside of the government and monetary authorities ... To simplify the model, we show the sovereign balance sheet:

Sovereign Assets	**Sovereign Liabilities**
	Foreign-currency debt
	Domestic currency debt + Monetary base

Table 2.5: Sovereign balance sheet

Sovereign liabilities are combined by two factors: foreign-currency debt and sum of domestic currency debt and monetary base. Foreign-currency debt is the debt of the public sector in foreign currency held by foreigners. Domestic currency debt is the debt of the public sector in domestic currency held by the private sector. The monetary base consists of currency in circulation, bank reserves (required bank reserves, excess reserves, vault cash). In banking, excess reserves are bank reserves in excess of the reserve requirement set by a central bank. They are reserves of cash in excess of the required amounts. Changes in base money correspond to changes in net foreign assets and net domestic assets. Governments borrow by issuing securities, government bonds (long-term) and bills (short term) or borrow directly from World Bank, IMF. The local-currency debt of the public sector is the debt that held by private sector (Gray and Malone 2008). The foreign-currency debt of the public sector is held usually primarily by foreigners. But according to Panizza 2008, there are 2 approaches to determine external debt/internal debt. The first one is focused on currency of debt issued, i.e., foreign-currency debt is considered external debt, and local-currency debt is internal debt. But this approach has a problem. Actually, there are some countries issued the foreign-currency debt in the internal market and issued domestic-currency debt in the international market. The second one is focused on the residence of the creditor, i.e., foreign-currency debt comes from non-residents debt. Primarily, the statistical information officially of external debt is based on the second approach.

In this section, we consider the foreign-currency debt that comes from non-residents and domestic-currency debt from the residents.

The sum of domestic currency debt and the monetary base is considered as "sovereign equity (SE)" and foreign currency debt is considered as sovereign risky debt. We refer to "foreign currency debt" as "risky debt" because the foreign debt is influenced by the exchange rate, i.e., more precisely, if the exchange rate between strong currency and domestic currency increases, which means that the amount of foreign debt increases, and in a worst case scenario, this country loses the ability to pay-off his foreign debt.

2.4.3 Definition

Sovereign default and default barrier

Sovereign default occurs when the values of sovereign assets fall below contractual liabilities also known as sovereign default barrier (named sovereign distress barrier or default threshold).

At a sovereign level, the distress barrier approach is different than the one in the original Merton model. In the original Merton model, the distress barrier is the firm's total debt. This means that a firm will default when the value of firm's asset is below the value of total debt. KMV model is based on the Merton model but with adjustments: the debt consists of short-term obligations and long-term debt. A firm has more time to recover with respect to the long-term debt. KMV's research led it to conclude that the distress barrier is really somewhere in between the short-term debt and the total debt. The default barrier is the face value[5] that will affect the pay-off in one year (Crosbie and R.Bohn 2001).

De Servigny and Renault 2007 used the ratio between long term foreign currency debt ($Debt_{LT}$) and short term foreign currency debt ($Debt_{ST}$) to define the default barrier. If the ratio of long term foreign-currency debt divided by short term foreign-currency debt is less than 1.5 then *default barrier* $=Debt_{ST} + 0.5 * Debt_{LT} +$ *one year interest payment*. Otherwise, *default barrier* $= Debt_{ST} + Debt_{LT} * (0,7 \quad 0,3 * Debt_{ST}/Debt_{LT})$.

In many cases, the default barrier was defined by the sum of short term foreign debt plus a portion (varied from 0.5 to 0.8) of long term foreign debt. In this research, we define the default barrier as the sum of short term foreign currency debt plus a half long term foreign currency debt.

Implicit sovereign asset and sovereign asset volatility

The Gray et al.'s model calculates the implicit sovereign asset (SA) and the sovereign asset volatility based on the sovereign liabilities. The sum of domestic currency debt and the monetary base is called "sovereign equity"(SE), and foreign currency debt is considered risky sovereign debt.

Likewise with the credit risk model, the "sovereign equity" value can be modelled as an implicit Call option, and sovereign risky debt is modelled as the default-

5. The "outstanding debt" may be used instead of a "face value"

free value of debt minus an implicit Put option, by using equation (2.3) and (2.7).

The first equation

The call value for the SE is computed by:

$$SE_{\$} = SA_{\$}\mathcal{N}(d_1) \quad D_f e^{\ r_f T} * \mathcal{N}(d_2) \tag{2.10}$$

where $d_1 = \dfrac{ln(\frac{SA_{\$}}{D_f}) + (r_f + 0,5\sigma_{SA}^2)T}{\sigma_{SA}\sqrt{T}}$ and $d_2 = d_1 \quad \sigma\sqrt{T}$; $SA_{\$}$ is the sovereign asset value, D_f is default barrier, r_f is risk-free foreign interest rate, σ_{SA} is sovereign asset volatility, T is maturity.

The second equation

We apply Itô's lemma to call-option formula to derive a formula for the equity volatility: (Ito's lemma to calculate volatility of the process SE)

$$SE * \sigma_{SE,\$} = \mathcal{N}(d_1) * \sigma_{SA} * SA_{\$} \tag{2.11}$$

where $d_1 = \dfrac{ln(\frac{SA_{\$}}{D_f}) + (r_f + 0,5\sigma_{SA}^2)T}{\sigma_v\sqrt{T}}$ and $d_2 = d_1 \quad \sigma\sqrt{T}$; $SA_{\$}$, σ_{SA} are sovereign assets value and sovereign asset volatility in foreign-currency.

One assumptions of Black & Scholes model is that there exists constant risk-free interest rate. But there is no clear market of risk-free interest rate. We have two possible of risk-free interest rates: the zero-coupon Treasury rates 10-year and swap rates. There are some recommendations of risk-free interest rate:

— Zhu 2006 used 5 year-US Swap rates as the risk-free rate and a 5-year time horizon for his analysis.

— Datastream recommended 3 month Treasury bills as risk-free interest rate.

— Bloomberg uses 10 year government bond rates as the risk-free interest rate.

In two main equations, there are two variables of risk-free interest rate: foreign interest rate and domestic interest rate. By default in this research, we define the foreign interest rate as a risk-free interest rate of US and domestic interest rate is risk-free interest rate of emerging countries.

We combine equations (2.10) and (2.11) to find the sovereign asset value $SA_{\$}$ and sovereign asset volatility σ_{SA} and then the sovereign default probability.

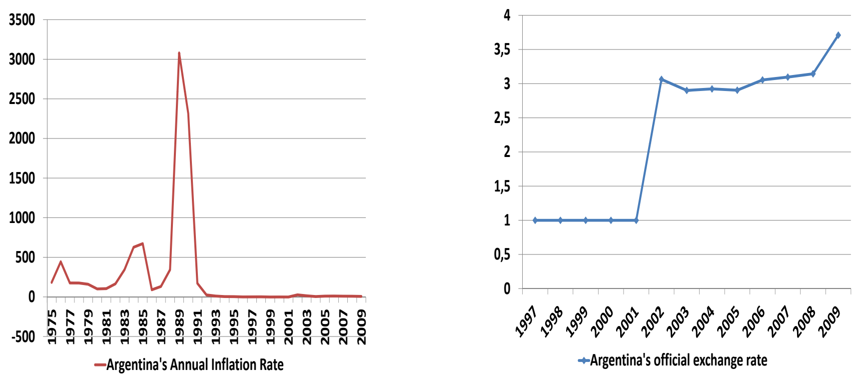
Probability of sovereign default under neutral risk is : $\mathcal{P} = \mathcal{N}(\quad d_{2r})$.

Probability of sovereign default under actual risk is : $\mathcal{Q} = \mathcal{N}(\quad d_{2\mu}) = \mathcal{N}(\quad d_2 \quad \rho_{A,M} S\sqrt{T})$

2.5 Empirical evidence from Argentina

2.5.1 Background of Argentina's economy

Argentina's crisis 1999-2002 and its debt default in 2001 were a serious crisis that damaged strongly the economy of this country. The overview of the Argentina economy can be considered in three factors: inflation rate, exchange rate and debt default. We can observe Figure 2.2(a) of inflation rate in the period 1975-2001: hyperinflation rate was 335% per year from 1975. Then, it maintained at the level of 10% and 20% per month during the next years, and peaked to 688% in 1984. Especially, in 1989, the inflation rate rocketed up to 3000%. By contrast, in 1997 it had dropped to 0.3%, and in 2001 it was negative (-1.5%).



(a) (b)

Source: National Institute of Statistics and Censuses and World Bank correspond to (a), (b) respectively

Figure 2.2: Argentina's annual inflation rate (%) and exchange rate

As shown in Figure 2.2(b), from 1997 to 2001, the exchange rate of Argentina currencies kept the regime of fixed exchange rate one-to-one Argentina peso-dollar (0.9995) but by early 2002 it jumped to 3%. This event marked the end of this regime. In 2002, a policy for all banks was to convert all bank accounts denominated in dollars to pesos at the floating exchange rate. From 2001 to 2009, after finishing the regime of fixed exchange rate, the peso became devalued.

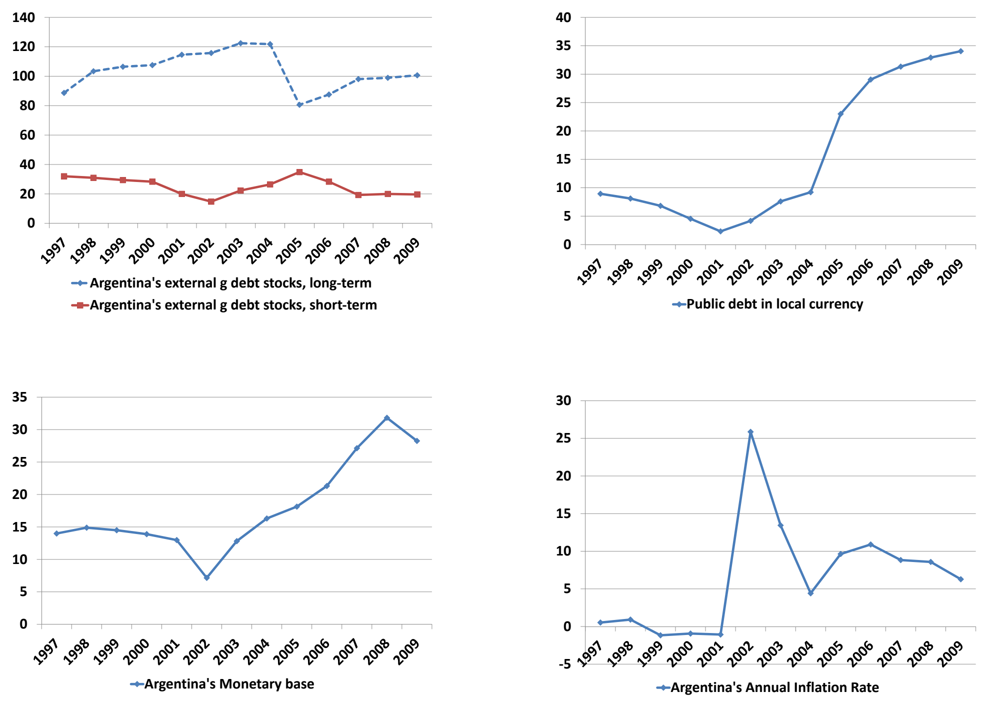
When reducing the budget deficit during the crisis 1999-2001, unfortunately, Argentina had to face failures repeatedly. So that it might burden a large foreign debt and the surged public debt displayed by a rapid increase of government debt. Particularly, the public debt ratio exceeded the allowed rate of 50% GDP in the end of 1999. In 2001, the amount of debt default in the total public debt went up to 80 billions \$. And this number marked the event of Argentina's default in this year (see in Figure 2.3 below).

Figure 2.3: Argentina's total defaulted debt (Source: Moody's, * since 1983)

2.5.2 Application CCA method to Argentina

Data sources

The data used in this study comes from many sources: The debt public in domestic currency is from MECON (Ministerio de Economia y production, Republic of Argentina), the external debt is taken from INDEC (National Institute of Statistic and Censuses, Argentina), Central Bank of Argentina (CBA).



Source: MECON, INDEC, CBA

Figure 2.4: Argentina's input data

Empirical results

In this study, we use an annual database for the period 1997-2009 for the following variables: interest rate 10-year of Government United States as the risk-free foreign interest rate, external debt, public debt monetary base in local currency and assume one year of maturity. We simply apply the official exchange rate to convert the value of the monetary base, public debt in local currency to foreign currency. For the default distress, we define the default barrier equal to the sum of external debt in the short term plus half of long term external debt. In order to find volatility of sovereign equity, we use the historical volatility method.

The main purpose in this section is to calculate the risk-neutral DP and the actual DP for Argentina by using the structural model of Gray et al. 2007; Gray and Malone 2008 and the Capital Asset Pricing Model (CAPM) respectively. Following these results, we show the evolution of two curves of DP with Argentina's situation. In addition, we verify these findings with the Girsanov's theorem.

The risk-neutral default probability is applied by the structural model of Gray et al. 2007; Gray and Malone 2008. The outputs also are the sovereign asset value and its volatility.

The actual default probability is calculated by the Capital Asset Pricing Model (CAPM). We recall equation (2.9):

$$\mathcal{N}(\quad d_{2\mu}) = \mathcal{N}(\quad d_2 \quad \rho_{A,M} S\sqrt{T})$$

In order to find two values of $\rho_{A,M}$ and Sharpe ratio[6], we apply the Capital Asset Pricing Model (CAPM) to find $\rho_{A,M}$.

$$E(R_i) \quad r_d = \beta_i(E(R_m) \quad r_d)$$

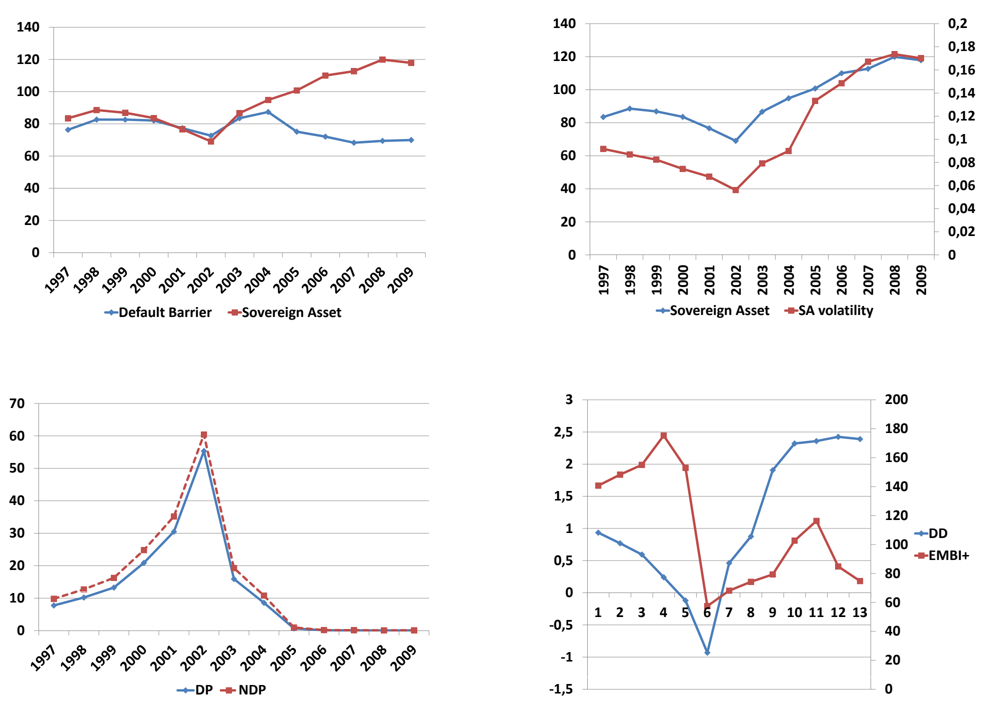
Where: $E(R_i)$ is the expected return on the Argentina's sovereign asset, r_d is Argentina's yield government bond, β_i is the sensitivity of the expected excess sovereign asset return to the expected excess market return, $E(R_m)$ is expected return on the Argentina stock market.

We propose the Merval Index[7] as the Argentina's stock market index. By using the Merval index return and Argentina's sovereign asset return, we obtain the correlation value between the Merval index return and sovereign asset return.

