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RISK FRAMEWORK ANALYSIS IN THE MANAGEMENT OF SOVEREIGN DEBT: THE ARGENTINE CASE

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Risk Framework Analysis in the Management of Sovereign Debt: The Argentine case

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Abstract

The main objective of this paper is to develop a practical approach to Argentina's sovereign risk management. Through Contingent Claim Analysis (CCA), Gape, Gray, Lim and Xiao (2008)[1] developed a sovereign risk framework whereby we can construct a *marked to market* sovereign balance sheet and obtain a set of credit risk indicators that can help policy-makers: set thresholds for foreign reserves, design risk mitigation strategies and select best policy options. The main contribution is that instead of using a conventional index such as GBI-EM[1] in order to estimate the volatility of domestic currency liabilities, we use 24 sovereign domestic currency bonds to construct an interest rate covariance matrix. That is, an interest rate sensitive sovereign portfolio, whose risk factor variations[2] are represented by a vector of the portfolio PV01 (*present value* of a basis point change) with respect to each interest rate of the zero-coupon yield curve. Since zero-coupon rates are rarely directly observable, we must estimate them from market data. In this paper we implemented a widely-used parametric term structure estimation method called Nelson and Siegel. For Argentina we generated two yield curves, i.e., sets of fixed maturity interest rates determined by Badlar and CER.

keywords: Contingent Claim Analysis (CCA), Debt Sustainability Analysis (DSA), Merton Model, Sovereign Risk, Distance to Default, Risk Neutral Spread.

Introduction

The CCA is a generalization of the Merton model (1973 and 1974)[2, 3] and Black & Scholes (1973)[4] applied to the analysis of corporate sector credit risk. The main purpose of this paper is to extend the CCA to Argentina and complement the traditional Debt Sustainability Analysis (DSA) approach that is commonly used to find fiscal adjustments for keeping the public sector debt ratio stable or decreasing. Although the traditional DSA approach is easy to estimate, it suffers from several deficiencies. One of the most important is that this ratio is highly aggregated and cannot properly account for changes in sovereign risk appetite or currency composition of the debt and its maturity structure.

Following Gray D. et al. (2008) IMF[5] we can mention the most significant shortcomings of traditional DSA: Firstly, the level of the GDP ratio does not necessarily imply sustainable/unsustainable debt dynamics. A country may increase expenditure on investment activities and structural reforms to enhance future growth prospects or have to run large deficits to smooth consumption. The theory of debt sustainability management does not impose a constraint or a bounded debt ratio; the only requirement is that a future primary surplus is sufficient to satisfy the government's inter-temporal budge constraint.

Secondly, and related to the above point, we know that the main objective of the traditional DSA is to secure a stable debt ratio. The problem is that we don't know whether the level might be too high or sufficiently low (unsustainable or sustainable). Many studies have tried to solve this optimal-level problem by carrying out research based on the analysis of the debt ratio of countries in default. These studies show values of optimal ranges for emerging countries spanning from 15/20 percent to 50/60 percent. Whereas for developed countries

*The opinions expressed in this document are those of the author and do not necessarily reflect the views of the UCEMA or CEBaFi. Comments are welcome at: `ed11@ucema.edu.ar`

[1] JPMorgan Government Bond Index-Emerging Markets

[2] Commonly called, risk factor *sensitivity*

optimal values range from 350 percent to 85 percent.

Thirdly, the traditional DSA does not take into account changes in the composition of asset and liabilities of the public sector which affect debt sustainability. That is, it fails to incorporate assets that are important at the moment of paying back debt, such as foreign currency reserves belonging to the monetary authority.

In fourth place the traditional DSA does not recognise the different nature of the credit risk associated with local currency denominated and foreign currency denominated debt. The risk premium of the foreign currency denominated debt is actually a default risk premium, whereas the local currency denominated debt combines inflation, dilution and default risk. In the case of foreign currency denominated debt we can find an active market of publicly listed Credit Default Swaps (CDS) which set a benchmark, while there are no CDS on offer for local currency denominated debt.

Finally, for empirical proof of the poor correlation between debt ratio and market based measures of credit risk (such as a CDS) we plot the debt to GDP ratio against CDS for a selected number of emerging market countries. See Figure 1.

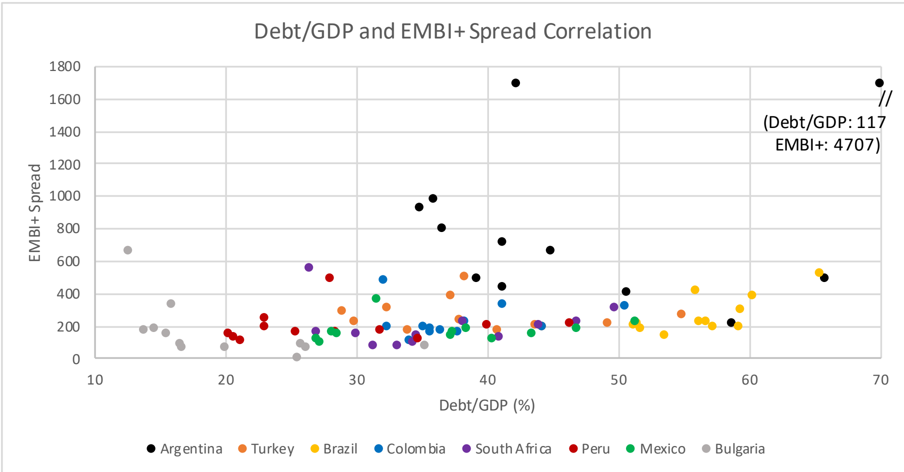


Figure 1: Correlation of debt to GDP ratio with CDS: Panel data for 8 Emerging Market Countries, 2004-2015

This risk based framework introduces the concept of distress (default) into the traditional DSA. The main difference is that here we define "distress" as the risk that the sovereign borrower will not have enough resources to meet outstanding debt service obligation on time. This distress event occurs when assets fall below pledged payment on liabilities. Likewise, sovereign borrowers of local currency debt pay creditors a spread for assuming the risk of loss of value either through non payment, inflation, or dilution.

Sovereign balance sheet and CCA were first introduced by Gapen et al. (2004 and 2005)[6], Gray (2002)[7], Gray, Merton and Bodie (2002 and 2006)[8], and Gray and Malone (2008)[9]. See this authors for a full description of the CCA approach.

Acknowledgments

It is a great pleasure to acknowledge the University of CEMA for supporting me in this project. I would also like to acknowledge the direct and indirect contributions of many colleagues, specially Arief Ramayandi, leading economist - Department of Economic Research and Regional Cooperation of the Asian Development Bank (ADB) for their collaboration. Last but not least, I am grateful to my wife for her love, support and encouragement, and James Castaneda for helping me in the final edition of this Ph.D. summary.