The results obtained can see in Figure 2.5: the line graph shows figures for the comparison between the Argentina's sovereign asset and its default barrier, the sovereign asset (left axis) and its volatility (right axis), risk-neutral default probability and actual default probability, the distance-to-default and the Argentina's EMBI+.

As shown in Figure 2.5: *The first graph* shows the evolution between the Argentina's sovereign asset and its default barrier between the years 1997 and 2009. From 1997 to 2001, they had a noticeable decrease. Furthermore, the distance

6. Sharpe ratio = Average of excess return/Standard Deviation of excess return
7. Merval Index is the most important index of the Buenos Aires Stock Exchange



Source: author's calculation. Notes: The sovereign asset corresponds to left axis and its volatility corresponds to right axis

Figure 2.5: Argentina's sovereign asset, its distress barrier, its volatility, its default probability, its distance-to-default

between the two lines in this period is more and more smaller. This means that the Argentina's default probability had a slight increase. This was explained by that the more the ratio of Argentina's sovereign asset to its default barrier increased, the more Argentina's default probability increased. At the end of 2001, the Argentina's sovereign asset reached to the distress barrier, i.e., in that year, Argentina had a default of 80 billion USD of external debt. In 2005, the ratio of Argentina's sovereign asset to its distress barrier was 1.3 while in 2008, this ratio was 1.7. Therefore, from 2002, there was a raise of the distance of the Argentina's sovereign asset and its default barrier. This reveals a decrease of the Argentina's default probability.

The second one is an important output that illustrates Argentina's implied sovereign asset and degree distribution of its implied volatility. These results suggest the sovereign asset and its implied volatility tended to decline from the beginning of 1998 to 2002, and both rose after 2002 that is exactly the period where Argentina's default occurred.

The third one compares Argentina's risk-neutral default probability and actual default probability. These plots confirm the Girsanov 1960's theorem that the risk-neutral default probability is greater than the actual one. The evolution showed the DP go up strongly until 2001 and go down in post-period of 2001. In fact, this decline is thankful to Argentina improved policies of the post-crisis.

Regarding the lines graph between the sovereign default probability in Figure 2.5 and the Argentina's inflation rate in Figure 2.4, these results also indicate both have the same evolution with Argentina's economic situation. Therefore, we conclude the default probability obtained from the model which very homogeneous with Argentinian economy.

The last one display the correlation between the distance-to-default and the Argentina's EMBI+ in order to validate the model. We compute the distance-to-default (DD):

$$DD = \frac{SA \quad D_f}{SA * \sigma_{SA}} \tag{2.12}$$

Gapen et al. 2008 argue that the distance-to-default is inverse related to the sovereign default probability, and it should be negatively correlated with the EMBI+ spread or the sovereign CDS spread [8], i.e. when the distance-to-default decreases, the sovereign default probability will increase. The correction coefficient between the Argentina's DD and the EMBI+ is -0.213** significant at 5% level, confirming the model is validated.

8. The Argentina's CDS spread database is available from 2007. Therefore, we use the EMBI+ for this estimation

2.6 Conclusion

This chapter shows the overview of the option pricing: Put and Call of the European option and its application for the credit risk model in order to calculate the default probability. The first objective of this chapter is to demonstrate and to show the Merton's model by re-establishing the Ito's lemma and the option pricing theory. According to the Merton's model, the default occurs when value of asset falls below the face value of all debt at maturity. Applying the option pricing theory, the difference between the asset and debt is the equity value that can be interpreted exactly as a Call option. From equation of Call option, we can find the default probability.

Based on the credit risk model and how to apply the Call option to calculate the default probability, we opted the idea of transposing Merton's model from the firm to the sovereign by Gray et al. 2007; Gray and Malone 2008. The hypothesis is to consider that the sovereign has two types of debts: a debt in local currency and one in foreign currency. The *central variable* is the *sovereign equity* that is the sum of the monetary base plus the domestic debt. Likewise, we could interpreted the sovereign equity as a Call European option, and we applied to calculate the sovereign asset, its volatility and its default probability.

The main purpose was to verify a case study of Argentina's default in 2002.

Our results show the Argentina's default probability tended to accelerate and reach a top in 2002 and decelerate after 2002. This mean that it is consistent with the Argentina's situation. Conclusively, this contribution adds an empirical result of the structure model based on the extensions of Gray et al. 2007; Gray and Malone 2008 which have confirmed exactly with the real Argentinian economy.

Furthermore, the demonstrations of Ito's lemma and the option pricing theory will be useful for the stochastic calculation in the third chapter.

CHAPTER 3

A stochastic model of sovereign credit spread

3.1 Introduction

Economic crises emerged widespread, notably in emerging countries. The Mexican financial crisis (1994), the Asian crisis spreading from Thailand (1997) and the Russian debt crisis (1998) were all due to political crises and bad executive policies. Especially during the early 2000s, the failure of regulation and risk management led to crises in the emerging countries, as exemplified by the Turkish currency devaluation in 2000, Argentina default in 2001 and Brazil crisis in 2002...

The most striking example of such a failure being the global crisis arising from the 2007 subprimes deflagration.

This context of repeated crises and recurrent financial instability brought measurement of sovereign risk to the fore as a key stake for policy-makers and regulators. Many indicators of country risk have been used recently such as sovereign credit ratings, default probability, sovereign credit spread, sovereign *credit default swap* spread (sovereign CDS spread) and sovereign bond...

In this chapter, we focus on the sovereign credit spread, which is the differential between yields on risky debt and those on what might be considered risk-free government bonds (Remolona et al. 2007). It is presented in a dynamic stochastic equilibrium model. Eaton and Gersovitz 1981 show that the government chooses to repay its debt because the impact of default on reputation will degrade the access to credit on the international market. In support of the latter argument J. Bulow and Rogoff 1989 study the exclusion from the international market due to default reputation. In reality, although many emerging countries were downgraded and defaulted on their debt, foreign investors have come back after the government has revived the economy and stabilised economic growth, eg: Argentina, Mexico, Russia, Malaysia, Ecuador. Malaysia and Ecuador are two typical examples of such a return of investors after a period of turmoil and a default on their debt. Thus, what really matters for investors are the fundamentals like macroeconomic stability while the default reputation is a thing one very easily forget.

Yue 2010 studies the role of renegotiation when the sovereign defaults takes place, and presents the bargaining power in reducing debt if the government does not have the capacity to repay. In addition, Andrade 2009 focuses on the asset pricing and renegotiation of sovereign debt when a country has negative economic growth and a bad endowment shock. Agreeing with the choice to default, the government accepts to pay the default cost. The default cost is mentioned in the work of Borensztein and Panizza 2008; Arellano 2008; Andrade and Chhaochharia 2011. There are some default models of reserve optimisation, such as Ben-Bassat and Gottlieb 1992; Alfaro and Kanczuk 2009. The interaction between fiscal policy and sovereign risk appears in Cuadra et al. 2010; Hatchondo et al. 2012. In the paper of Andrade 2009, the author creates a yield spread on sovereign bond by using two ratios of Price-Earnings (P/E) and expected return. His model suggests that the P/E ratio of an emerging market stock decreases with the average sovereign yield spread, and that the valuation discount of stock price increases with the average sovereign yield spread. Besides, Jeanneret 2013 studies the dynamic sovereign credit risk model by finding the sovereign credit spread. His model indicates that when the sovereign defaults, the government will be incited to issue debt and to negotiate with its lenders to reduce its debt. The empirical results of this paper for the period 2000-2011 derive from two groups: a first one is emerging countries and the second one is European countries.

In this paper, we propose an enhanced version of Jeanneret 2013 model. Our model allows for two parallel policies: the government can choose between increasing corporate tax and negotiating a reduction in its debt. The major contribution of this work is to suggest a method determinating the sovereign credit spread while accounting for the two kind of policies. Empirical investigations are lead using daily data for four emerging countries, namely Brazil, Mexico, Peru and Turkey, for the period 2000-2011.

The following section introduces the model and section 3 is devoted to the empirical investigation. The Last section concludes.

3.2 Model

We suppose that a country consists of a government and a representative firm. The firm asset, V_t, is represented by its income and follows a Geometric Brownian Motion (GBM) with a drift μ and volatility σ:

$$dV_t = \mu(1 \quad \tau \quad \Delta)V_t dt + \sigma(1 \quad \tau \quad \Delta)V_t dW \tag{3.1}$$

where W is a Brownian motion, $\Delta \geq 0$.

The constant tax rate of the firm income by the government is τ. Thus, the government's fiscal revenue at the time t is τV_t, and the net firm's asset is $(1 \quad \tau)V_t$. The government pays a perpetual debt service C to its lenders.

The government defaults when sovereign asset V_t reaches a threshold default V_D, called barrier default, at time $T_D = \inf\{t \geq 0, V_t \leq V_D\}$[1]. In case of a default, we allow for two policies: (1) The government negotiates with its lender to reduce the debt service by a fraction $\phi \in [0,1]$. (2) The government increases firm's income tax rate from τ to $\tau + \Delta$ ($\Delta > 0$). In the absence of government default, $\Delta = 0$. According to Shiller 2013, *"increasing taxes during an economic crisis makes perfect sense"*. In additional, in the European crisis 2011, Greece, Spain, Portugal increased the income tax to decrease the deficit (OCDE-Publishing 2013). If the government choose to default, it must pay a default cost[2]:

$$\lambda \mathbb{E}_t \left[\tau V_{T_D} e^{\quad r(T_D \quad t)} \right] \tag{3.2}$$

where λ is a fraction of reduction in the firm asset, r is the risk-free interest rate. Jeanneret 2013 argues that because the firm pays its income tax to the government, sovereign asset is a fraction of the firm asset. At the default time T_D, in order to pay the default cost, the government must reduce firm asset by a fraction λ. Equation (3.2) is the present value of the default cost.

Definition 1. The net sovereign asset (NSA) is equal to the present value of

1. We can write $\tau V_t < V_{D1}$, so $V_t < V_D$ where $V_D = V_{D1}/\tau$
2. The asset value at the default point T_D is V_{T_D} which is equal to default threshold V_D

the net government income at time t minus the default cost:

$$NSA = \mathbb{E}_t \left[\int_t^{T_D} (\tau V_u - C) e^{-r(u-t)} du + \int_{T_D}^{\infty} \{(\tau + \Delta) V_u - (1 - \phi) C\} e^{-r(u-t)} du \right] - \lambda \mathbb{E}_t \left[\tau V_D e^{-r(T_D - t)} \right] \quad (3.3)$$

Equation (3.3) shows the intertemporal value of the net sovereign asset: The first term depicts the NSA before default time T_D; the second term is the NSA after default when the set of policies have been applied. At the default time T_D, the government increases the income tax by $\tau + \Delta$ while negotiating a reduction in its debt service by a fraction ϕ. The rest of coupon service is $(1 - \phi)C$. The third term is the default cost.

Proposition 1. By using **Lemma A.1** and **Lemma A.2**, we obtain the net sovereign asset:

$$NSA = \frac{\tau V_t}{r - \mu} - \frac{C}{r} + \left(\frac{V_t}{V_D} \right)^{\beta} \left[\left(\frac{\Delta}{r - \mu} - \lambda \tau \right) V_D + \frac{\phi C}{r} \right] \quad (3.4)$$

where $\beta = -\frac{2r}{\sigma^2}$

Proof. See Appendix A.

The government policy is to maximize the net sovereign asset value. The optimal default barrier derived from this policy is displayed in the Proposition 2 below:

Proposition 2. The default barrier, V_D, is determined at the time when the sovereign asset reaches to the default barrier:

$$V_D^* = \frac{C\phi\beta(r \quad \mu)}{r(1 \quad \beta)[\Delta \quad \lambda\tau(r \quad \mu)]} = C\varphi \tag{3.5}$$

where $\varphi = \dfrac{\phi\beta(r \quad \mu)}{r(1 \quad \beta)[\Delta \quad \lambda\tau(r \quad \mu)]}$; $\beta = \quad \frac{2r}{\sigma^2}$

Proof. See Appendix A.

The central purpose of this paper is to determine the sovereign credit spread from the two policies: increasing the corporate income tax and partially reducing the debt. The sovereign credit spread is the difference between the yield on risk debt and the risk-free rate, which is shown by equation (3.6) in the Proposition 3.

Proposition 3: Sovereign Credit Spread (SCS) is measured by:

$$SCS = r\left[\frac{1}{1 \quad \phi\left(\dfrac{V_t}{C\varphi}\right)^{\beta}} \quad 1\right] \tag{3.6}$$

Proof. See Appendix A.

Maximum Likelihood Estimation method

In order to estimate the sovereign credit spread in equation (3.6), we must find the unknown asset value that cannot be observed. To do that, we draw upon the Maximum Likelihood Estimation (MLE) proposed by Duan 1994. The transformed-data method will find unknown asset value from observed equity value through the log-likelihood function.

We have the observed equity is a function of the unknown asset value $E = f(V)$, which yields $V = f^{\;\;1}(E)$. We express the log-likelihood function for the observed equity as:

$$L(E,\theta) = L(V,\theta) \quad \sum_{t=2}^{n} ln \frac{\partial f(V_t)}{\partial V_t} = L(V,\theta) \quad \sum_{t=2}^{n} ln \frac{\partial E_t}{\partial V_t} \tag{3.7}$$

where $\theta = (\mu, \sigma)$, $L(V, \theta)$ is the log-likelihood function for unknown asset V_t.

Using $\partial E_t / \partial V_t = \mathcal{N}(d_t)$, we obtain:

$$L(E,\theta) = L(V,\theta) \quad \sum_{t=2}^{n} ln(\mathcal{N}(d_t)) \tag{3.8}$$

$$L(E,\theta) = \quad \frac{n \quad 1}{2} ln(2\pi) \quad \frac{n \quad 1}{2} ln(\sigma^2) \quad \frac{1}{2\sigma^2} \sum_{t=2}^{n} [ln(\frac{V_t}{V_{t \quad 1}}) \quad \mu]^2 \quad \sum_{t=2}^{n} ln(\mathcal{N}(d_t)) \tag{3.9}$$

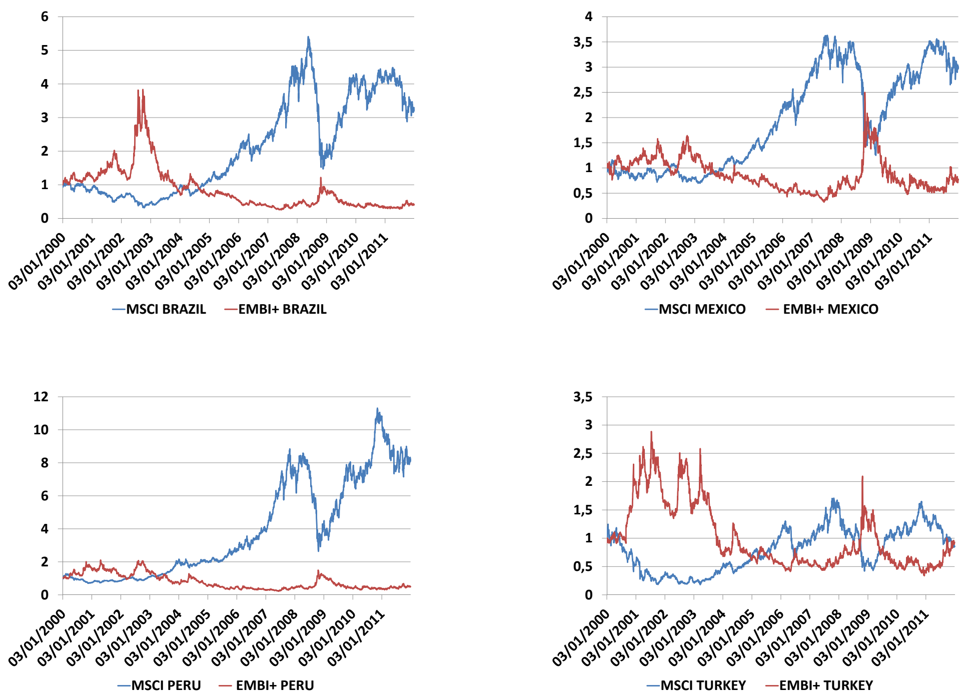
Duan 1994 uses the algorithm of quadratic Hill-Climbing proposed by Goldfeld et al. 1966 to find the maximum likelihood value. In our empirical results, we apply the *simplex algorithm*[3] to maximum likelihood proposed by Lagarias et al. 1998. Using maximum likelihood estimation helps to find estimated value $\hat{\theta} = (\hat{\mu}, \hat{\sigma})$ and $\hat{V}_t$ from input data of observed equity and default barrier.