Developing a Risk Adjusted Balance Sheets for Argentina

Basing ourselves on Gray and Malone (2008)[9] framework we have two "partner" balance sheets: the Government's and the Monetary Authority's. Government assets include a claim on a portion of the foreign currency reserves held by the Monetary Authority and other public sector assets such as the present value of the primary fiscal surplus. While the liabilities side include foreign currency debt, domestic currency debt, obligations owed by the Government to the Monetary Authorities, and guarantees to "too important to fail" entities. The balance sheet of the Monetary Authority has assets consisting of foreign reserves (net foreign assets) and credit to Government (net domestic assets). While the liabilities side of it has base money and the Government's claim on a portion of foreign currency debt (Table 1).

The processes of merging the "partner" balance sheets is carried out as follows: On the Government Asset's side of the balance sheets the *"Obligation from monetary authority to supply FX to government to pay FX debt"* matches and cancels out the *"Obligation to supply FX to government to pay FX debt"* on the Liability side of the Monetary Authority's balance sheets. Equally, the *"Credit to Government"* on the Asset side of the Monetary Authority's balance sheets matches and cancels out the *"Credit from monetary authorities"* on the Liability side on the Government's balance sheets. These matching items are italicized on Table 2. For more details see Merton (1970)[10], Gray, Merton and Bodie (2002, 2006)[8], Gapen and others (2004)[6] and Van den End and Tabbae (2005)[11][3].

The final Sovereign balance sheet is arranged so that the market values of the liabilities can all be observed. Another consideration is to translate it into a common currency (foreign currency simplifies the analysis). The final Inputs include: the observed value and volatility of sovereign local currency debt, part of the monetary base (in foreign currency terms), and foreign currency denominated debt (the distress barrier) book value.

GOVERNMENT "PARTNER"

Assets	**Liabilities**
• Net fiscal asset	• Foreign Currency Debt
• Other public sector assets	• Guarantees (to *too important to fail* entities)
• *Obligation from monetary authority to supply FX to government to pay FX debt*	• Domestic Currency Debt held outside of the government and monetary authorities
	• *Credit from monetary authorities*

MONETARY AUTHORITY "PARTNER"

Assets	**Liabilities**
• Foreign Reserves	• Base Money
• Credit to other sectors	• *Obligation to supply FX to government to pay FX debt*
• *Credit to Goverment*	

Table 1: Segregated balance sheet for the public sector

CONSOLIDATED PUBLIC SECTOR BALANCE SHEET

Assets	**Liabilities**
• Foreign Reserves	• Domestic Currency Debt
• Net Fiscal Assets (Discounted Value of Primary Fiscal Surpluses)	• Base Money
• Value of Monopoly over Issue of Money	• Foreign Currency Debt
• Other public assets minus Guarantees	

Table 2: Sovereign Balance Sheet

[3]Gapen et al, 2005, Measuring and Analysing Sovereign Risk with Contingent Claims IMF vol 55 No. 1

Estimating market value of sovereign assets and volatility through CCA

Just as in the classic Merton (1974)[3] model, the market value and volatility of assets are not directly observable. To solve this problem CCA estimates an "implied" value and volatility for assets. The balance sheet relationships between assets and liabilities allows the observed prices of liabilities to be used to obtain the implied value of the assets. To solve this, we constructed a liability side of the Consolidated Public Sector Balance Sheet that is directly observable in the market, that is, value and volatility of domestic currency debt, monetary base and foreign currency debt. Both domestic currency debt and monetary base are expressed in a common foreign currency, US dollar.

Domestic currency debt can be diluted or inflated away. Domestic nominal debt, including the monetary base, is a residual claim on government surpluses, just as Microsoft stock is a claim to Microsoft earnings. If surpluses are not sufficient the government must default on or inflate away the debt. Therefore the value of money and domestic currency debt multiplied by the exchange rate can be seen as the "market capitalization" of the Government (J. Cochrane (2005)[12]), while foreign currency debt cannot be diluted or inflated away. That is why this simple model of the type "two kinds of contingent rights" (junior and senior) combines the circulating money and the debt issued in local currency to build what we will call "Local Currency Liabilities" (LCL).

Under this CCA framework the value of local currency liabilities in foreign currency terms, LCL, is a call option on sovereign assets in foreign currency terms, A, where the strike price is equal to the distress barrier, B, which is derived from the promised payments on foreign currency debt (that is, the book value) and interest payments up to time t. The Black & Scholes (1973)[4] formula for the call option can be written as:

$$E = LCL = A\, N\left(d_1\right) - Be^{-r_f t}\, N\left(d_2\right)$$

Where $N\left(.\right)$ is the cumulative standard normal distribution with zero mean and unit variance, t is the time horizon and:

$$d_2 = \frac{ln\left(\frac{A}{B}\right) + \left(r_f - \frac{\sigma_A^2}{2}\right)t}{\sigma_A\sqrt{t}}$$

and

$$d_1 = d_2 + \sigma_A\sqrt{t}$$

The Black–Scholes formula above (d_2) contains two unknowns: A and σ_A. From Itô's lemma we can obtain another equation:

$$E\,\sigma_E = A\,\sigma_A\,N\left(d_1\right)$$

$$LCL\,\sigma_{LCL} = A\,\sigma_A\,N\left(d_1\right)$$

Rearranging:

$$\sigma_{LCL} = \frac{A\,\sigma_A\,N\left(d_1\right)}{LCL}$$

We can use these two equations below (the call option and the LCL volatility from Itô's lemma) and finally calculate the implied value of two unknowns (implied assets and implied asset volatility) by iteration.

Volatility estimation for LCL

Traditionally, the estimation for LCL volatility is done through a common sovereign index such as GBI-EM (JPMorgan Government Bond Index-Emerging Markets). This index is a local emerging markets debt benchmark that tracks local currency government bonds issued by emerging countries[4]. Argentina does not have a common sovereign index. Given the complex sovereign domestic currency debt structure in Argentina (bond prospectus) we need to develop a methodology that can capture the risk (volatility) of all sovereign bonds and their cash flows.

Giving a set of cash flows and a present value, there is no yield or discount rate for swaps, this happens

[4]Czech Republic, Hungary, Poland, Turkey, Russia, Brazil, Chile, Colombia, Mexico, China, India, Indonesia, Malaysia, Thailand, Hong Kong, Singapore, South Korea, Israel, and South Africa.

because a cash flow swap might be negative. Thus, we cannot estimate the value for duration or convexity. To solve this problem there is a methodology commonly called $PV01$ or $PVBP$ (present value of a basis point move). This represents the change in the present value of a cash flow, given that the yield changes by one basis point, that is, when all the zero coupon interest rate change by one basis point.