3.3 Empirical results

3.3.1 Data Description

In this chapter, we use daily data from the period 2000-2011 for four emerging countries: Brazil, Mexico, Peru and Turkey. MSCI is a stock market price which represents the sovereign equity index. EMBI+ is the Emerging Market Bond Index which represents the benchmark sovereign credit spread. Both MSCI and EMBI+ are taken from Datastream. The evolution of the MSCI and EMBI+ is shown in Figure 3.1:

3. To find the maximum likelihood value $L(E)$, we switch the problem by finding the minimum value $\quad L(E)$



Source: Datastream. Notes: (a), (b), (c) and (d) are the curves of Brazil, Mexico, Peru and Turkey respectively. Both curves of MSCI and EMBI+ are normalised to unity in 2000

Figure 3.1: Evolution of MSCI and EMBI+ of Brazil, Mexico, Peru and Turkey

To set-up the remaining variables, we use the calibrate value from Jeanneret 2013 because we calculate in the same period and the same country. We set: the average 10-year U.S. Treasury rate represent the risk-free interest rate r=0.04, the corporate income tax for emerging country $\tau = 0.3$, the default cost rate $\lambda = 0.05$, reduce rate of debt $\phi = 0.6$ and C = 1%, Δ =1%.

3.3.2 Estimation from MLE

The difference of default threshold of each country depends on the estimated value of $\hat{\mu}$, $\hat{\sigma}$ from the maximum likelihood estimation. The loop of *simplex algorithm* in MLE requires a starting point for μ, σ. Like Jeanneret 2013, we use the mean and volatility of MSCI growth as a starting point of μ, σ. The estimated coefficients $\hat{\mu}$, $\hat{\sigma}$ are reported in Table 3.1 in below:

Variable	Brazil	Mexico	Peru	Turkey
$\hat{\sigma}$	0.3014	0.2511	0.2575	0.4550
$\hat{\mu}$	0.1315	0.1152	0.1761	0.0933

Source : author's calculation

Table 3.1: Estimated coefficients from MLE

The estimated default barrier in equation (3.5) is calculated from estimated coefficient of $\hat{\mu}$, $\hat{\sigma}$.

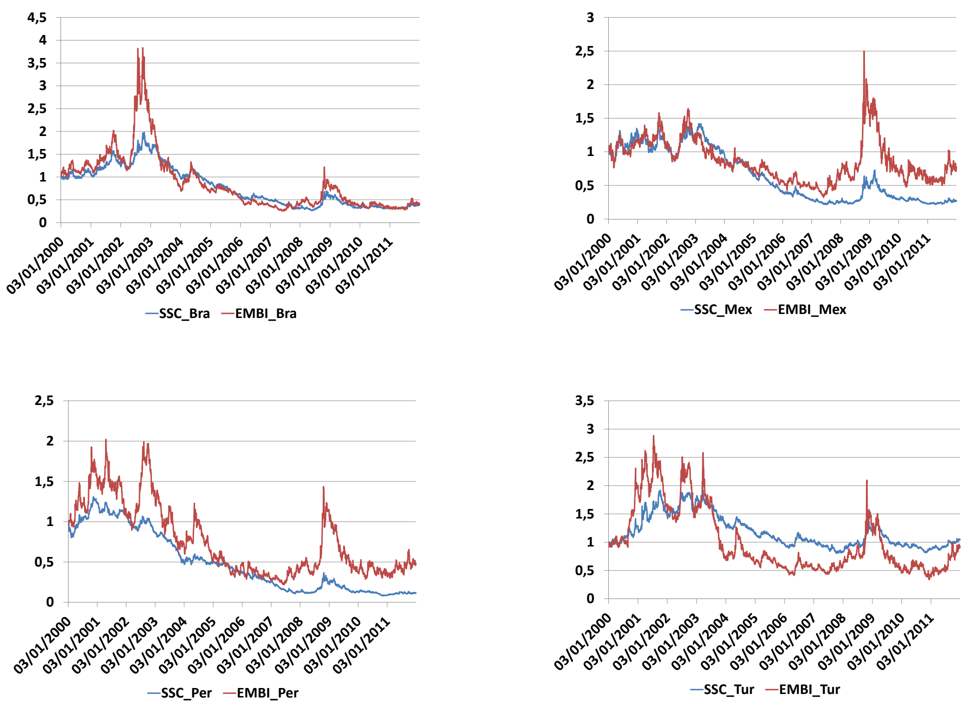
3.3.3 Comparing between estimated Credit Spread and benchmark Credit Spread

The estimated sovereign credit spread is calculated from the estimated coefficient of $\hat{\mu}$, $\hat{\sigma}$ in Table 3.1 and the estimated asset value from maximum likelihood estimation.

We compare the estimated sovereign credit spread with the Emerging Market Bond Index represented by the benchmark sovereign credit spread in order to verify the tendency and the fluctuation of the two curves. The comparison shows in Figure 3.2 below:

As shown in Figure 3.2, the estimated sovereign credit spread and EMBI+ are fairly homogeneous and have an upward slope throughout the period. Two crises occurred in the period 2000-2011: the 2002 internet bubble and the global financial crisis in 2007. The estimated country risk increases for each of the crises, following with EMBI+ benchmark. For the case of Brazil and Mexico, the two curves almost coincide in this period. Especially, there is a small residual in 2002 for Brazil and after 2007 for Mexico. For the case of Peru and Turkey, the two curves do not coincide, but they do follow the same path.

To test the robustness of the path-relevance of our model, we make use of an econometric model assessing the statistical significance of the relationship between the model and the benchmark. Is there a cointegration relationship in the long-



Source : author's calculation. Notes: (a), (b), (c) and (d) are the curves of Brazil, Mexico, Peru and Turkey respectively. Both curves of estimated sovereign credit spread and EMBI+ are normalised to unity in 2000.

Figure 3.2: Comparison between the estimated Sovereign Credit Spread and EMBI+

run? This question will be answered in the next section.

3.3.4 Model Validation

In this section, we investigate two econometric methods to validate the model of sovereign credit spread. We test the evolution between estimated sovereign spread and the benchmark spread. If the two series have the same evolution, we will apply the second econometric method to verify the long-run existence of the evolution by using a cointegration test.

Evolution between estimated sovereign spread and benchmark spread

The graphics in Figure 3.2 show the same evolution of two curves of estimated sovereign spread and the benchmark spread. Here, we test the relationship of evolution of the two curves, i.e., we verify whether there is an increase (decrease) of the estimated sovereign spread respectively when EMBI+ increases (decreases). We use the following equation:

$$EMBI{+}_t = \alpha + \gamma SCS_t + \varepsilon_t \tag{3.10}$$

where SCS is the estimated sovereign credit spread from the model, EMBI+ is Emerging Market Bond Index Plus, represented for country's observed credit spread. The expected sign of γ is positive. The results are mentioned in Table 3.2:

Coefficient	Brazil	Mexico	Peru	Turkey
α	-0.161***	0.0515***	0.2575***	-1.0259***
	(0.0093)	(0.0082)	(0.0061)	(0.0021)
γ	1.317***	0.5429**	1.0921***	1.7285**
	(0.010)	(0.0108)	(0.010)	(0.0175)
Adj R^2	0.835	0.443	0.791	0.756
Observations	3130	3130	3130	3130

Notes: standard errors in parentheses; ***,**,* means that the coefficient is significant at the 1%, 5%, 10% level.

Table 3.2: Regression Coefficients

The estimated coefficients are reported in Table 3.2. The coefficients of γ are positive and significant at 1% level as expected which are 1.317, 1.0921 for Brazil and Peru, and are 0.5429, 1.7285, significant at 5% level as expected for Mexico and Turkey respectively. These results reflect the evolution of estimated sovereign credit risk of the model explained by the evolution of EMBI+ in the period 2000-2011. The results also suggest the magnitude by which the sovereign credit spread would fluctuate for a given change in EMBI+.

Cointegration test between estimated sovereign spread and benchmark spread

In this section we test whether there is a cointegration relationship between the estimated sovereign spread and the EMBI+ in the long-run. The existence of such a cointegration relationship would be a strong sign of the relevance of the model.

Before testing for cointegration test, we start by testing the stationarity of the two series SCS and EMBI+. For each test, the optimal lag is obtained by choosing the critical AIC selection [4] and Augmented Dickey-Fuller (ADF) statistic. The null hypothesis is that the series contains a unit root. We study two model: the first model with intercept only, the second model with intercept and trend. The results are mentioned in Table 3.3 below:

	Model	Brazil	Mexico	Peru	Turkey
Stat-SCS	Constant	-0.7359	-1.0074	-0.7190	-1.7260
		(0.8358)	(0.7527)	(0.8401)	(0.4180)
Stat-SCS	Constant and Trend	-2.0966	-2.1620	-1.7341	-2.8074
		(0.5469)	(0.5101)	(0.7360)	(0.1946)
Stat-EMBI	Constant	-1.6568	-2.3034	-1.7275	-1.9245
		(0.4532)	(0.1710)	(0.4172)	(0.3212)
Stat-EMBI	Constant and Trend	-2.5490	-2.5111	-2.6501	-2.6681
		(0.3043)	(0.3227)	(0.2579)	(0.2501)
Stat-ΔSCS	Constant	-11.5661***	-15.8172***	-12.1003***	-10.6001***
		(0.0000)	(0.0000)	(0.0000)	(0.0000)
Stat-ΔSCS	Constant and Trend	-11.5723***	-15.8146***	-12.0975***	-10.6141***
		(0.0000)	(0.0000)	(0.0000)	(0.0000)
Stat-ΔEMBI	Constant	-10.2390***	-10.0320***	-51.9538***	-18.5117***
		(0.0000)	(0.0000)	(0.0001)	(0.0000)
Stat-ΔEMBI	Constant and Trend	-10.2393***	-10.0295***	-51.9455***	-18.5090***
		(0.0000)	(0.0000)	(0.0000)	(0.0000)

Notes: Δ is first difference, p-value in parentheses. *** means that we reject the null hypothesis of a unit root at the 1%.

Table 3.3: Unit root test

Table 3.3 gives the ADF statistics for SCS and EMBI+ series in level and in the first difference of each countries. The two series SCS and EMBI+ in level are non-stationary based on the reported p-value. The first difference of both variables rejects the null hypothesis of a unit root at the 1% level. Finally, both are integrated in the same order I(1). Therefore, we can use the cointegration test between SCS and EMBI+ in order to verify the long-run cointegration between

4. Maxlag=28

SCS and EMBI+.

We compute the residual between the EMBI+ and the estimated sovereign credit risk from equation (3.10), $e_t = EMBI_t \quad \hat{\gamma} SCS_t \quad \hat{\alpha}$, in order to verify the stationary of the residual series. To ensure that the cointegration relationship being accepted, the residual must be stationary. We study two model: the first model with intercept only, the second model without intercept. The unit root test estimation of the residual between EMBI+ and SCS is shown in Table 3.4:

Model		Brazil	Mexico	Peru	Turkey
Constant	t-statistic	-2.713*	-3.091**	-3.708***	-2.656*
	Prob	(0.071)	(0.027)	(0.004)	(0.082)
None	t-statistic	-2.713***	-3.092***	-3.709***	-2.656***
	Prob	(0.0065)	(0.002)	(0.000)	(0.007)

Notes: p-value in parentheses. ***,**,* means that the coefficient is significant at the 1%, 5%, 10% level.

Table 3.4: Unit root test of the residual between EMBI+ and SCS

Table 3.4 gives the ADF statistics for the residual series in level of each countries. Based on the reported p-value, the residues in level are stationary for both models. Therefore, we can estimate the error correction model.

When the series are non-stationary and cointegrated, it should estimate their relationship across a error correction model (ECM). We use the cointegration tests for times series proposed by Granger 1981, Engle and Granger 1987. According to Engle and Granger 1987, if two cointegrated series can be represented by an ECM. We test the short-run dynamic effect from the error correction model from equation (3.11):

$$\Delta EMBI{+}_t = \beta \Delta SCS_t + \delta e_{t\quad 1} + \nu_t \tag{3.11}$$

where $e_{t\quad 1} = EMBI_{t\quad 1} \quad \hat{\gamma} SCS_{t\quad 1} \quad \hat{\alpha}$, the coefficient $\delta < 0$ must be negative and significant in long-run equilibrium.

The estimation of the error correction model is presented in Table 3.5:

Coefficient	Brazil	Mexico	Peru	Turkey
β	1.566**	0.956**	0.829**	1.201**
	(0.038)	(0.037)	(0.063)	(0.035)
δ	-0.0085***	-0.0046***	-0.0081***	-0.0141***
	(0.0029)	(0.0018)	(0.0027)	(0.004)
Adj R^2	0.354	0.176	0.055	0.266

Notes: standard errors in parentheses; ***,**,* means that the coefficient is significant at the 1%, 5%, 10% level.

Table 3.5: Regression coefficients of the error correction model

The results observed in Table 3.5: We have four coefficients of δ be negative which are -0.0085, -0.0081, -0.0141, -0.0046 significant at 1% for Brazil, Peru, Turkey and Mexico respectively. This result confirms that the error correction model is validated.

Therefore, by examining two case of the test of cointegration and the error correction model between the two series EMBI+ and the estimated sovereign credit spread, the results are robust indicating the relationship between the two series be similar and consistent in long-run.

3.4 Conclusion and Perspectives

This chapter provided a stochastic model to determine the *daily* sovereign credit spread when the government propose two policies: increasing corporate income tax and reducing a part of debt. The sovereign credit spread is computed by the difference between the yield on risky debt and risk-free rate. To deal with the important step of estimating the sovereign credit spread from the unobservable asset value, we opted for the *simplex algorithm* to find the maximum likelihood estimation proposed by Lagarias et al. 1998. Then, we could estimate the asset value from the sovereign equity and its debt represented by the MSCI and the default barrier.

Our findings for Brazil, Mexico, Peru and Turkey indicate that two series of the estimated sovereign credit spread and the Emerging Market Bond Index Plus follow a common evolution. We performed a regression between the two in order to verify the similarity in path and its statistical relevance of the two series. In other words, if the EMBI+ increases/decreases, the estimated sovereign credit spread increases/decreases respectively.

Furthermore, we use the cointegration test to investigate the existence of a relationship in long-run between the sovereign credit spread and the EMBI+. We conclude on the existence of such a relationship. Therefore, the estimated sovereign spread credit will be similar to the EMBI+ in the long-run. This mean that the two policies we propose are reasonable and significant. Hence, this index also become a proxy to determine the sovereign default risk.

Perspective

This result sketch promising avenues of research. Notably, investigating the case of a country initial gross endowment as assumed in Andrade 2009 or the case of using other collateral assets when borrowing from international markets could prove useful for deepening the understanding of the sovereign default risk dynamics.

CHAPTER 4

Long-Run Determinants of the Sovereign CDS spread in emerging countries

4.1 Introduction

Credit Default Swap (CDS) is an insurance contract between a seller and a buyer that allows investors to buy protection against default. It was invented from JP Morgan in 1994. The buyer pays a fee to the seller (called CDS premium or spread), in exchange, the buyer of the CDS receives compensation from the seller if a default occurs. The aim of sovereign CDS is to insure the sovereign bonds buyer against the default of government bond. The larger the CDS spread on a government bond, the higher the risk of default on that bond by the issuing government.

The CDS spread quotes in basis points, and the majority of the quotation is denominated in USD. The quotation of CDS provides the information of CDS to traders or investors as well as gives us information on the perception of market risk. In fact, a decline in the equity market leads to an increase in credit spread which implies an increase of the probability of default as well as an increase of demand for CDS protection. Hence, the higher the risk of default, the larger the CDS spread as demonstrated by Chan-Lau 2003, 2006. In addition, the default probability can be computed and predicted from the CDS spread. Hence, since then the CDS spread has been a proxy of country default risk. Moreover, the economic crisis raises a number of important questions regarding the determinants of the sovereign CDS spread. And more importantly, clarifying the long-run determinants of sovereign CDS spread in long-run should help regulators designing policies aiming at reducing a country default risk. Therefore, in this chapter, we suggest a study of the long-run and short-run determinants of the sovereign CDS spread.

The remainder of this chapter is organized as follows: In section 2, we show the determinants of sovereign CDS spread. In section 3 we present the econometric methodology to investigate long-run determinants of sovereign CDS spread as well as the empirical results. We conclude in the third section.

4.2 Determinants of sovereign CDS spread

In fact, numerous articles link the relationship between the fundamental factors and sovereign credit default proxies such as sovereign credit ratings and sovereign default probability.

Actually, J. I. Bulow and Rogoff 1988 show that exchange rate variations have a direct impact on a country's terms of trade, which may affect the ability of the country to generate dollar revenue and so make payments on its external debt.

Hernandez-Trillo 1995 indicates that the default probability of sovereign depends on: the degree of openness, international reserves and the risk-free interest rate. According to his model, he creates a spread index over LIBOR and debt service ratio to determine the sovereign default probability, and defines the default probability as a function of the cost of default. He concludes for 33 debtors emerging countries in the period 1970-1988 where liberalization policies decreases the probability of default by both raising the GDP and increasing openness. A country default will induce a loss in access to future credit. This model displays a negative effect of openness and international reserves on the default probability.

Then, Cantor and Packer 1996 regress a country's ability and willingness-to-service its debt for a panel of developing countries. They find six variables affecting the sovereign credit rating which are per capita income, GDP growth, inflation rate, external debt, default history and an economic development indicator.

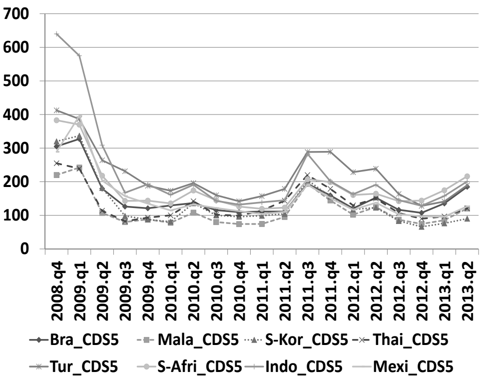
Additionally, Mellios and Paget-Blanc 2006 determine two other factors: government income and change in the real exchange rate. These variables have a positive impact on default probability except for the inflation rate. Baek et al. 2005 show the link between sovereign risk in emerging countries and macroeconomic variables such as government budget balance and current account balance.

Georgievska et al. 2008 use the Bayesian approach to find three classified variables explaining sovereign default: total debt to GDP ratio and Export to GDP ratio represent solvency variables, international reserves to GDP ratio express liquidity and currency account balance to GDP ratio and imports to GDP ratio variables represent macroeconomic variables. More recently, Ramos-Francia and Rangel 2012 create a sovereign spread index as the difference between the long-term government bonds yield and the 10-year US Treasuries yield. They test the relationship of this index with macroeconomic variables such as inflation, economic growth, fiscal and current account deficits, international reserves and nominal exchange rate variations. These results illustrate that international reserves and exchange rate appreciations are associated with lower default risk in emerging markets.

Nevertheless, there are a few studies mentioning the determinants of sovereign CDS in emerging markets. For example, IMF-Report 2013 introduces the determinants of the CDS spread by regressing it on various macroeconomics and financial explanatory variables. This paper finds that the debt/GDP ratio and GDP growth rate increase the spread whereas international reserves reduce it. Aizenman et al. 2013 show that the external debt/GDP ratio and inflation explain the sovereign CDS spread in the crisis period while in the post-crisis period, this index is caused by inflation and public debt/GDP ratio. However, these regressions take into account the influence of these explanatory variables to the sovereign default proxies over a specific period but do not examine their effect in the long-run.

The sovereign CDS 5-year spread is the most traded in the CDS market because of its liquidity. In 2007, this index appeared in the emerging markets. Since then, it has been considered as a proxy of sovereign default risk. Figure 4.1 shows the development of sovereign CDS 5-year spread of eight typical emerging countries between 2008.Q4 and 2013.Q2. The graph clearly indicates that the country default risk for all countries of this panel is homogeneous in this period. Moreover, the economic crisis raises a number of important questions regarding the determinants of the sovereign CDS spread. And more importantly, clarifying the long-run determinants of sovereign CDS spread in long-run should help regulators designing policies aiming at reducing a country default risk.

In this chapter, our contribution is an empirical result of the long-run relationship between the sovereign CDS spread and fundamental macroeconomics for this panel group. The explanatory variables we propose are the government's solvency, the government's liquidity and macroeconomics situation represented by the external debt to GDP ratio, the international reserves to GDP ratio and the current account to GDP ratio respectively. These variables are very important to determine the sovereign default risk. In fact, the sovereign CDS spread captures the external debt in emerging countries. Hence, when the external debt burden increases, it would be expected to increase spreads. The second variable we mention above is international reserves. This variable has negative effects on sovereign CDS spread, i.e., the higher government's liquidity, the smaller the sovereign default probability as well as sovereign CDS spread. The current account is an important macroeconomic variable represented by economy's health which is influenced by numerous factors such as policies of trade balance, investment and others. According to Baek et al. 2005; Ramos-Francia and Rangel 2012, the current account and international reserves would reduce the sovereign CDS spread.



Source: Reuters

Figure 4.1: Sovereign CDS spread 5-year

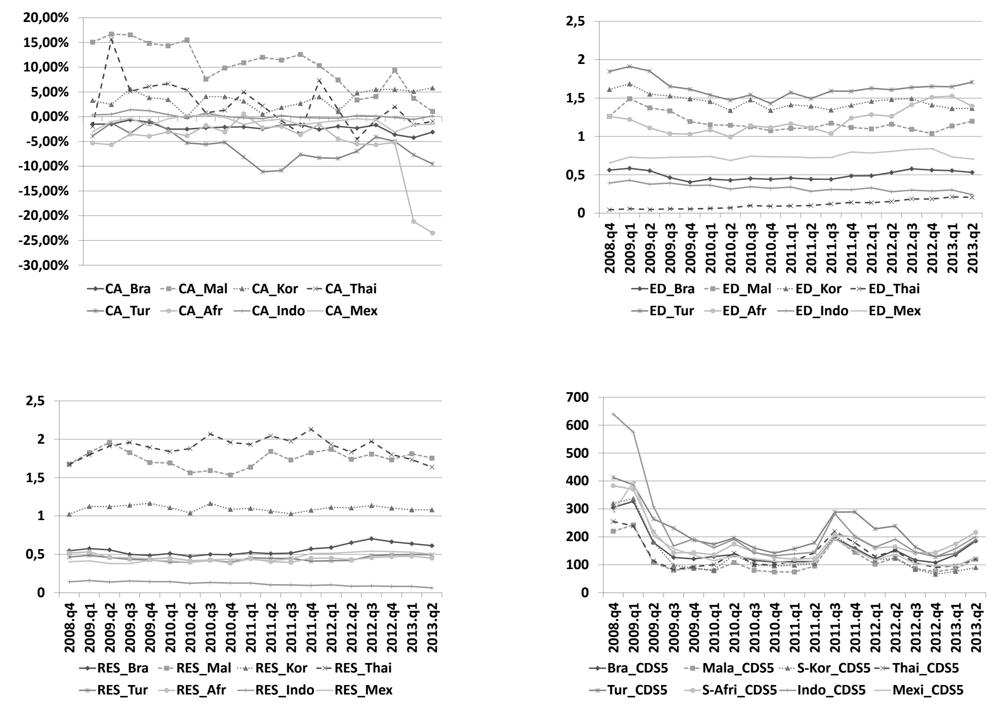
4.3 Econometric approach and Empirical results

Data Description

In this paper, we use quarterly data from 2008.Q4 to 2013.Q2 [1] for eight emerging countries: Brazil, Malaysia, South-Korea, Thailand, Turkey, South Africa, Indonesia and Mexico. Sovereign CDS 5-year in log denoted LCDS is taken from Reuters. CA is a ratio of the current account to GDP, ED is a ratio of the external debt to GDP. Both are found in Central Bank of each country. RES, the ratio of international reserves to GDP, is from the IMF International Financial Statistic. The evolution of the current account, the external debt, international reserves and

1. Our time period is constrained by data availability.

the sovereign CDS spread is shown in Figure 4.2, and the descriptive statistics are resumed in Table 4.1:



Source: indicate in the section of data description

Figure 4.2: Evolution of the current account, the external debt, international reserves and the sovereign CDS spread

In order to test the long-run relationship between the sovereign CDS spread and the explanatory variables for the emerging panel, we apply the panel unit root and the panel cointegration tests. The panel unit root aims at verifying that all variables are integrated with the same order. The panel cointegration test is to study the existence of cointegration between all variables. These tests are the necessary condition to test the panel long-run estimation.

		Bra	Mala	S-Kor	Thai	Tur	S-Afri	Indo	Mexi
LCDS	Min	4.677	4.304	4.189	4.409	4.853	4.782	4.855	4.562
	Max	5.791	5.490	5.820	5.541	6.022	5.948	6.461	5.982
	Mean	4.985	4.669	4.787	4.851	5.333	5.154	5.290	4.947
	Range	1.114	1.186	1.631	1.132	1.170	1.166	1.606	1.419
	StDev	0.328	0.372	0.459	0.338	0.332	0.330	0.458	0.375
	Variance	0.107	0.138	0.210	0.114	0.110	0.109	0.210	0.141
	Skewness	1.466	1.130	1.147	0.865	0.650	1.378	1.689	1.582
	Kurtosis	1.570	0.284	0.663	-0.254	-0.258	1.586	2.297	2.331
CA	Min	-0.042	0.011	0.000	-0.045	-0.111	-0.235	-0.005	-0.031
	Max	-0.006	0.167	0.058	0.156	-0.007	0.006	0.014	0.003
	Mean	-0.022	0.104	0.035	0.024	-0.061	-0.055	0.002	-0.010
	Range	0.036	0.156	0.058	0.202	0.104	0.241	0.020	0.034
	StDev	0.008	0.048	0.017	0.048	0.030	0.062	0.005	0.009
	Variance	0.000	0.002	0.000	0.002	0.001	0.004	0.000	0.000
	Skewness	-0.668	-0.475	-0.559	1.085	0.071	-2.436	1.042	-0.802
	Kurtosis	1.007	-0.794	-0.512	1.979	-0.759	5.402	0.820	0.363
RES	Min	0.473	1.533	1.022	1.636	0.395	0.386	0.062	0.379
	Max	0.704	1.958	1.164	2.129	0.498	0.531	0.158	0.541
	Mean	0.559	1.742	1.097	1.892	0.444	0.448	0.114	0.453
	Range	0.231	0.425	0.141	0.494	0.102	0.145	0.096	0.162
	StDev	0.068	0.111	0.041	0.129	0.035	0.036	0.028	0.057
	Variance	0.005	0.012	0.002	0.017	0.001	0.001	0.001	0.003
	Skewness	0.712	-0.209	-0.230	-0.285	0.180	0.580	-0.151	0.381
	Kurtosis	-0.559	-0.327	-0.449	-0.107	-1.265	0.933	-1.192	-1.518
ED	Min	0.405	1.038	1.338	0.044	1.429	0.993	0.241	0.656
	Max	0.584	1.491	1.685	0.211	1.912	1.526	0.429	0.841
	Mean	0.495	1.178	1.453	0.111	1.631	1.208	0.330	0.744
	Range	0.180	0.453	0.347	0.167	0.482	0.533	0.188	0.185
	StDev	0.058	0.113	0.095	0.056	0.127	0.161	0.047	0.047
	Variance	0.003	0.013	0.009	0.003	0.016	0.026	0.002	0.002
	Skewness	0.195	1.549	0.883	0.539	0.810	0.685	0.298	0.576
	Kurtosis	-1.549	2.229	0.585	-1.013	0.492	-0.450	-0.189	0.208

Table 4.1: Descriptive statistics

4.3.1 Panel unit root

Theoretical introduction

Before testing cointegration test, we verify that all variables are integrated with the same order. We employ the first generation panel unit root tests of Levin et al. 2002, Im et al. 2003 which are denoted LLC and IPS, and the second generation one of Pesaran 2007 which is denoted CIPS. The null hypothesis is that the series contain a unit root, while the alternative hypothesis is that the series do not contain a unit root. All tests of the first generation are based on the Augmented Dickey-Fuller (ADF) regression.

We consider a autoregressive process AR(1) for panel data:

$$y_{it} = \rho_i y_{it \ 1} + X_{it}\delta_i + \epsilon_{it} \tag{4.1}$$

where $i = 1, 2, .., N$ cross-section series, $t = 1, 2, ..., T$ period. X_{it} are the explanatory variables, ρ_i are the autoregressive coefficient.

The first generation tests assume independently distributed residuals.

The basic equation of LLC test (**Levin et al. 2002**) for the panel unit root:

$$\Delta y_{it} = \alpha y_{it \ 1} + \sum_{j=1}^{p_i} \beta_{ij} \Delta y_{i,t \ j} + X'_{it}\delta + \varepsilon_{i,t} \tag{4.2}$$

where $\alpha = \rho \quad 1$. The null and alternative hypothesis are:

$$\begin{cases} H_0 : \alpha = 0 \\ H_1 : \alpha < 0 \end{cases}$$

Levin et al. 2002 assumes that all panels have the same autoregressive parameter, and consider the terms ρ_i as homogeneous between individuals. They assume that all inter-individual heterogeneity is captured by the fixed effects.

The LLC statistic (t-statistic) is based on ADF statistics and can be computed:

$$\hat{t} = T \quad (\Sigma p_i/N) \quad 1 \tag{4.3}$$

But Im et al. 2003 allow each panel to have its own autoregressive parameter. Im et al. 2003 challenge the homogeneity of autoregressive root hypothesis which seems irrelevant.

The basic equation of IPS (**Im et al. 2003**) for the panel unit root is:

$$\Delta y_{it} = \alpha y_{it \quad 1} + \sum_{j=1}^{p_i} \beta_{ij} \Delta y_{it \quad j} + X'_{it}\delta + \varepsilon_{i,t} \tag{4.4}$$

where: i = 1,2,...N cross-section series; t = 1,2,...T; α_i is the individual fixed effect; $\varepsilon_{i,t}$ is the error term.

The null hypothesis is $H_0 : \alpha = 0, \forall i$, while the alternative hypothesis H_1 are:

$$\begin{cases} \alpha = 0, i = 1, 2, ..., N_1 \\ \alpha < 0, i = N_1 + 1, N_1 + 2, ..., N \end{cases}$$

The IPS statistic (t-statistic) is based on average ADF statistics and can be calculated following:

$$\bar{t} = \frac{1}{N} \sum_{j=1}^{N} t_i \tag{4.5}$$

where t_i is the ADF t-statistic for country i.

The second generation test will then apply an *interdependence* between the individual. We present the second generation of the panel unit root by the method of Pesaran 2007. The panel unit root of Pesaran 2007 takes into account cross-sectional dependence.

The CIPS statistic (**Pesaran 2007**) is based on average of individual Cross-Sectional ADF (CADF) statistics and can be written as follow:

$$\Delta y_{it} = \alpha_i + \rho_i y_{it\ \ 1} + c_i y_{t\ \ 1} + d_i \Delta \bar{y}_{t\ \ 1} + \nu_{it} \sum_{j=1}^{p} \phi_{ij} y_{i,t\ \ j} + \varepsilon_{i,t}; \tag{4.6}$$

$$CPIS = \frac{1}{N}\sum_{j=1}^{N} t_i(N,T) \tag{4.7}$$

where t_i is the statistics from each CADF administered to each individual i of the panel.

Panel unit root result

The panel unit root tests are presented for all variables in levels and in first differences in Table 4.2.