This $PV01$ methodology is important because it can be applied to any sequence of cash flows, either positive or negative. In consequence, through this measure we can estimate the volatility of any kind of instrument. In general terms we can define the $PV01$ for any sequence of cash flows given a set of zero coupon interest rates for each maturity of this cash flow as[5]:

$$c = (C_{t1}, ..., C_{tn})'$$

$$r = (R_{t1}, ..., R_{tn})'$$

Where c is for cash flows and r stands for zero coupon interest rate. Given a set of c and r we can set the present value as $PV = (c, r)$ and $\dot{r} = r - 0,01\% * \mathbf{1}$ where $\mathbf{1}$ correspond to a vector whose elements are equal to one. Hence, $\dot{r}$ denotes the interest rate when these move one basis point:

$$PV01\,(c, r) = PV01\,(c, \dot{r}) - PV01\,(c, r)$$

The $PV01$ is the exact sensitivity of a bond when the term structure of interest rates moves in parallel by one basis point.

Risk Factors and Risk Factors' Sensitivities

The traditional approach to measuring market risk in portfolios (that is, used by banks) consists of disaggregating the irreducible or "non-diversifiable" risk of a portfolio into two parts: the risk due to market *volatility* of a risk factor and the risk due to the *sensitivity* of the portfolio to this risk factor.

The *sensitivity* of the portfolio to risk factors is difficult to add, unless expressed in terms of value. Even in these cases, it is difficult to compare "sensitivities" to different activities. For example, the $PV01$ of a bond portfolio cannot be compared with the "Beta" of an equity portfolio (shares). Therefore, the risk factors, and their sensitivities, should be analyzed separately with their particular methodology. In our analysis, the portfolio is integrated by sovereign bonds, it has therefore an interest rate risk factor whose risk sensitivity corresponds to the $PV01$.

Taking $PV01$ as a measure of risk sensitivity, the mapping of the risk factor produces changes in the discounted $P\&L$ of the portfolio subject to a change of one basis point in the term structure of interest rate. That is, the $P\&L$ is a weighted sum of all discounted cash flows relating to absolute changes in the interest rate whose weights are built into the $PV01$ vector. All the non lineal relationship between prices and interest rates are captured by that vector.

Continuing with the coupon and interest rate notations (c, r) and supposing a small change in the interest rate denoted by $\triangle R$ the $PV01$ value corresponds to a change in the present value when the interest rate changes. We can estimate the total change in the present value of a cash flow with maturity T_i such as: $\triangle R \approx -PV01_{T_i} \triangle R_{T_i}$. If we suppose that all interest rate changes are in basis points then: $\triangle r = \triangle\,(R_{t1}, ..., R_{tn})'$ then the portfolio $P\&L$ is the sum of the changes in the present value:

$$\triangle PV = -\sum_{t=1}^{n} PV01_{T_i} \triangle R_{T_i}$$

In matrix notation:

$$\triangle PV = -\theta' \triangle r$$

Where:

$$\theta = (PV01_{T_i}, ..., PV01_{T_n})'$$

In fact, knowing the the risk factor sensitivity ($PV01$), that is, the θ vector, we get a portfolio discounted $P\&L$ as a linear function to any absolute change in the interest rate. Besides, if $\triangle r$ has a covariance matrix V then,

[5]For more details see C. Alexander (2008)[13]

based on the linear approximation $\triangle PV = -\theta' \triangle r$ its variance is $\theta' V \theta$.

To estimate the variance (and the standard deviation) of a portfolio we need to estimate a covariance matrix. This is a symmetric square matrix with variance on its diagonal and covariances outside the main diagonal.

$$\mathbf{\Omega} = \mathbf{DCD} = \begin{pmatrix} \sigma_1^2 & \rho_{1,2}\,\sigma_1\sigma_2 & \rho_{1,m}\,\sigma_1\sigma_m \\ \rho_{2,1}\,\sigma_2\sigma_1 & \sigma_2^2 & \rho_{2,m}\,\sigma_2\sigma_m \\ \rho_{m,1}\,\sigma_m\sigma_1 & \rho_{m,2}\,\sigma_m\sigma_2 & \sigma_m^2 \end{pmatrix} \tag{1}$$

$$Volatility = \sqrt{\theta'\Omega\theta}$$

Where $\theta = (PV01_1, PV01_n)'$ is the risk factor interest rate sensitivity vector, $\rho_{m,m}$ it corresponds to correlation of the assets and σ^2 and σ corresponds to the variance and standard deviation of the assets.

Scaling Factor

For the estimation of the zero coupon yield curve we use weekly prices reported by Bloomberg and Thomson Reuters. Because the CCA model needs to be on an annual frequency we need to implement a scaling factor for the above covariance matrix. It is commonly assumed that returns follow an i.i.d process, that is, returns are independent and identically distributed random variables. If we adopt the assumption that returns follow and i.i.d process with volatility σ (standard deviation) and set r_{ht} the next h periods of returns at the time t we can get:

$$r_{ht} = \triangle_h ln\left(P_t\right) = ln\left(P_{t+h}\right) - ln\left(P_t\right)$$

Given that the h period return is the sum of all consecutive returns:

$$r_{ht} = \sum_{i=0}^{h-1} r_{t+i}$$

Given that the random process is independent the covariances are zero, therefore the variance calculation is:

$$Var\left(r_{ht}\right) = h\sigma^2$$

Finally the standard deviation is equal to $SD\left(r_{ht}\right) = \sqrt{h}\sqrt{\sigma}$

Although the scaling factor methodology developed above is a common practice, there is another methodology than doesn't consider that the returns distributions are an i.i.d. process. Conversely, this assumes that returns are auto-correlated, a hypothesis that is empirically more accepted. This methodology establishes that returns follow a first order auto-regressive process (AR1) where φ is the auto-correlation (that is, the correlation between adjacent returns). We implement this methodology in our equity volatility model estimation.

Given that the h period return is the sum of all consecutive returns for a period: $r_{ht} = \sum_{i=0}^{h-1} r_{t+i}$ and they are identically distributed but not independent, we can set that: $\mu = E\left(r_{t+i}\right)$ and $\sigma^2 = V\left(r_{t+i}\right)$ for all i. The auto-correlation does not affect the expected value of the scaling factor h given that $E\left(r_{ht}\right) = E\left(r_{t+i}\right) = h\mu$ but it affects the standard deviation of the scaling factor. Under the first order auto-regressive model, the variance for the logarithmic return of period h is:

$$V\left(r_{ht}\right) = \sum_{i=0}^{h-1} V\left(r_{t+i}\right) + 2\sum_{i\neq j}\left(r_{t+i}, r_{t+j}\right) = \sigma^2\left(h + 2\sum_{i=0}^{h-1} V\left(h-i\right)\varphi^i\right)$$

Applying the identity:

$$\sum_{i=1}^{n}\left(n-i+1\right)x^i = \frac{x}{\left(1-x\right)^2}\left[n\left(1-x\right) - x\left(1-x^n\right)\right], \quad \mid x \mid < 1$$

Substituting $x = \varphi$ and $n = h-1$ in the above equation:

$$V\left(r_{ht}\right) = \sigma^2\left(h + 2\frac{\varphi}{\left(1-x\right)^2}\left[h-1\left(1-\varphi\right) - \varphi\left(1-\varphi^{h-1}\right)\right]\right)$$

This shows that when returns are auto-correlated with a first order auto-regressive coefficient φ, the scaling factor of the standard deviation is no longer $\sqrt{h}$ but $\sqrt{\hat{h}}$ where:

$$\hat{h} = h + 2\frac{\varphi}{(1-x)^2}\left[h - 1(1-\varphi) - \varphi\left(1-\varphi^{h-1}\right)\right]$$

Zero Coupon Yield Curve Estimation

The term structure of interest rates, or spot/yield curve, at a certain time, defines the relationship between the yield of a fixed income investment and the time to maturity of its cash flows. That is, it provides an "implicit" interest rate at any time that is consistent with the market prices of the valued assets (bonds). It also serves as the basis for the valuation of other fixed income instruments (i.e. *mark-to-model*) and as an input for various models, for example: risk management, monetary policy, derivatives pricing. Although we can use *zero coupon* prices directly in order to construct a term structure, the lack of market liquidity and available maturities necessarily forces us to an estimated term structure based on the observed coupon bond prices.