Series	*Levin, Lin, Chu*	*Im, Pesaran, Shin*	*Pesaran (CIPS)*
LCDS	**-9.2466***(0.0000)**	**-3.4171***(0.0003)**	-1.671 (0.564)
CA	-0.9600(0.1685)	**-1.3269*(0.0923)**	-2.008(0.222)
RES	-0.2669(0.3948)	-0.7367(0.2306)	-1.888(0.332)
ED	**-1.3043*(0.0961)**	0.0450(0.5179)	-1.918(0.303)
$\Delta LCDS$	-5.1157***(0.0000)	-4.7774***(0.0000)	-2.559** (0.011)
ΔCA	-6.8535***(0.0000)	-6.5774***(0.0000)	-2.944*** (0.003)
ΔRES	-4.3401***(0.0000)	-6.4481***(0.0000)	-2.817***(0.001)
ΔED	-0.5025(0.3076)	-6.6663***(0.0000)	-3.339*** (0.000)

Notes: ***, * mean that we reject the null hypothesis of unit root at the 1%, 10% level. P-value in parentheses

Table 4.2: Panel unit root for sovereign CDS, current account, external debt and exchange rate

For the first generation of panel unit root: The variables LCDS is stationary according to LLC and IPS at a 1% level. The variable CA is stationary according to the IPS test at a 10% level but not according to the LLC test. The variable RES is not stationary according to both LLC, IPS tests. The variable ED is stationary with LLC test at the 10% level, but not IPS test. Variables in first-differences are all stationary no matter the test.

The second generation CIPS test solves the biased results in the first generation. Focusing on the CIPS test, all variables in level are integrated with the same order *I(1)*. Therefore, we can test the existence of cointegration relationship among LCDS, CA, RES, ED.

4.3.2 Panel cointegration Test

We apply the panel cointegration tests proposed by Pedroni 1999 and Kao 1999. Both tests are based on the cointegration test of Engle and Granger 1987. The null hypothesis of the both tests is no cointegration.

We consider the following long-run regression:

$$LCDS_{it} = \alpha_{0t} + \delta_i t + \sum_{j=1}^{M} \alpha_{jt} X_{ji,t} + \varepsilon_{it} \tag{4.8}$$

where: $i = 1, 2, ...N$; $t = 1, 2, ...T$; X are the explanatory variables (CA,RES,ED). $LCDS$ and X are assumed to be integrated order I(1).

The estimated residual is constructed as follows:

$$\hat{\varepsilon}_{it} = \hat{\rho}_i \hat{\varepsilon}_{it\ \ 1} + \hat{u}_{it} \tag{4.9}$$

where ρ_i is the autoregressive term of the residual.

The null hypothesis of no cointegration is $H_0 : \rho_i = 1$, while the two alternative hypothesis H_1 are:

$$\begin{cases} (\rho_i = \rho) = 1, \forall i \\ \rho_i < 1, \forall i \end{cases}$$

Pedroni 1999 presents seven statistics depended on the two alternative hypothesis:

— The homogeneous alternative $(\rho_i = \rho) = 1$, Pedroni shows the four statistics are based on within-dimension: Panel-v, Panel-ρ, Panel-PP, Panel-ADF.

— The heterogeneous alternative $\rho_i < 1$, Pedroni shows the three statistics are based on between-dimension: Group ρ-statistic, Group PP-statistic, Group ADF-statistic.

These tests allow for heterogeneous intercepts and trends coefficients across cross-sections. The calculation of the seven statistics is found in the original article of Pedroni 1999.

Kao 1999 based the same approach as the Pedroni test, but specified cross-section specific intercept and homogeneous coefficients on the first-stage regressors[2]. Kao's test is performed over the residual estimation based on Augmented Dickey-Fuller test.

2. See Kao 1999 and Eviews 6 User's Guide for detail

The results are shown in Table 4.3 and Table 4.4 in below:

Pedroni(1999)	Statistic	Prob.
Panel-v	0.7316	0.4977
Panel-ρ	-1.3928	0.1267
Panel-PP	**-2.300*** **	**0.0030**
Panel-ADF	**-1.5619*** **	**0.0026**
Group ρ-statistic	0.1727	0.5686
Group PP-statistic	**-2.9813*** **	**0.0014**
Group ADF-statistic	**-3.1012*** **	**0.0010**

Notes: *** means that we reject the null hypothesis of no cointegration at the 1% level. We choose the AIC critical with a max lag of 3; No intercept or trend and Newey-West and Bartlett kernel selection.

Table 4.3: Panel cointegration test: Pedroni test

Kao(1999)	Statistic	Prob.
ADF	1.4535*	0.0730

Notes: * means that we reject the null hypothesis of no cointegration at the 10% level. We choose the AIC critical with a max lag of 4; No trend and Newey-West and Quadratic Spectral kernel selection.

Table 4.4: Panel cointegration test: Kao test

Table 4.3: Regarding the Panel-PP, Panel-ADF (within-dimension) statistic and Group PP-statistic and Group ADF-statistic (between-dimension), the results present that we have 4/7 tests that reject the null hypothesis of no cointegration at the 1 % level, except Panel-v, Panel-ρ and Group-ρ are not significant. More that, the results in Table 4.4 confirm that we reject the null hypothesis of no cointegration with ADF statistic at the 10 % level. Therefore, we can conclude

that there is cointegration between sovereign CDS spread and current account, external debt and international reserves.

4.3.3 Panel cointegration Estimation : Pooled Mean Group estimation

In order to test Panel cointegration estimation, we use Pooled Mean Group (PMG), Mean Group estimation (MG) and Fixed Effect Estimation approach. Pooled Mean Group estimates the presence of dynamic long-run based on the methodology of M Hashem Pesaran et al. 1997, 1999.

We analyse the role of the current account, the external debt and international reserves with sovereign CDS spread for all countries in this panel. The use of the PMG estimator is consistent with some recent literature such as Martinez-Zarzoso and Bengochea-Morancho 2004; Bangake and Eggoh 2012.

The approach we adopted here is the determination of long-term relationship among LCDS, CA, RES, ED, LER. Here, we investigate cointegration estimation using an empirical formalization using panel data.

We assume that the long-run sovereign CDS function:

$$LCDS_{it} = \alpha_{0t} + \alpha_{1t}CA_{it} + \alpha_{2t}RES_{it} + \alpha_{3t}ED_{it} + \mu_i + \varepsilon_{it} \tag{4.10}$$

Where LCDS is sovereign CDS in log; CA is ratio of the current account to GDP;

RES is ratio of international reserves to GDP; ED is ratio of the external debt to GDP; $i = 1, 2, ..., 8$ is the number of countries; $t = 1, 2...T$ is number of periods.

We assume that all these variables are I(1) and co-integrated for individual countries, leading the error term an I(0) process for all i.

The ARDL(1,1,1,1) dynamic panel specification of equation (4.10) is:

$$LCDS_{it} = \delta_{10i}CA_{it} + \delta_{11i}CA_{i,t\ \ 1} + \delta_{20i}RES_{it} + \delta_{21i}RES_{i,t\ \ 1} + \delta_{30i}ED_{it} + \delta_{31i}ED_{i,t\ \ 1} + \lambda_i LCDS_{i,t\ \ 1}\mu_i + \epsilon_{it} \quad (4.11)$$

The error correction (ec) of equation (4.11) is:

$$\Delta LCDS_{it} = \phi_i(LCDS_{i,t\ \ 1}\quad \alpha_{0i}\quad \alpha_{1i}CA_{it}\quad \alpha_{2i}RES_{it}\quad \alpha_{3i}ED_{it}) + \delta_{11i}\Delta CA_{it} + \delta_{21i}\Delta RES_{it} + \delta_{31i}\Delta ED_{it} + \epsilon_{it} \quad (4.12)$$

Where

$\phi_i = \quad (1 \quad \lambda_i)$, $\alpha_{0i} = \dfrac{\mu_i}{1 \quad \lambda_i}$, $\alpha_{1i} = \dfrac{\delta_{10i} + \delta_{11i}}{1 \quad \lambda_i}$, $\alpha_{2i} = \dfrac{\delta_{20i} + \delta_{21i}}{1 \quad \lambda_i}$, $\alpha_{3i} = \dfrac{\delta_{30i} + \delta_{31i}}{1 \quad \lambda_i}$,

The error-correction of adjustment parameter is ϕ_i, the long-run coefficient is α_{1i}, α_{2i}, α_{3i} for CA, RES, ED respectively. In long-run equilibrium, the coefficient of error-correction ϕ_i must be negative and significant. PMG allows for heterogeneous common long-run for all countries, and short-run dynamic the sovereign CDS, the current account to GDP, the external debt to GDP and international reserves to GDP. However, MG will produce consistent estimates of the average of the parameters (M Hashem Pesaran et al. 1997, 1999).

Variable	*Long-run coef. (PMG)*	*Long-run coef. (MG)*	*Long-run coef. (DFE)*
CA	-3.535***	-13.981**	-5.132**
	(1.139)	(5.796)	(2.211)
ED	2.470***	-1.959	0.088
	(0.319)	(4.263)	(0.532)
RES	-5.610***	-4.379**	-0.807
	(0.873)	(1.904)	(0.655)
constant	2.611***	4.259***	2.128
	(0.560)	(1.193)	(0.211)
ec	-0.437***	-0.606***	-0.385***
	(0.112)	(0.100)	(0.181)

Notes: Standard errors in parentheses. ***, ** means that the coefficient is significant at the 1%, 5% level

Table 4.5: Panel cointegration estimation: Pooled Mean Group, Mean Group and Dynamic Fixed Effect

Table 4.5 shows the Pooled Mean Group, Mean Group estimation and Dynamic Fixed Effect estimation. In these estimations, the coefficient sign of the current account is always negative and significant at the 5 % level. But, the coefficient sign of international reserves is negative and significant at the 1 % for Pooled Mean Group and 5 % for Mean Group, not for Dynamic Fixed Effect estimation. Addition, the coefficient sign of the external debt is negative for Mean Group and positive as expected with theoretical economic for the Pooled Mean Group and the

Dynamic Fixed Effect, but only significant statistically at the 1% level for Pooled Mean Group estimation, not for the Dynamic Fixed Effect.

By taking into account both statistical and theoretical significance, the Pooled Mean Group estimation is the best among the three. The PMG's result in long-run and short-run is shown in Table 4.6:

Variable	*Long-run coef.*	*Variable*	*Short-run coef.*
CA	-3.535***	ΔCA	3.148**
	(1.139)		(1.237)
ED	2.470***	ΔED	1.779**
	(0.319)		(0.817)
RES	-5.610***	ΔRES	-1.803*
	(0.873)		(1.923)
constant	2.611***		
	(0.560)		
ec	-0.437***		
	(0.112)		

Notes: Standard errors in parentheses. ***, **, * means that the coefficient is significant at the 1%, 5%, 10%, level

Table 4.6: Panel cointegration estimation: Pooled Mean Group

The results of the long-run and short-run of the current account to GDP, the external to GDP, international reserves to GDP and the error correction coefficient report in Table 4.6. The estimated coefficient of error-correction in PMG is negative (-0.437) and significant at the 1% level as expected, confirming the existence of long-run equilibrium.

The estimation results show that the coefficient of the current account to GDP ratio is negative (-3.535) and significant at the 1 % level for all countries. This result reflects that a one unit increase in current account for all countries implies a 34 basic points decrease in the sovereign CDS spread. In a more detailed fashion, if a country improves its current account deficit, it will have more money to service its debt and its sovereign default probability, as well as its sovereign CDS spread, will fall.

The coefficient of the external debt to GDP ratio is positive (2.470) and significant for all countries at the 1 % level as expected. This finding clearly shows that if the external debt increases by 1 %, the sovereign CDS spread will rise by 11 basic points. Indeed, the increase of the external debt burden leads to the rise of the sovereign default probability. This affects the growth of the sovereign CDS spread.

The coefficient of international reserves is negative (-5.610) and significant at the 1 % level as expected. This result implies that if government's liquidity increases by 1 %, then the sovereign CDS spread will decline by 273 basic points. By comparing the three coefficients, an interesting result that emerges is that the impact of international reserves is the largest one. This issue suggests that in order to reduce country's risk in the long run, governments belonging to this panel should focus more on increasing their international reserves rather than decreasing their external debt and their current account deficit. Furthermore, to serve their debt governments could use international reserves instead of trying to reduce the external debt burden and the current account deficit.

The estimation of the short-run coefficients are mentioned in Table 4.6 for the global panel and in Table 4.7 for each country.

Variable	Bra	Mala	S-Kor	Thai	Tur	S-Afri	Indo	Mexi
ΔCA	-0.409	-0.902	5.122**	0.479	8.352***	0.989	5.714	5.838
	(6.739)	(1.716)	(2.383)	(1.013)	(1.257)	(1.349)	(15.89)	(5.564)
ΔRES	-2.053	-0.791	2.529	-0.486	**-3.918*** **	3.867*	-13.83	0.263
	(3.219)	(0.599)	(2.679)	(0.760)	(1.269)	(2.161)	(15.94)	(2.819)
ΔED	3.933	**2.218*** **	-0.739	3.982	0.708	-1.634**	4.634	1.132
	(3.076)	(0.651)	(1.507)	(5.448)	(0.439)	(0.726)	(5.338)	(1.818)
Constant	2.132**	1.760*	6.033***	1.770	3.601***	1.036***	1.767**	2.787**
	(0.939)	(0.925)	(1.625)	(1.298)	(0.712)	(0.386)	(0.789)	(1.123)
ec	-0.315**	-0.150*	-0.813***	-0.120	-1.000***	-0.231***	-0.362**	-0.505**
	(0.140)	(0.0792)	(0.205)	(0.0847)	(0.169)	(0.0808)	(0.149)	(0.201)
Observations	144	144	144	144	144	144	144	144

Standard errors in parentheses

***, **, * means that the coefficient is significant at the 1%, 5%, 10%, level

Table 4.7: Panel cointegration estimation: short-run for each country in PMG

For the all countries, three short-run coefficients are significant statistically. But in as expected, the external debt to GDP and international reserves to GDP are significant as theoretical economics at the 5% and 1% level respectively. As Figure 4.7 show, the short-run coefficient of international reserves is -3.918 significant as expected at the 1% level for Turkey. Likewise, the short-run coefficient of external debt is 2.218 significant at the 1% level for Malaysia as expected. The coefficient of the current account to GDP is not significant vis-à-vis theoretical economics for the global panel and each country also.

4.4 Conclusion

This chapter focused on linking between the sovereign CDS spread and the current account, the external debt and international reserves in long-run and short-run for eight emerging countries by using the model of the Pooled Mean Group, Mean Group and Dynamic Fixed Effect.

Results from the panel unit root test show that the second generation CIPS test of Pesaran 2007 solves the biased results in the first generation of Levin et al. 2002; Im et al. 2003. This result indicates that all variables in level are integrated with the same order $I(1)$. Hence, we can examine the panel cointegration test. In the next step, we used the panel cointegration test proposed by Pedroni 1999; Kao 1999. Our findings can consider that we reject the null hypothesis of non cointegration, reporting the existence of a co-integration relationship among the sovereign CDS spread, the current account, the external debt and international reserves.

The main purpose of this chapter would be to focus in the long-run by using the Pooled Mean Group, Mean Group of M Hashem Pesaran et al. 1997, 1999. Our findings suggest a strong long-run effect of the current account, the external debt and international reserves on the sovereign CDS spread in the whole panel. In a more detailed fashion, we found the negative effect of the current account, international reserve and the positive effect of the external debt on the sovereign CDS spread confirming all coefficients are significant and consistent with the economic theory for all countries in the long-run. This contribution fills a gap in the previous studies of Georgievska et al. 2008 and IMF-Report 2013 which take into account only a specific and limited time period without examining the long run effects. Finally, we find interestingly that international reserves have the largest impact. In other words, regulators should focus on policies aiming at increasing international reserves rather than solving the external debt burden and the current account deficit.

Note also that our estimations also indicate that in the short-run, the external debt and international reserves are significant for eight emerging countries. Especially, the short-run coefficients of international reserves, the external debt are significant for Turkey, Malaysia respectively. The current account is not significant in the short-run for all countries.

CHAPTER 5

Long-run determinants of sovereign bond in emerging markets: New evidence from asymmetric and nonlinear pass-through

5.1 Introduction

Since the financial crises in the 90s for Asia, in the 2000s for Latin America to the current global financial crisis, the sovereign bond spread has been an important indicator to measure the country risk. In this chapter, we investigate how to estimate the sovereign bond index, represented by *Emerging Market Bond Index Plus (EMBI+)*. This index will be determined in the short-run (SR) and long-run (LR) from the fundamental macroeconomic variables by using an asymmetric model. According to JP-Morgan 2004, the EMBI+ is a JPMorgan's index capturing the total return for liquid sovereign debt in emerging markets.