Particularly, the Nelson and Siegel (NS) parametric model has gained considerable popularity in recent years, not only in the academic field but also in the field of financial application. For example, the European Central Bank publishes daily *spot curves* using this methodology[6]. The FED has published the *US treasury yield curve* since 1961[7]. Likewise, there are other central banks that use the zero coupon yield curve, such as those of Germany, Belgium, Spain, Finland, France, Italy and Switzerland, among others. It is also applied in the LIBOR market. Part of its usefulness and popularity lies mainly in the financial properties of its parameters[8].

Parametric models were introduced by Nelson and Siegel (1987)[14] and then extended by Svensson (1994), these models "impose" a functional form on the instantaneous forward rate that captures the typical "hump" shape. Here, the spot rate is the average of the instantaneous forward rates:

$$NS = s(m_{ij}, \beta) = \beta_0 + \beta_1\left[\frac{1 - e^{\left(-\frac{m_{ij}}{\tau}\right)}}{\left(\frac{m_{ij}}{\tau}\right)}\right] + \beta_2\left[\frac{1 - e^{\left(-\frac{m_{ij}}{\tau}\right)}}{\left(\frac{m_{ij}}{\tau}\right)} - e^{\left(-\frac{m_{ij}}{\tau}\right)}\right]$$

Where:

- $s()$ is the spot rate function;
- β_0 is the asymptotic value of the spot rate function, which can be considered to be the long-term interest rate;
- β_1 determines the rate of convergence with which the spot rate function approaches its long-term trend. The slope will be negative if $\beta_1 > 1$ and vice-versa;
- β_2 determines the size and the form of the hump. If $\beta_2 > 0$ results in a hump at τ whereas $\beta_2 < 0$ produces a U-shape;
- τ specifies the location of the first hump or the U-shape on the curve.

Government debt structure

The debt structure used for the present work considers only those sovereign bonds that offer market liquidity, that is, that are frequently quoted and whose price vary over time. The time period considered for the present work is from January 2005 to December 2015. The starting point (2005) corresponds to the restructuring period of sovereign debt. In the case of local currency sovereign bonds,we took into account 24 types which met the minimum liquidity conditions of the model. In the Annex we list the bonds used. The total debt taken into account represents 95% of the actual volume issued in pesos as of July 2006.

The average value issued at December 2005 reached \$15,000 million dollars. Then, after the issuance of the Cuasipar bond (June 2006), the outstanding amount reached \$23,700 million dollars. The chart below (see

[6]http://www.ecb.int/stats/money/yc/html/index.en.html

[7]http://www.federalreserve.gov/pubs/feds/2006/200628/200628abs.html

[8]The only theoretical financial criticism raised regarding the NS model is that it does not account for a non-arbitrage model approach. However, several studies have shown that the model fits correctly to models without arbitrage.

Figure 2[9]) shows the evolution of the amount of debt issued denominated in local currency (expressed in dollars at the BCRA[10] exchange rate) taking into account repurchases and new debt issues on the aforementioned securities. It can be observed that the amount outstanding adjusted by CER reached a maximum in July 2006 (close to $23,900 million dollars) while the bonds adjusted by Badlar[11] began to be issued in 2009 (see Figure below).

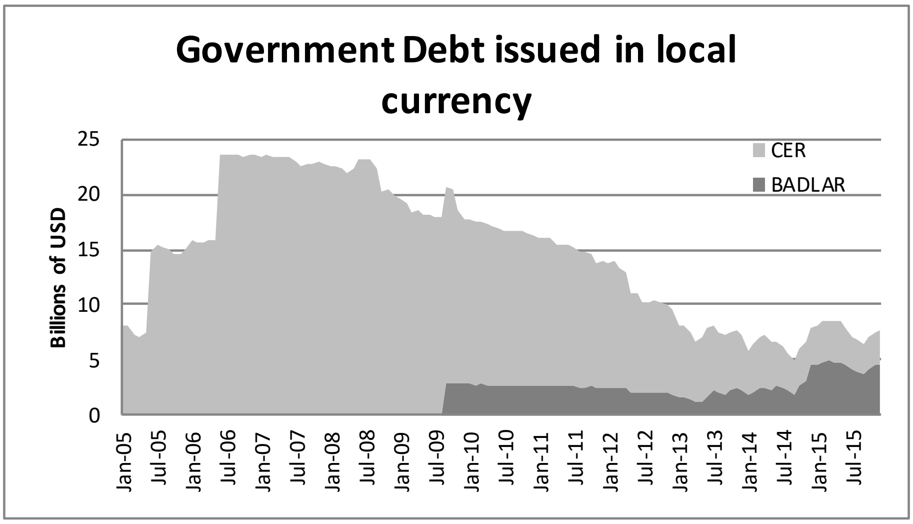


Figure 2: Government Debt issued in local currency

Sovereign bonds denominated in foreign currency were taken into account in order to calculate the CCA Distress Barrier. A total of 35 sovereign bonds were considered throughout the analysis period (Figure 3[12]). The Distress Barrier included 100% of the debt issued in the short-term (one year to maturity), plus 50% of long-term debt (more than one year to maturity), plus contractual interest.

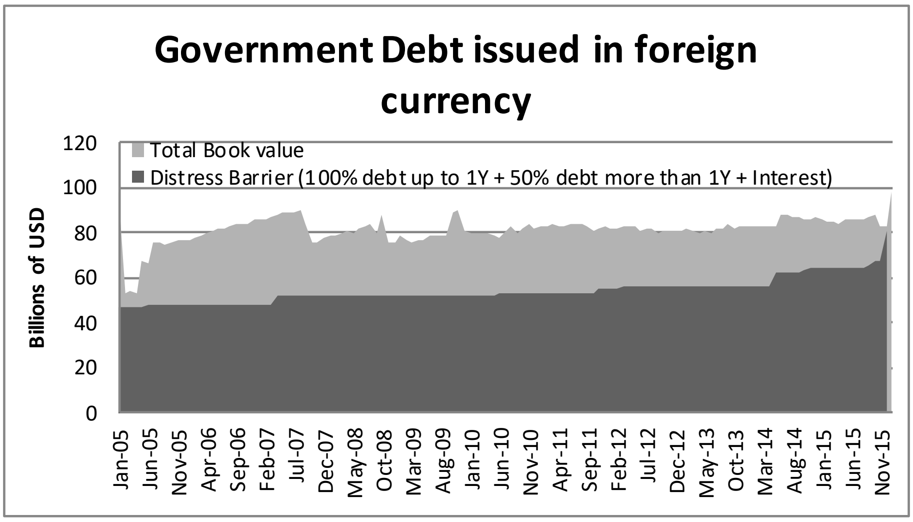


Figure 3: Government Debt issued in foreign currency

[9]Source: Thomson Reuters. Own elaboration.

[10]Central Bank of Argentina.

[11]Buenos Aires Deposits of Large Amount Rate.

[12]Source: Ministry of Finance, Undersecretariat of Financing, Public Debt Information (https://www.minfinanzas.gob.ar). Own elaboration.

Evolution of market prices

Regarding the evolution of sovereign bond prices denominated in local currency [13], we can see that during the second half of 2008 there was a significant fall in prices, which triggered a rise in the yields of theses sovereign bonds (see Figures 4 to 11). Briefly, we can say that during 2008 and part of 2009 all markets in the world were affected by the *sub-prime* crisis in the United States. Although the international crisis had worldwide repercussions, the situation in the Argentine market was also affected by some local events. During this period in 2008-2009, Argentina experienced a major agricultural strike that heightened the international impact of the crisis (despite the fact that there was a certain level of isolation from the external context). Thus, for the last quarter of 2008 and the beginning of 2009, sovereign bonds (issued in pesos) suffered the most damage, reaching yields of, for example 59% in March 2009 for Boden 2012 (PR12) and Boden 2009 (PRE9), whereas Boden 2008 reached a rate of 72% (PRE8)[14].

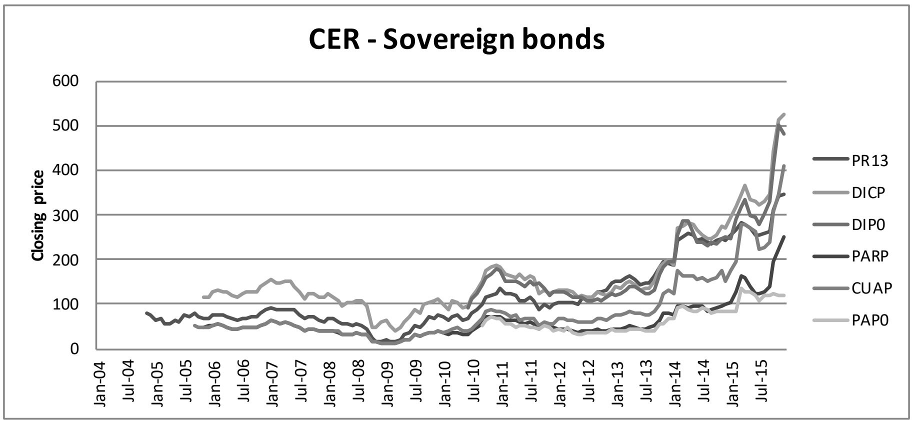


Figure 4: CER - Closing price evolution

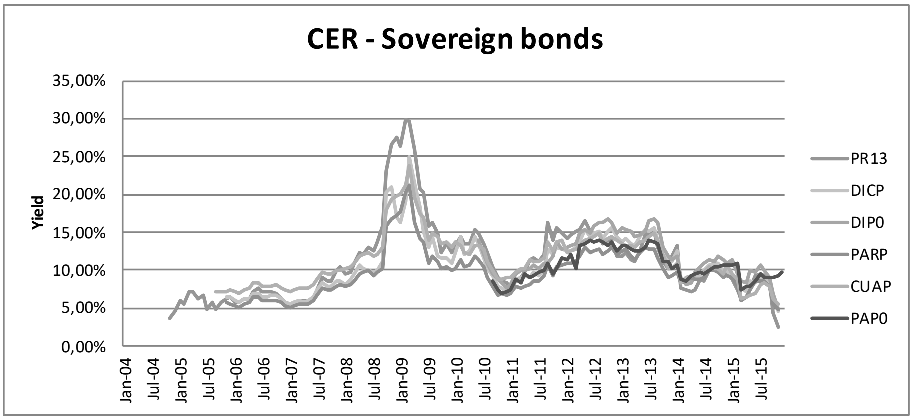


Figure 5: CER - Yield evolution

[13] Source: Thomson Reuters and Bloomberg, close price and weekly frequency.

[14] Another relevant event was the issuance of two sovereign bonds to Venezuela through direct subscription for approximately $1,000 million dollars each, in May and June 2009, which the Venezuelan government later sold to its local banks, which caused a drop in the price of this sovereign bonds.