In this section, we start by reviewing the literature of determination of Emerging Market Bond Index Plus by fundamental macroeconomics variables. Many papers have studied the relationship between the sovereign bond and the fundamental macroeconomics by the panel technique, but a limited number have used time-series (Nogués and Grandes 2001; Ebner 2009). In a more detailed fashion, Ferrucci 2003 tests 11 emerging countries from the period 1997-2002 in order to determine the EMBI+ and EMBI Global in the short and long-term. His work finds that external liquidity conditions are important factors of market spreads. Moreover, Petrova et al. 2010 have developed the work of Ferrucci 2003 by using fixed effect for a long period from 1997.Q1-2009.Q2 for a panel of 14 emerging markets. There are two groups of explanatory variables, the first consists of macroeconomic variables such as the external debt/GDP [1], interest payments on external debt/reserves, short-term debt/reserves, external debt amortization/reserves, fiscal balance/GDP, current account balance/GDP, trade openness, the second of financial

1. They use an interpolation technique in order to convert the annual external debt to quarterly data

variables such as a financial stress index, risk-free rate, U.S. 3-month Treasury bill rate, 10-year government bond yield, and volatility index *VIX* (Min 1998).

Rowland and Torres 2004 use a random-effect generalized least squares regression for a panel of 16 emerging markets from 1998 to 2002. They find significant explanatory variables including the economic growth rate, the debt-to-GDP ratio, the reserves-to-GDP ratio, and the debt-to-exports ratio. Furthermore, Gupta et al. 2008 explain the sovereign bond spreads by opting two-stage least squares and Generalized Method of Moments for a panel of 30 emerging market economies from 1997 to 2007. Their paper highlights the fiscal variable that is most essential and has a larger impact on EMBI+. Jaramillo and Tejada 2011 study the fixed effect for a panel of 35 emerging markets in the period 1997-2010 which indicates that the investment grade status reduces bond spreads by 36 percent.

There are rare papers that analyse a specific country. Nogués and Grandes 2001 focus on how to determine Argentina's EMBI+ in the period 1994 to 1998 by applying the estimation technique of M. Hashem Pesaran et al. 2001. They find the existence of a long-run relationship between the following series: the debt-service-to-export ratio, the GDP growth rate, the fiscal balance and the 30-year US Treasury yield had a significant impact on the spread. In addition, for the advanced markets, Ebner 2009 creates the spread between 10 year Euro denominated Central and Eastern European government bonds and their German counterpart.

To explain the rising of these spreads, that article finds during crisis periods that there are three explanatory factors: the market volatility, political instability and global factors. The limitations of the previous papers is that they have not examined any asymmetric effect in the long-run and short-run. The contribution of my chapter will fill this gap.

The literature reviewing of asymmetric and non-linear model begins with Balke and Fomby 1997 who introduce the threshold cointegration with a regime-switching type model. Granger and Yoon 2002 highlight the "hidden cointegration" explaining that if the positive and negative components are cointegrated, the series bear the "hidden cointegration". Schorderet 2003 develop the paper of Granger and Yoon 2002 in order to estimate the asymmetric effect of hidden cointegration. Based on the work of M. Hashem Pesaran et al. 2001, some studies test the cointegration for small samples (Romilly et al. 2001; Narayan 2005; Baek and Gweisah 2013).

The asymmetric nonlinear approach is used in the recent articles: Katrakilidis and Trachanas 2012 present the asymmetric consumer price index and GDP to housing price for Greece's case. Delatte and López-Villavicencio 2012; Elbejaoui 2013 study the asymmetric exchange rate pass-through to domestic general price and to export/import prices respectively. Shin et al. 2014 show the empirical result of the asymmetric unemployment on output. Atil et al. 2014 propose the pass through of crude oil prices to gasoline and natural gas prices.

The remainder of this chapter is organized as follows: in the next section we present the econometric methodology to examine the long-run, short-run asymmetry of the sovereign bond and then empirical results. The last section is a conclusion.

5.2 Econometric approach

In this chapter, we study the cointegration autoregressive distributed lag (ARDL) to examine the fundamental macroeconomics to emerging market bond index. The ARDL symmetry is developped by M. Hashem Pesaran et al. 2001, and the nonliear ARDL (NARDL) asymmetry is extended for by Shin et al. 2014. This methodology allows to estimate the asymmetry long-run and short-run relationship. We contribute the empirical results of the long-run and the short-run asymmetric relationship between the sovereign bond index and fundamental macroeconomics for two emerging market. Likewise the fourth chapter, we propose the explanatory variables in this chapter are the current account to GDP ratio represented *macroeconomic variable*, the external debt to GDP ratio and international reserves to GDP ratio represented the *government's solvency* and the *government's liquidity* variable respectively.

We assume that the cointegration long-run regression:

$$LE_t = \alpha_0 + \alpha_1 CA_t + \alpha_2 ED_t + \alpha_3 RES_t + \epsilon_t \tag{5.1}$$

where LE is Emerging Market Bond Index Plus (EMBI+) in log; CA is ratio of current account to GDP; ED is ratio of external debt to GDP; RES is international reserves to GDP ratio; t=1,2...T is number of periods.

Following Shin et al. 2014, we adopt the error correction model (ECM) to estimate linear relationship:

$$\Delta LE_t = c + \rho_e LE_{t\ \ 1} + \rho_c CA_{t\ \ 1} + \rho_d ED_{t\ \ 1} + \rho_r RES_{t\ \ 1} + \sum_{i=1}^{p} b_i \Delta LE_{t\ \ i}$$
$$+ \sum_{i=0}^{q} c_i \Delta CA_{t\ \ i} + \sum_{i=0}^{q} d_i \Delta ED_{t\ \ i} + \sum_{i=0}^{q} e_i \Delta RES_{t\ \ i} + \upsilon_t \tag{5.2}$$

where Δ is the first difference operator. $\rho_e, \rho_c/\quad \rho_e, \rho_d/\quad \rho_e, \rho_r/\quad \rho_e$ are the error term, long-run coefficients of the current account, the external debt and international reserves respectively; c_i, d_i, e_i are the short-run coefficients.

In order to determine asymmetry pass-through of current account [2] to sovereign bond index, we employ the approach of Schorderet 2003; Shin et al. 2014. This model requires the decomposition variables that are expressed by excess current

2. We do not present asymmetric effect of the external debt and international reserves in this chapter because we do not find the cointegration between the EMBI+ and explanatory variables if we allow the asymmetric effect of the external debt and international reserves in the model

account and deficit current account. Two variables CA^+ and CA^- are partial sums of positive and negative changes of the current account. These are calculated by:

$$CA_t^+ = \sum_{j=1}^{t} \Delta CA_j^+ = \sum_{j=1}^{t} max(\Delta CA_j, 0); CA_t^- = \sum_{j=1}^{t} \Delta CA_j^- = \sum_{j=1}^{t} min(\Delta CA_j, 0). \quad (5.3)$$

Equation (5.3), equation (5.2) can be expressed by long-run and short-run asymmetry relationship by:

$$\Delta LE_t = c + \rho_e LE_{t-1} + \rho_c^+ CA_{t-1}^+ + \rho_c^- CA_{t-1}^- + \rho_d ED_{t-1} + \rho_r RES_{t-1} + \sum_{i=1}^{p} \varphi_i \Delta LE_{t-i}$$
$$+ \sum_{i=0}^{q} \{\pi_i^+ \Delta CA_{t-i}^+ + \pi_i^- \Delta CA_{t-i}^- + d_i \Delta ED_{t-i} + e_i \Delta RES_{t-i}\} + \upsilon_t \quad (5.4)$$

where $L_{ca}^+ = \rho_c^+ / -\rho_e$ and $L_{ca}^- = \rho_c^- / -\rho_e$ are positive and negative long-run coefficients of the current account to EMBI+ respectively, and $L_d = \rho_d / -\rho_e$, $L_r = \rho_r / -\rho_e$ the long-run coefficient of the external debt, international reserves to EMBI+.

Following Shin et al. 2014, Equation (5.4) can be modified to allow for long-run symmetry & short-run asymmetry (Equation (5.5)) and long-run asymmetry & short-run symmetry (Equation (5.6)).

Only short-run asymmetry:

$$\Delta LE_t = c + \rho_e LE_{t\;\;1} + \rho_c CA_{t\;\;1} + \rho_d ED_{t\;\;1} + \rho_r RES_{t\;\;1} + \sum_{i=1}^{p} \varphi_i \Delta LE_{t\;\;i}$$
$$+ \sum_{i=0}^{q} \{\pi_i^+ \Delta CA_{t\;\;i}^+ + \pi_i\;\; \Delta CA_{t\;\;i} + d_i \Delta ED_{t\;\;i} + e_i \Delta RES_{t\;\;i}\} + \upsilon_t \quad (5.5)$$

Only long-run asymmetry:

$$\Delta LE_t = c + \rho_e LE_{t\;\;1} + \rho_c^+ CA_{t\;\;1}^+ + \rho_c\;\; CA_{t\;\;1} + \rho_d ED_{t\;\;1} + \rho_r RES_{t\;\;1} + \sum_{i=1}^{p} \varphi_i \Delta LE_{t\;\;i}$$
$$+ \sum_{i=0}^{q} \{\pi_i^+ \Delta CA_{t\;\;i} + d_i \Delta ED_{t\;\;i} + e_i \Delta RES_{t\;\;i}\} + \upsilon_t \quad (5.6)$$

Equation (5.4), (5.5), (5.6) present the long-run cointegration between EMBI+ and positive/negative component of the current account with the two control variable, such as the external debt and international reserves.

In order to test the existence of an asymmetric long-run cointegration, Shin et al. 2014 propose the *bounds test* that is a joint test on all the lagged levels regressors. There are two tests: t-statistic of Banerjee et al. 1998 and F-statistic of M. Hashem Pesaran et al. 2001. The t-statistic tests the null hypothesis of $\rho_e = 0$ against the alternative hypothesis $\rho_e < 0$. The F-statistic tests the null hypothesis of $\rho_e = \rho_c^+ = \rho_c\;\; = \rho_d = \rho_r = 0$ for the case of long-run asymmetry; and $\rho_e = \rho_c = \rho_d = \rho_r = 0$ for the case of only long-run symmetry. If we reject the null hypothesis of no cointegration, indicating there is not a long-run relationship among the variables.

The long-run symmetry can be tested by the *Wald test* of the null hypothesis of $L_{ca}^{+} = L_{ca}$; to test the existence of short-run symmetry, we use the *Wald test* to test the null hypothesis of $\sum_{i=0}^{q} \pi_i^{+} = \sum_{i=0}^{q} \pi_i$. If we reject the null hypothesis of symmetric, implying the model allow the asymmetric effect.

When the null hypothesis of symmetric is rejected, we can find the asymmetric dynamic multiplier of the change of the current account CA^{+} and CA respectively:

$$m_h^{+} = \sum_{j=0}^{h} \frac{\partial LE_{t+j}}{\partial CA_t^{+}}; m_h = \sum_{j=0}^{h} \frac{\partial LE_{t+j}}{\partial CA_t} \tag{5.7}$$

where $h \to \infty$, $m_h^{+} \to L_{ca}^{+}$ and $m_h \to L_{ca}$. The dynamic multipliers could capture the positive and negative shock of the current account on the EMBI+ from an initial equilibrium to the new equilibrium (Shin et al. 2014).

5.3 Econometrics Results

5.3.1 Data

In this chapter, we use quarterly data from 2000.Q1 to 2011.Q4 for two typical emerging countries: Brazil, Turkey. Emerging Market Bond Index in log denoted LE is taken from Datastream. CA is the current account to GDP ratio, ED is the external debt to GDP ratio. Both are found in Central Bank of each country. RES is international reserves to GDP ratio (IMF International Financial Statistic). Table 5.1 shows the descriptive statistics.

	Var.	Min	Max	Mean	StDev	Skewness	Kurtosis
Turkey	LE	5.16	6.81	5.88	0.50	0.52	-1.07
	CA	-0.11	0.04	-0.04	0.03	0.34	0.14
	ED	1.31	2.59	1.66	0.30	1.40	1.58
	RES	0.25	0.49	0.40	0.05	-0.56	0.17
Brazil	LE	5.05	7.36	5.96	0.62	0.43	-0.82
	CA	-0.06	0.03	-0.01	0.02	-0.10	-0.68
	ED	0.40	1.99	0.95	0.50	0.51	-1.24
	RES	0.17	0.57	0.37	0.12	0.21	-1.28

Table 5.1: Descriptive statistics

5.3.2 Results

We first present the long-run relationship results by the bound test for the four models: LR & SR symmetry with equation (5.2), LR, SR asymmetry with equation (5.4), LR symmetry & SR asymmetry with equation (5.5) and LR asymmetry & SR symmetry with equation (5.6). Both t-statistic and F-statistic are reported in Table 5.2 below:

		LR & SR symmetry	LR symmetry & SR asymmetry	LR asymmetry & SR symmetry	LR & SR asymmetry
Turkey	t_{BMD}	**-3.813****	-0.782	3.586^{i}	-0.543
	F_{PSS}	**5.767****	**4.258****	**4.784****	**5.278****
	W_{LR}	-	-	**9.659**	0.264
	W_{SR}	-	**6.066**	-	**16.236**
Brazil	t_{BMD}	**-3.217***	**-3.649****	3.112^{i}	**-3.941****
	F_{PSS}	3.496^{i}	4.605^{i}	2.491^{i}	**4.777****
	W_{LR}	-	-	0.021	**4.829**
	W_{SR}	-	1.324	-	1.727

Notes: t_{BMD} denotes the t-statistic of Banerjee et al. 1998 and F_{PSS} is the F-statistic of M. Hashem Pesaran et al. 2001 testing the null hypothesis $\rho_e = 0$ and $\rho_e = \rho_c = \rho_d = \rho_r = 0$ (for only short-run asymmetric), $\rho_e = \rho_c^+ = \rho_c = \rho_d = \rho_r = 0$ (for long-run asymmetric) respectively. *,** indicate the rejection of the null hypothesis of no cointegraion at the 10 %, 5 % level, and i implies that we cannot reject the null hypothesis of no cointegration. For Brazil, equation (5.4),(5.5),(5.6) is without the RES variable cause the sign of RES is positive. Hence in order to avoid many table, we do not present the Brazil's results with the RES variable, therefore to test long-run relationship, we test $\rho_e = 0$, $\rho_e = \rho_c = \rho_d = 0$ (for only short-run asymmetric), $\rho_e = \rho_c^+ = \rho_c = \rho_d = 0$ (for long-run asymmetric)

Table 5.2: Bounds cointegration test

As shown in Table 5.2 for Turkey, all of F-test statistics exceed their upper critical values so we can reject the null hypothesis of no cointegration relationship between the EMBI+ and explanatory variables. Nevertheless, t-test statistics are infer the lower critical values for long-run symmetry & short-run asymmetry and long-run & short-run asymmetry model, implying we do not reject the null hypothesis of no cointegration. However, for long-run asymmetry & SR symmetry model, t-test statistic is between the lower and upper critical values, so we cannot reject the null hypothesis of cointegration. In this case, we can consider the existence of long-run relationship between the EMBI+ and the explanatory variables for Turkey.

Regarding F-test and t-test statistics for Brazil: t-test statistic is between its lower and upper critical value for LR asymmetry & SR symmetry, indicating we cannot reject the null hypothesis of cointegration for this case. The three others of t-test statistic exceed their upper critical values, suggesting that we reject the null hypothesis of no cointegration. As seen, only F-test statistic of long-run & short-run asymmetry model is rejected the null hypothesis of no cointegration while others F-test statistics are between their lower and upper critical values, reporting that we cannot reject the null hypothesis of no cointegration. Hence, both t-statistic and F-statistic confirm to reject the null hypothesis of no cointegration if we allow the short-run and long-run asymmetric. By considering the existence of long-run cointegration for symmetric model, we can therefore conclude the cointegration between EMBI+ and the explanatory variables for Brazil.

In total, the preferred models that we will present in the next section which are symmetric model and LR asymmetric & SR symmetric model for Turkey, and symmetric model and long-run & short-run asymmetric model for Brazil.

Table 5.3 reports the long-run estimations of the ARDL symmetric and asymmetric models for Turkey and Brazil. The error correction terms are significant at 1% level for four case of Turkey and Brazil.

The overall impression is the sign of all coefficients long-run is as expected and consistent with the economic theory.

The sign coefficient of the current account for Turkey is negative as expected for two cases, but it is not significant statistically with symmetric model, and it becomes significant with long-run asymmetry model at 5% level. The long-run coefficient of the current account with symmetric model for Turkey is -3.574, indicating that the increase (decrease) by 3.574 of LMBI makes the current account to improve (decline). The long-run coefficients of the positive and negative component of the current account are -8.065, -6.565 respectively, implying that LMBI increases -8.065 when the current account improves 1% and decreases 6.565 when the current account declines 1%. The asymmetric long-run effect is confirmed by the *Wald test* (9.659) that exceeds its upper critical value of M. Hashem Pesaran et al. 2001, reflecting the fact that we reject the null hypothesis of symmetric in the model.

The long-run coefficient of the current account with symmetric model for Brazil is weaker than one of Turkey which is -0.902. The long-run coefficients of the posi-

		Symmetric ARDL			*NARDL with LR asymmetry*	
Turkey	*Var.*	*Coeff.*	*t-stat*	*Var.*	*Coeff.*	*t-stat*
	ρ_e	-0.491***	-3.813	ρ_e	-0.492***	-3.586
	ρ_c	-1.755	-1.113	ρ_c^+	-3.968**	-2.561
	ρ_d	0.854***	4.155	ρ_c	-3.230**	-2.105
	ρ_r	-1.747**	-2.421	ρ_r	-0.551	-0.736
				ρ_d	0.766***	3.841
	L_{ca}	**-3.574**		L_{ca}^+	**-8.065**	
	L_d	**1.739**		L_{ca}	**-6.565**	
	L_r	**-3.558**		L_d	**1.557**	
	R^2	0.701		L_r	**-1.119**	
				t_{BMD}	-3.586	
				F_{PSS}	4.784	
				R^2	0.626	
Brazil		*Symmetric ARDL*			*NARDL with LR,SR asymmetry*	
	ρ_e	-0.409***	-3.217	ρ_e	-0.529***	-3.941
	ρ_c	-0.369	-0.312	ρ_c^+	-0.643	-0.452
	ρ_d	0.477***	3.065	ρ_c	-3.536*	-1.879
				ρ_d	0.994***	4.179
	L_{ca}	**-0.902**		L_{ca}^+	**-1.216**	
	L_d	**1.166**		L_{ca}	**-6.684**	
	R^2	0.646		L_d	**1.879**	
				t_{BMD}	-3.941	
				F_{PSS}	4.777	
				R^2	0.757	

Notes: we apply a general-to-specific approach to find the final specification by setting $p = q = 4$. L_{ca}^+, L_{ca}, L_{ca}, L_d and L_r are the long-run coefficients of the current account, the external debt and international reserves to LMBI. t_{BMD} denotes the t-statistic of Banerjee et al. 1998 and F_{PSS} is the F-statistic of M. Hashem Pesaran et al. 2001 testing the null hypothesis $\rho_e = 0$ and $\rho_e = \rho_c = \rho_d = 0$ respectively

Table 5.3: Long-run estimates of the symmetric and asymmetric current account pass-through

tive, negative component of the current account for Brazil are -1.216, -6.684 respectively, suggesting that LMBI increases 1.216 when the current account improves 1% and decreases 6.684 when the current account declines 1%. More specifically, the positive component effect is higher than the negative one for Turkey but that phenomenon is on the other way round for Brazil. The long-run asymmetric for Turkey is confirmed by the *Wald test* (9.659) that exceeds its upper critical value of M. Hashem Pesaran et al. 2001, reporting that we reject the null hypothesis of symmetry in the model.

The finding of the long-run coefficient of the external debt for Turkey is 1.739 in symmetric model which is higher than 1.557 for the asymmetric model, announcing that LMBI will increases (decreases) 1.739 and 1.557 when the external debt increases (declines) 1% for the symmetric model and asymmetric model respectively. But in Brazil, the long-run coefficient of the external debt is 1.116 smaller than the one when we allow both long-run and short-run asymmetric effect that is 1.879, revealing that LMBI increases (decreases) 1.116, 1.879 when the external debt increases (declines) 1%.

Comparing our results with the finding of Petrova et al. 2010, who use the pooled mean group approach for 14 emerging markets including Turkey and Brazil. The long-run coefficient current account varies from -3.033 to -3.364, and the long-run coefficient external debt flutters from 2.205 to 2.655. The previous results have just linear coefficients for all countries including Turkey and Brazil which do not distinct the impact of the positive and negative shocks. Successfully, our findings show clearly the change of the LMBI with the different positive and negative shocks.

The long-run coefficients of international reserves for Turkey are -3.558 for symmetric model and -1.119 for asymmetric model, signalling if Turkey's government increases its liquidity then EMBI+ decreases -3.558, -1.119 for the symmetric model and asymmetric model respectively. We do not present international reserves for the Brazil in this chapter because the sign of long-run coefficient of international reserves is positive not as expected with theoretical economic.

The long-run asymmetric statistic test for Brazil is confirmed by the Wald test (4.829) that exceeds its upper the critical value of M. Hashem Pesaran et al. 2001, indicating we reject the null hypothesis of symmetric in the model, and the *Wald test* for short-run asymmetric is 1.727 below the its critical value, but we cannot to reject the null hypothesis of short-run symmetry.

From the view point of risk management, the findings of Turkey show very interesting. In order to reduce country risk, the current account and international reserves have more important role than the external debt in long-run. The role of these two factors is almost equality in the symmetric model ($L_{ca} = \quad 3.574, L_r = \quad 3.558,$). But improving the current account will reduce higher than increasing international reserves ($L^{+}_{ca} = \quad 8.065, L_r = \quad 1.119,$). In to order explain the role of external debt, the government has sufficient time in long-run to restructure the external debt. For the Brazil, we do not find the same results.

Table 5.3 and Table 5.4 present the short-run coefficients of the symmetric and asymmetric model for the Turkey and Brazil respectively.

		Symmetric ARDL			*NARDL with LR asymmetry*	
Turkey	*Var.*	*Coeff.*	*t-stat*	*Var.*	*Coeff.*	*t-stat*
	$\Delta LE_{t\ 1}$	0.512**	2.485	$\Delta LE_{t\ 1}$	0.329***	2.067
	$\Delta LE_{t\ 2}$	-	-	$\Delta LE_{t\ 2}$	-	-
	$\Delta LE_{t\ 3}$	0.173	1.165	$\Delta LE_{t\ 3}$	-	-
	$\Delta LE_{t\ 4}$	0.302**	2.063	$\Delta LE_{t\ 4}$	-	-
	ΔCA_t	-	-	ΔCA_t	-	-
	$\Delta CA_{t\ 1}$	0.982	0.780	$\Delta CA_{t\ 1}$	0.771	0.607
	$\Delta CA_{t\ 2}$	-	-	$\Delta CA_{t\ 2}$	-	-
	$\Delta CA_{t\ 3}$	-	-	$\Delta CA_{t\ 3}$	-	-
	$\Delta CA_{t\ 4}$	-	-	$\Delta CA_{t\ 4}$	-	-
	ΔED_t	0.511***	3.083	ΔED_t	0.575***	3.739
	$\Delta ED_{t\ 1}$	-	-	$\Delta ED_{t\ 1}$	-	-
	$\Delta ED_{t\ 2}$	-0.727**	-2.653	$\Delta ED_{t\ 2}$	-	-
	$\Delta ED_{t\ 3}$	-0.167	-1.099	$\Delta ED_{t\ 3}$	-	-
	$\Delta ED_{t\ 4}$	-0.281*	-2.002	$\Delta ED_{t\ 4}$	-	-
	ΔRES_t	-	-	ΔRES_t	-	-
	$\Delta RES_{t\ 1}$	-2.535***	-2.952	$\Delta RES_{t\ 1}$	-1.992***	-2.774
	$\Delta RES_{t\ 2}$	2.956**	2.260	$\Delta RES_{t\ 2}$	-	-
	$\Delta RES_{t\ 3}$	-	-	$\Delta RES_{t\ 3}$	-	-
	$\Delta RES_{t\ 4}$	-	-	$\Delta RES_{t\ 4}$	-	-
	c	2.092***	2.901	c	2.049***	3.018

Notes: we apply a general-to-specific approach to find the final specification by setting $p = q = 4$. L_{ca} and $L_d$are the long-run coefficients of current account and external debt to LMBI. t_{BMD} denotes the t-statistic of Banerée(1998) and F_{PSS} is the F-statistic of PSS(2001) testing the null hypothesis $\rho_e = 0$ and $\rho_e = \rho_c = \rho_d = 0$ respectively

Table 5.4: Short-run estimates of the symmetric and asymmetric model for Turkey

		Symmetric ARDL		*NARDL with LR, SR asymmetry*		
Brazil	*Var.*	*Coeff.*	*t-stat*	*Var.*	*Coeff.*	*t-stat*
	$\Delta LE_{t\ 1}$	0.223*	1.793	$\Delta LE_{t\ 1}$	0.411**	2.309
	$\Delta LE_{t\ 2}$	-	-	$\Delta LE_{t\ 2}$	-	-
	$\Delta LE_{t\ 3}$	0.156	1.259	$\Delta LE_{t\ 3}$	0.341*	-2.001
	$\Delta LE_{t\ 4}$	-	-	$\Delta LE_{t\ 4}$	0.333**	2.128
	ΔCA_t	-	-	ΔCA^+_t	-	-
	$\Delta CA_{t\ 1}$	-	-	$\Delta CA^+_{t\ 1}$	-	-
	$\Delta CA_{t\ 2}$	-2.504	-1.543	$\Delta CA^+_{t\ 2}$	-7.829**	-2.463
	$\Delta CA_{t\ 3}$	-	-	$\Delta CA^+_{t\ 3}$	-	-
	$\Delta CA_{t\ 4}$	-	-	$\Delta CA^+_{t\ 4}$	-	-
	ΔED_t	1.248***	6.691	ΔCA_t	-10.453**	-2.320
	$\Delta ED_{t\ 1}$	-	-	$\Delta CA_{t\ 1}$	-	-
	$\Delta ED_{t\ 2}$	-	-	$\Delta CA_{t\ 2}$	-	-
	$\Delta ED_{t\ 3}$	-	-	$\Delta CA_{t\ 3}$	-6.141*	-1.707
	$\Delta ED_{t\ 4}$	-	-	$\Delta CA_{t\ 4}$	-	-
	c	2.005***	3.127	ΔED_t	1.671***	6.308
				$\Delta ED_{t\ 1}$	-0.848**	-2.701
				$\Delta ED_{t\ 2}$	-	-
				$\Delta ED_{t\ 3}$	-0.361	-1.279
				$\Delta ED_{t\ 4}$	-0.822**	-2.764
				c	1.743**	2.504

Notes: we apply a general-to-specific approach to find the final specification by setting $p = q = 4$. L_{ca} and $L_d$are the long-run coefficients of current account and external debt to LMBI. t_{BMD} denotes the t-statistic of Banerée(1998) and F_{PSS} is the F-statistic of PSS(2001) testing the null hypothesis $\rho_e = 0$ and $\rho_e = \rho_c = \rho_d = 0$ respectively

Table 5.5: Short-run estimates of the symmetric and asymmetric model for Brazil

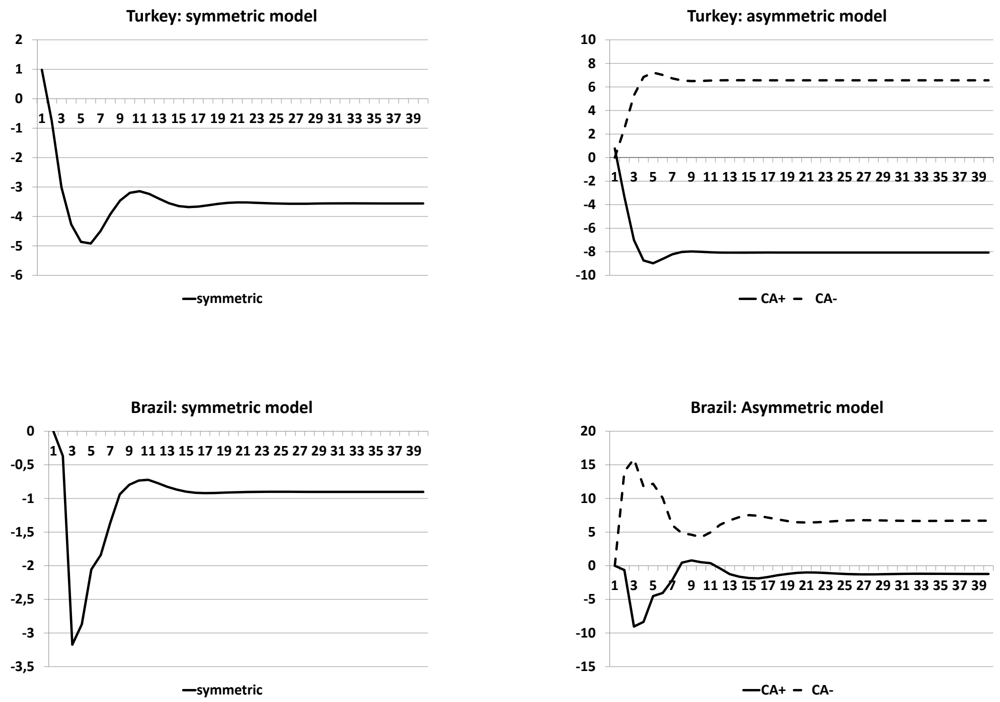
As shown in Table 5.4, 5.5: in Turkey, the short-run coefficients of the current account are not significant for both symmetric model and follows long-run asymmetric model. The other coefficients of the external debt and international reserves are significant in short-run, indicating the important role in short-run to determine the EMBI+.

The short-run results for Brazil are very interesting vis-à-vis in Turkey. The short-run of the current account is not significant with symmetric model, it becomes significant when the model allows long-run and short-run asymmetric effect. The external debt coefficient is significant in short-run for both two case, implying the level of EMBI+ in short-run depends on the reimburse capacity of the external debt.

The dynamic multipliers up to 40 quarters presented in Figure 5.1 based on Equation (5.7). This shows the new long-run equilibrium for the EMBI+ with the positive and negative shock of the current account from an initial long-run equilibrium.

The evolution of dynamic multipliers in symmetric model for Turkey and Brazil is the same by regarding two peak shocks after 4 periods and 11 periods (about 1 year and 2 year respectively). An seen, the dynamic multipliers go to the long-run equilibrium after about 4 years.

These findings in Table 5.3 and Figure 5.1 show the presence of the positive



Source: author's calculation.

Figure 5.1: Dynamic multipliers

and negative shock of the current account on the EMBI+. In fact, when we allow only asymmetric long-run effect for Turkey, the sovereign bond responds very asymmetric in positive and negative shock of the current account with reference to Figure 5.1, suggesting the sovereign bond run to equilibrium after 2 years. In view of the Brazil's curves of dynamics multipliers, there is a great shock positive and negative of the current account after 1 year and 2 years, and the only positive effect is not significant during the third year. This explication maybe from without international reserves effect in the model. The new equilibrium takes after 4 years to converge to the long-run multipliers. From a risk-management point of view, the positive and negative shock of the current account provides the useful information for predict the sovereign bond.

5.4 Conclusion

In this chapter, we investigate the recent technique of asymmetric modelling proposed by Shin et al. 2014 in order to determine the sovereign bond index by the current account, the external debt and international reserves for Turkey and Brazil in the period 2000.Q1-2011.Q4. We used the positive and negative partial sum compositions of the current account expressing the excess current account and the deficit current account in order to determine their asymmetric effect on the sovereign bond index.

The findings from the *bounds test* of t-test and F-test statistic proposed by Banerjee et al. 1998; M. Hashem Pesaran et al. 2001 respectively highlight the existence of long-run cointegration between the Emerging Market Bond Index Plus and the three explanatory variables for both countries in the symmetric model, for Turkey in only long-run asymmetry model and for Brazil with both long-run, short-run asymmetric model.

Our results suggest a great asymmetric long-run effect of the current account on the sovereign bond of Turkey and Brazil in a model including variables such as the external debt and international reserves. Especially, we only detect long-run asymmetric effect for Turkey while both long-run and short-run asymmetric effects exist for Brazil. The sign of international reserves variable for Brazil does not corroborate economic theory when we allow the short-run and asymmetric long-run effect.