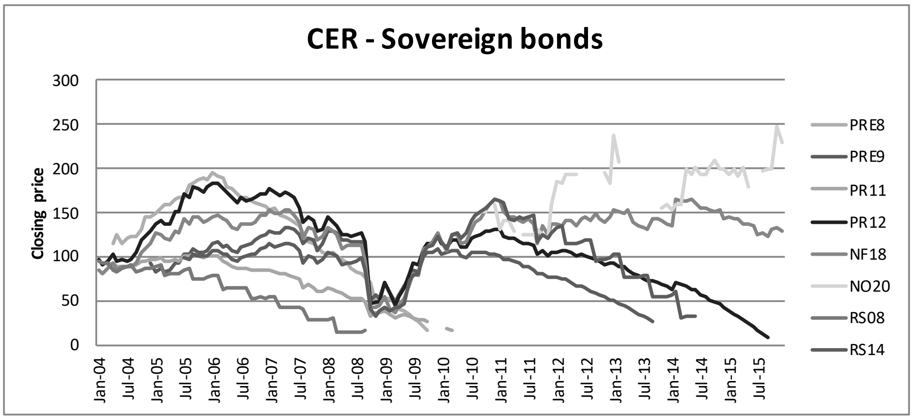


Figure 6: CER - Closing price evolution

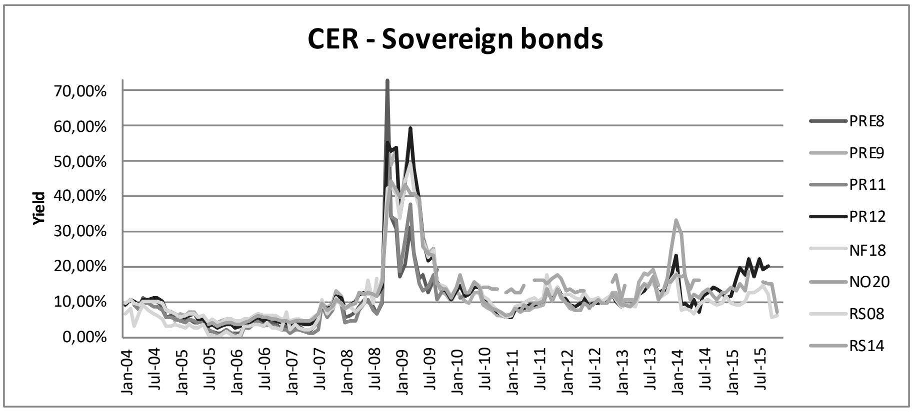


Figure 7: CER - Yield evolution

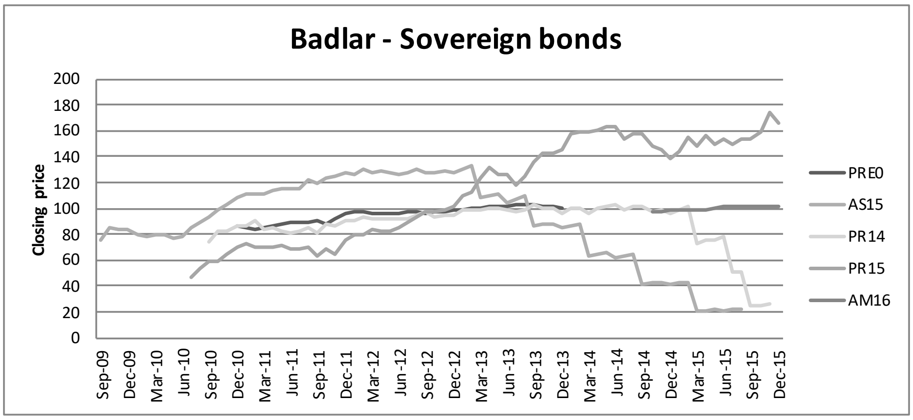


Figure 8: Badlar - Closing price evolution

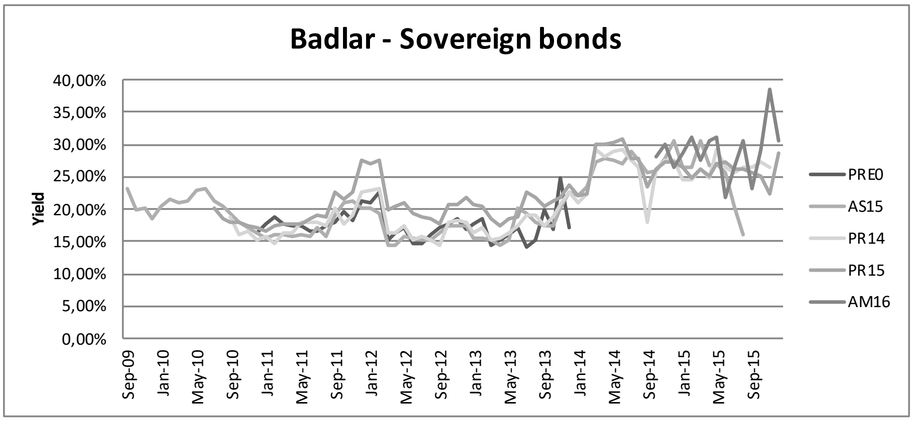


Figure 9: Badlar - Yield evolution

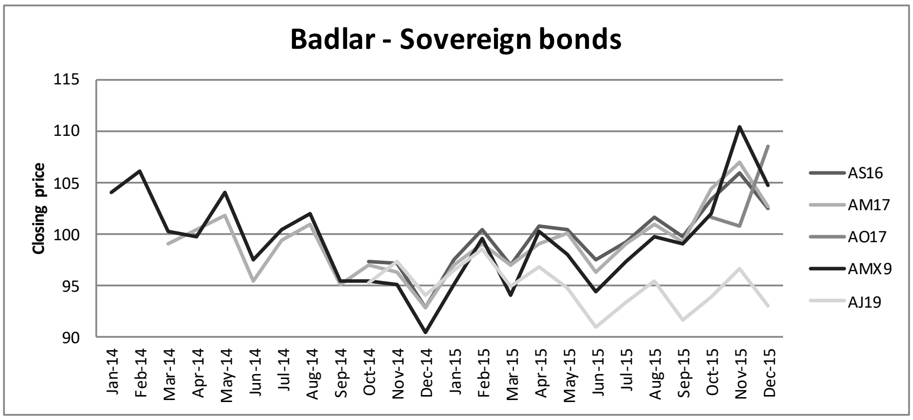


Figure 10: Badlar - Closing price evolution

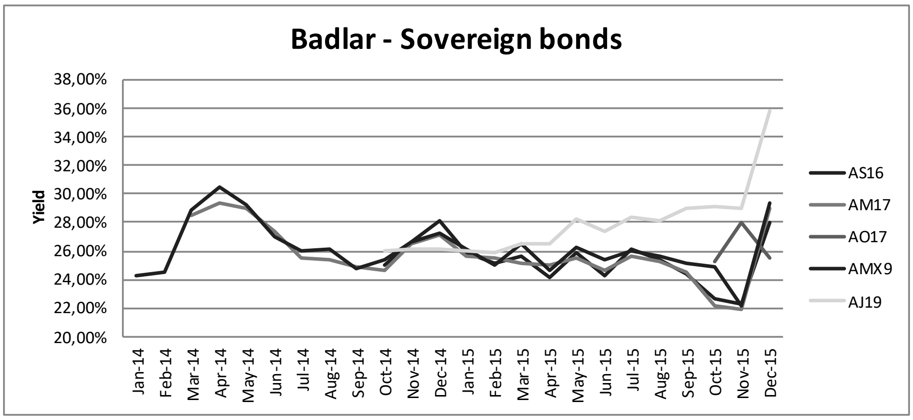


Figure 11: Badlar - Yield evolution

Term Structure of Interest Rates

From the point of view of the analysis of the Term Structure of Interest Rates or the Zero Coupon Yield Curve, two types of parametric curves were developed in local currency through the application of the NS model. One of these curves adjusts for Badlar and another curve adjusts for CER. Regarding the latter, the stress episode experienced in 2008 is reflected in the period of very high interest rates that can be observed on the curve for the range 1 to 5 maturity (see Figure 12).

From the analysis of the evolution of the Zero Coupon Yield Curve adjusted by Badlar we can see in Figures 13 and 14 below that the short term yield curves (up to one year) not only remained in the ranges within which the domestic underlying interest rate fluctuated historically, that is, Badlar itself, but they also show a high positive correlation.