The asymmetric long-run coefficients of the current account are greater than one of symmetry for both Turkey and Brazil. Besides, the asymmetric long-run coefficients of the external debt and international reserves for Turkey are smaller than one of symmetry. This finding highlights the importance of precisely specifying the long-run relationship when we allow asymmetric effect. In addition, the positive component of the current account is higher than the negative one for Turkey. In contrast, the positive component of the current account is smaller than the negative one for Brazil. These issues can be interpreted that the positive component of the current account is stronger impact to EMBI+ than the negative one for Turkey, but it reverses for Brazil. The asymmetric long-run coefficient of the external debt is greater than one of symmetry for Brazil. This result means the allowing for asymmetry increases the magnitude and the significance for Brazil.

The finding of dynamic multipliers permits to capture the new long-run equilibrium from the initial equilibrium which confirms the long-run coefficients effect of these explanatory variables. This useful information will provide good strategies to risk managers for the future.

General Conclusion

The main objective of this thesis is to determine the sovereign default risk in emerging countries. How can we determine and evaluate the sovereign default risk in emerging countries? What are types of model and indicators to express the sovereign default risk? These questions are addressed in the five chapters of this thesis (except the general introduction and the general conclusion).

My first contribution was to resume a global picture of the literature reviews of the sovereign default risk. We talked briefly about the history of default and the default cost when the government decides to default. The most important contribution in this chapter is the conceptual and methodological issues as well as findings from selected theoretical and empirical researches focusing on the determination of sovereign default risk: the structural model, the dynamic stochastic model and the econometric model. Each approach has some limitations that were my avenue of research in the next chapter.

We could separate the four empirical results into two channels: the first one is a structure model & a stochastic model (chapter two and chapter three) and the second one is econometric models (chapter four and chapter five). Chapter 2 show a method to calculate the sovereign default probability. Chapter 3 propose to estimate the sovereign spread credit. Chapter 4 and chapter 5 aim to empirically investigate the aspects related to these issues for the long-run, short-run (chapter 4) and long-run asymmetric effects (chapter 5).

In the second chapter, we presented how to transfer the credit risk model in corporate level to sovereign default model by using the model of Gray et al. 2007. We provided empirical evidence from Argentina. Our aim of this chapter was to verify the evolution of Argentina's default in 2002 and the post-default period. Cause of availability data, we studied in annual data for a small period from 1997-2009. The result of this chapter recognized that Argentina's default probability rose from 1997 to 2002 and dropped in the post-crisis period. At the same time, it also describes the Argentina's economic situation where it had the biggest default in the twenty-first century. Another important issue that we mentioned is to clarify the role of option pricing and the Ito's lemma in order to extend a gap in the structural model. In the next chapter, the default date is defined at the first time, instead of maturity, when the sovereign asset infer to the default barrier.

The third chapter aimed to create a stochastic model of the sovereign default risk in some emerging markets so as to compute the daily sovereign spread credit. We proposed two policies when the sovereign defaults: an increase of corporate income tax and a reduce of a part of debt. In order to validate this model, then when we verified and compared the results obtained with the index observed from the market if they are consistent together, we found: firstly, the evolution between estimated sovereign credit spread and Emerging Market Bond Index plus (EMBI+) is fairly homogeneous in the period from 2000 to 2011. Secondly, by using a simple regression between them, the positive sign of this relationship and coefficients are 0.634, 0.8158, 0.7549, 0.437 for Brazil, Mexico, Peru and Turkey respectively, confirming when the EMBI+ increases (decreases), the estimated sovereign credit will increase (decrease) 63.4%, 81.58%, 75.49%, 43.7% for Brazil, Mexico, Peru and Turkey respectively. A fascinating question appeared "*This strong relationship will verify in the long-run?*" leads our interest to examine. To do that, using the cointegration test of Johansen 1991, 1995 we found the existence of cointegration between the estimated sovereign credit spread and the EMBI. That explains that the sovereign credit spread and EMBI also have a same/similar evolution in the long-run. As a result, this finding can help us respond the question above. In the long-run, it exists, in fact, a strong relationship between the estimated sovereign credit spread and the EMBI+. This result also opens a new index of the sovereign default risk that would assist risk managers and regulators in designing policies aim to reduce a country default risk.

The fourth chapter has attempted to find out the long-run determinant of the sovereign CDS spread for eight emerging countries in the 2008.Q4-2013.Q2 periods. The sovereign CDS spread is a proxy of the sovereign default risk. This feature can be explained by three factors related to the government's solvency, the government's liquidity and macroeconomic situation that are the external debt, international reserves and the current account respectively. These variables are the most important to evaluate the sovereign default risk. We opted for the Pooled Mean Group cointegration estimation in order to study the long-run and short-run sovereign CDS spread. We were successful to find that all variables are integrated with the same order *I(1)*, and there is an existence of cointegration between these variables indicated above. So that we validated the necessary conditions to use the Pooled Mean Group estimation.

Our main results obtained from the Pooled Mean Group cointegration estimation suggest that: first, the coefficients of the current account, the external debt and international reserves are significant in the long-run for all countries. Second, we found the negative effect of the current account, international reserves and the positive effect of the external debt on the sovereign CDS spread in long-run. Third, we find interesting that international reserves have the largest impact which will help regulators designing policies aiming at increasing international reserves rather than solving the external debt burden and the current account deficit. Last, in short run was significant just for the external debt and international reserves, not for the current account in short-run.

The last chapter analysed the asymmetric long-run and short-run determinants of sovereign bond index, which is a proxy of sovereign default, for two typical emerging countries: Turkey and Brazil in the 2000.Q1-2011.Q4 period. Likewise the fourth chapter, the sovereign default risk was explained by the government's solvency, the government's liquidity and macroeconomic situation (the external debt, international reserves and the current account respectively). We used positive and negative partial sum compositions of the current account in order to determine how it has an asymmetric effect on sovereign bond based on Shin et al. 2014. In addition, we also opted for the bounds tests of t-statistic and F-statistic proposed by Banerjee et al. 1998; M. Hashem Pesaran et al. 2001 respectively to study the existence of the co-integration between the EMBI and the explanatory variables that is the necessary condition to apply the asymmetric effect model of Shin et al. 2014. Results obtained link that it exists the cointegration between them for the two countries in the symmetric model, for Turkey in only long-run asymmetry model, and for Brazil with both long-run, short-run asymmetric models.

Our main empirical results provide interesting findings: first, we detected only asymmetric long-run for Turkey and both asymmetric short-run and long-run effect for Brazil. Second, the asymmetric long-run effect of the current account is greater than symmetric model for both Turkey and Brazil. But the asymmetric long-run coefficients of the external debt and international reserves for Turkey are smaller then one of symmetry for Turkey, whereas the asymmetric long-run coefficient of the external debt is greater than one of symmetry for Brazil. This issues feature the importance of precisely specifying the long-run relationship when we allow asymmetric effect. Third, more precisely, the long run coefficients of the positive and negative components of the current account for Turkey are - 8.065, -6.565 respectively. This means that LMBI decreases 8.065 when the current account improves 1 % and decreases 6.565 when the current account decline 1 %. The long-run coefficients of the positive are negative components of the current account for Brazil are -1.216, -6.684 respectively. This suggests that LMBI decreases 1.216 when the current account improves 1 % and decreases 6.684 when the current account declines 1%. Last, the dynamic multipliers could capture the positive and negative shocks of the current account on the EMBI from an initial equilibrium to the new equilibrium. Basing this dynamic multipliers, regulators can design good strategies to risk managers for the future.

Research Outlook

Overall impression, my thesis provided and filled some gaps in the research of sovereign default risk. However, this thesis may have some limitations and further research to extend our results in the future.

The main gap is availability data (chapter two and chapter five). In the second chapter, although we only used the annual data in the short period (1997-2009), we obtained the evolution of Argentina's default probability which is similar strongly with the Argentina's economic situation. However, this result cannot reflects the significance statistically in econometric. Furthermore, in the chapter five, we only used 44 observations but we also find out the great results which is an asymmetric effect of the current account on the Emerging Market Bond Index Plus. In fact, this gap was solved in previous published articles of two authors: Romilly et al. 2001; Narayan 2005. Especially, Narayan 2005 based on the article of M. Hashem Pesaran et al. 2001 in order to produce a table of the F-statistic critical value for 30-80 observations to compare F-statistic critical value and F-estimated value in the bounds testing. Therefore, this means that new interesting research results is found which are more important than the constraint of data availability.

An interesting research question will be extended in the third chapter: "how can we determine sovereign credit spread if a country has an initial gross endowment as in the paper of Andrade 2009 and the use of other collateral assets in order to borrow from the international market?". In fact, when a country has an initial gross endowment and other collateral assets, the sovereign liquidity will increase. Therefore, this feature will affect the sovereign credit spread.

2

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Appendix A

Lemma A.1.

Let V_t be a GBM follow with the drift μ and volatility σ.

$$\mathbb{E}_t \left[\int_t^{\infty} e^{\ \ r(u \ \ t)} V_u du \right] = \frac{V_t}{\mu \quad r}$$

Proof. See Andrade 2009

Lemma A.2.

Let V_t be a GBM follow with the drift μ and volatility σ. Let $V_D < V_t$ and $T_D = min \{u : V_u = V_D\}$:

$$\mathbb{E}_t \left[e^{\ \ r(T \ \ t)} \right] = \left(\frac{V_t}{V_D} \right)^{\beta}$$

where $\beta = \quad \frac{2r}{\sigma^2}$

Proof. See page 349 of Shreve 2004 or Andrade 2009.

Proof. of Proposition 1

The "net sovereign asset (NSA)" is proven based on the appendix of Andrade 2009:

$$NSA = \mathbb{E}_t\left[\int_t^{T_D}(\tau V_u - C)e^{-r(u-t)}du + \int_{T_D}^{\infty}\{(\tau+\Delta)V_u - (1-\phi)C\}e^{-r(u-t)}du\right] - \mathbb{E}_t\left[\lambda\tau V_D e^{-r(T_D-t)}\right] \quad (8)$$

where

$$\mathbb{E}_t\left[\int_t^{T_D}(\tau V_u - C)e^{-r(u-t)}du\right] = \mathbb{E}_t\left[\int_t^{\infty}(\tau V_u - C)e^{-r(u-t)}du\right] - \mathbb{E}_t\left[\int_{T_D}^{\infty}(\tau V_u - C)e^{-r(u-t)}du\right] \quad (9)$$

$$= \frac{\tau V_t}{r-\mu} - \frac{C}{r} - \mathbb{E}_t\left[e^{-r(T-t)}du\right]\mathbb{E}_{T_D}\left[\int_{T_D}^{\infty}(\tau V_u - C)e^{-r(u-t)}du\right] = \frac{\tau V_t}{r-\mu} - \frac{C}{r} - \left(\frac{V_t}{V_D}\right)^{\beta}\left(\frac{\tau V_D}{r-\mu} - \frac{C}{r}\right) \quad (10)$$

$$\mathbb{E}_t\left[\int_{T_D}^{\infty}\{(\tau+\Delta)V_u - (1-\phi)C\}e^{-r(u-t)}du\right] = \left(\frac{V_t}{V_D}\right)^{\beta}\left(\frac{(\tau+\Delta)V_D}{r-\mu} - \frac{(1-\phi)C}{r}\right)$$

$$\mathbb{E}_t\left[\lambda\tau V_D e^{-r(T_D-t)}\right] = \lambda\tau V_D(\frac{V_t}{V_D})^{\beta}$$

we obtain :

$$NSA = \frac{\tau V_t}{r-\mu} - \frac{C}{r} + \left(\frac{V_t}{V_D}\right)^{\beta}\left[\left(\frac{\Delta}{r-\mu} - \lambda\tau\right)V_D + \frac{\phi C}{r}\right]$$

Proof. of Proposition 2

The "default barrier" is proven based on the appendix of Jeanneret 2013: The default barrier is found by taken the first-order maximization of the net sovereign asset $\frac{\partial NSA}{\partial V_t}$.

$$\frac{\partial NSA}{\partial V_t} = \frac{\tau}{r \quad \mu} + \frac{\beta V_t^{\beta \quad 1}}{V_D^{\beta}} \left[V_D \left(\frac{\Delta}{r \quad \mu} \quad \lambda\tau \right) + \frac{\phi C}{r} \right]$$

Using the smooth-pasting condition $\left.\frac{\partial NSA}{\partial V_t}\right|_{V_t = V_D} = \frac{\partial NSA(V=V_D)}{\partial V_D}$ (Robert C Merton 1974)

where $\frac{\partial NSA(V=V_D)}{\partial V_D} = \frac{\tau}{r \quad \mu} + \left(\frac{\Delta}{r \quad \mu} \quad \lambda\tau \right)$

we obtain:

$$V_D^* = \frac{C\phi\beta(r \quad \mu)}{r(1 \quad \beta)[\Delta \quad \lambda\tau(r \quad \mu)]} = C\varphi$$

Proof. of Proposition 3:

Sovereign Credit Spread (SCS) is demonstrated based on Jeanneret 2013

$$SCS = \frac{C}{D} \quad r = r \left[\frac{1}{1 \quad \phi \left(\frac{V_t}{V_D} \right)^{\beta}} \quad 1 \right] = r \left[\frac{1}{1 \quad \phi \left(\frac{V_t}{C\varphi} \right)^{\beta}} \quad 1 \right]$$

where D is the sovereign debt. Using **Lemma A.2** we found :

$$D = \mathbb{E}_t \left[\int_t^{T_D} Ce^{\quad r(u \quad t)} du \right] + \mathbb{E}_t \left[\int_{T_D}^{\infty} (1 \quad \phi) Ce^{\quad r(u \quad t)} du \right] = \frac{C}{r} \left[1 \quad \phi \left(\frac{V_t}{C\varphi} \right)^{\beta} \right]$$

Résumé en Français: Cette thèse sur travaux empiriques en quatre articles s'intéresse aux déterminants de risque de défaut souverain. Le premier chapitre résume l'état de l'art du risque de défaut souverain et trois principales approches des déterminants du risque de défaut souverain: le modèle structurel, le modèle dynamique stochastique et les modèles économétriques. Le deuxième chapitre étudie la probabilité de défaut de l'Argentine (2002) en utilisant un modèle structurel proposé par Gray and Malone 2008. Le troisième chapitre propose un modèle stochastique afin de calculer le spread du crédit souverain journalier. Les deux derniers chapitres économétriques déterminent deux proxies du risque de défaut souverain: Sovereign CDS spread et Emerging Market Bond Index Plus (EMBI+). Le quatrième chapitre essaye de déterminer le sovereign CDS spread à long-terme et court-terme en utilisant trois estimations: *Pooled Mean Group, Mean Group* et *Dynamic Fixed Effect*. Dans le dernier chapitre, on applique un modèle non-linéaire asymétrique *Autorégressif à retards échelonnés* pour étudier l'effet d'asymétrie à long-terme de compte courant sur l'EMBI+ y compris les variables explicatives telles que la dette extérieure et les réserves internationales pour deux pays émergents: la Turquie et le Brésil.

Titre en anglais: Essays on sovereign default risk in emerging countries

Titre en français: Essais sur le risque de défaut souverain dans les pays émergents

Résumé en anglais: This thesis on empirical results in four articles focused on the determinants of the sovereign default risk. The first chapter summarizes the state of the art of sovereign default risk and the three main approaches of determinants of sovereign default risk: the structure model, the dynamic stochastic model and the econometric models. The second chapter studies the default probability in Argentina (2002) by using a structural model proposed by Gray and Malone 2008. The third chapter provides a stochastic model to calculate the daily sovereign credit spread. Last two econometric chapters determine two sovereign default risk proxies: Sovereign CDS spread and Emerging Market Bond Index Plus. The fourth chapter focuses on the sovereign CDS spread in long-run and short-run by using three estimations of *Pooled Mean Group, Mean Group* and *Dynamic Fixed Effect*. The last chapter applies a nonliear *Autoregressive Distributed Lag* asymmetry model to study the long-run asymmetric effect of the current account to the EMBI+ including the explanatory variables such as the external debt and international reserves for the two typical emerging countries Turkey and Brazil

Discipline : Sciences économiques.

Mots-clés : Sovereign default risk, Sovereign credit spread, Sovereign CDS spread, EMBI+

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