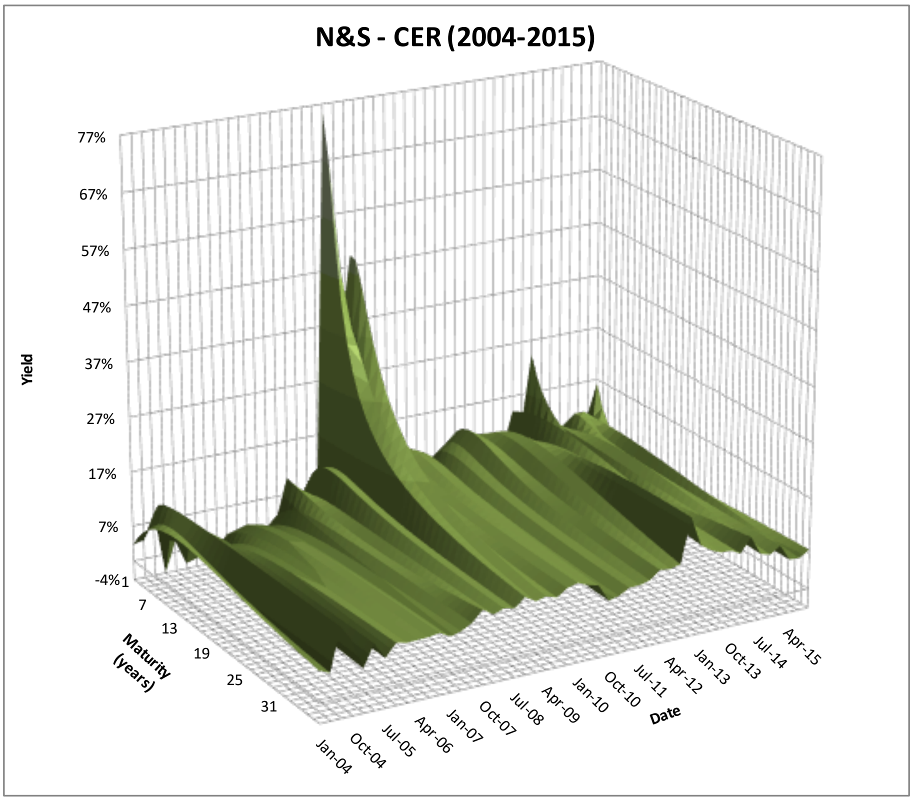


Figure 12: CER NS Zero Coupon Yield Curve evolution

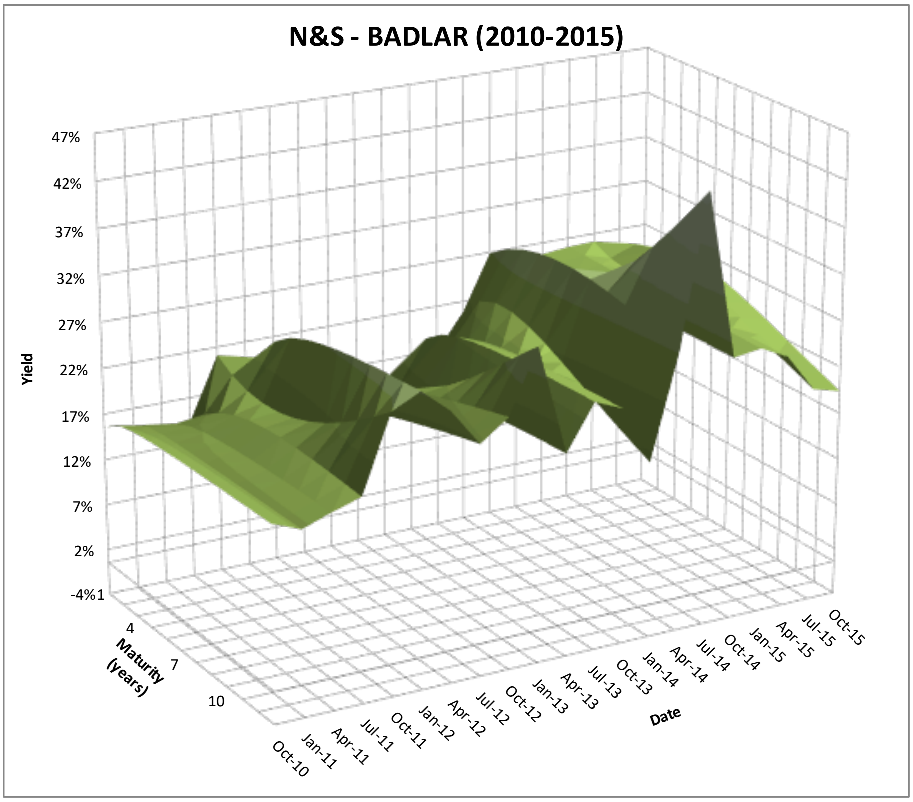


Figure 13: Badlar NS Zero Coupon Yield Curve evolution

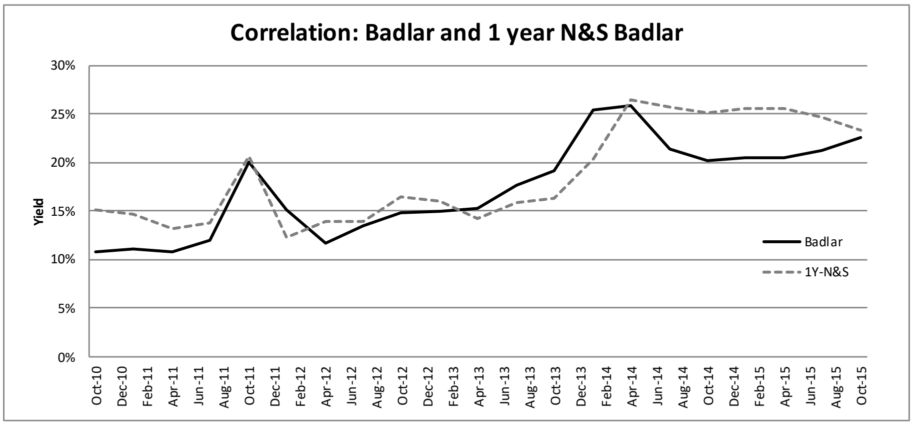


Figure 14: Correlation between Badlar and 1 year Badlar NS Zero Coupon Yield Curve

BCRA's debt structure and exchange rate

From the Monetary Authority's balance sheet we can map three accounting categories regarding the CCA developing process: monetary base, foreign currency reserves and the exchange rate. The exchange rate considered for the model is the *Contado con Liquidación* or CCL (also known as Blue Chip Swap or Dolar Cable), this FX corresponds to offshore operations (dollar purchases) through buy/sell market operations, such as sovereign bonds or stocks. We decided to use this FX because the Official FX market was controlled from 2012 to 2015 in Argentina. Nevertheless the CCL reflected investors expectations and market frictions. In the Figures below (Figure 15 and 16) we can see both level and volatility difference between the official exchange rate and the CCL from 2012.

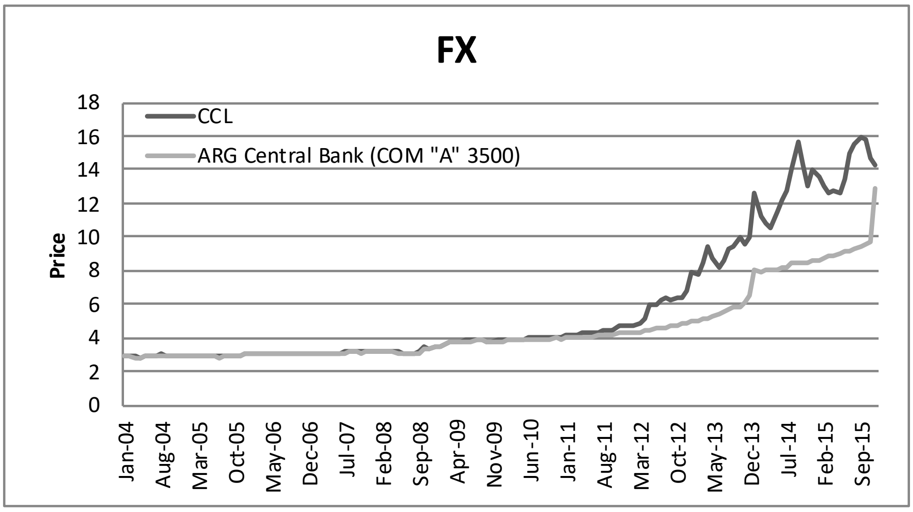


Figure 15: FX price level

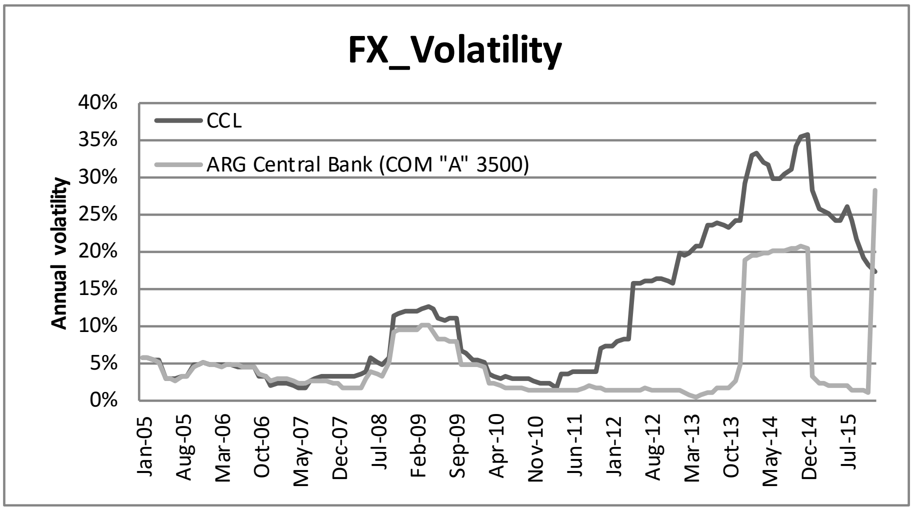


Figure 16: FX volatility

The evolution of the monetary base (volume) shows a constant rise through the period of analysis. But, if we look at the evolution in terms of fluctuations, we can separate it into different cycles: a period of increase between January 2004 and July 2007 that reached a level of expansion of 30%, followed by a slowdown from this level to a contraction of -1% as at March 2009, and then another period of acceleration that reached an expansion of 40% as at February 2011. From 2011 to 2013 the Monetary Authority maintained an expansion level of 38% and slowed it down to 23% in March 2015. Finally, from March to December 2015 we can see an expansion of the monetary base that reached a level of 35% (Figure 17 and 18).

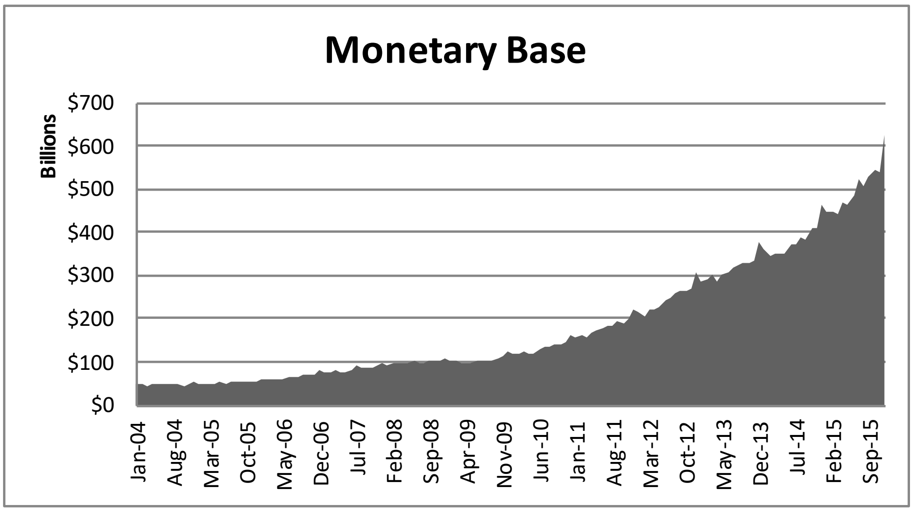


Figure 17: Monetary Base evolution

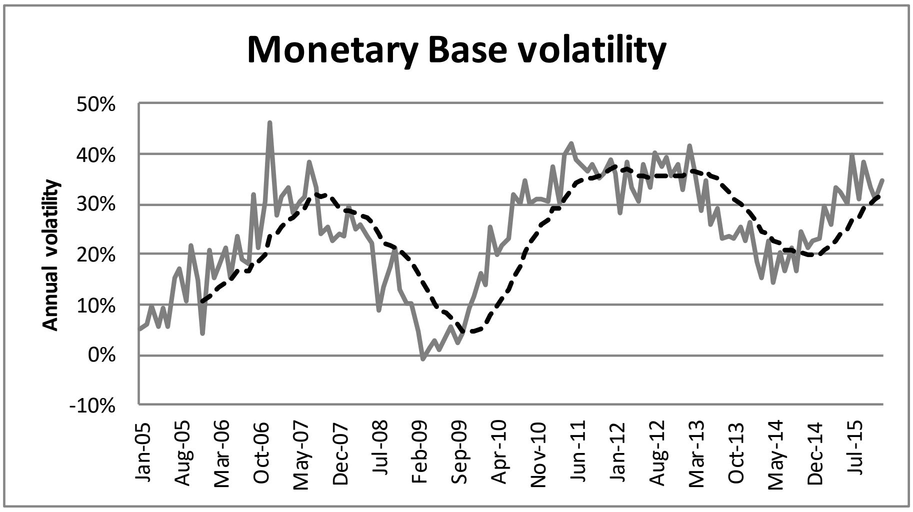


Figure 18: Monetary Base Volatility

Finally the Figure 19 below shows the evolution of the level of foreign currency reserves. We can observe a period of sustained accumulation from 2004 to mid-2007. After this, reserves stabilize at a level of approximately \$47,000 million dollars. Then, from December 2012 there is sustained loss of foreign currency reserves, reaching a minimum of \$27,000 million in March 2014. Finally, at the end of December 2015 the Monetary Authority reached a level of \$25,000 million dollars.

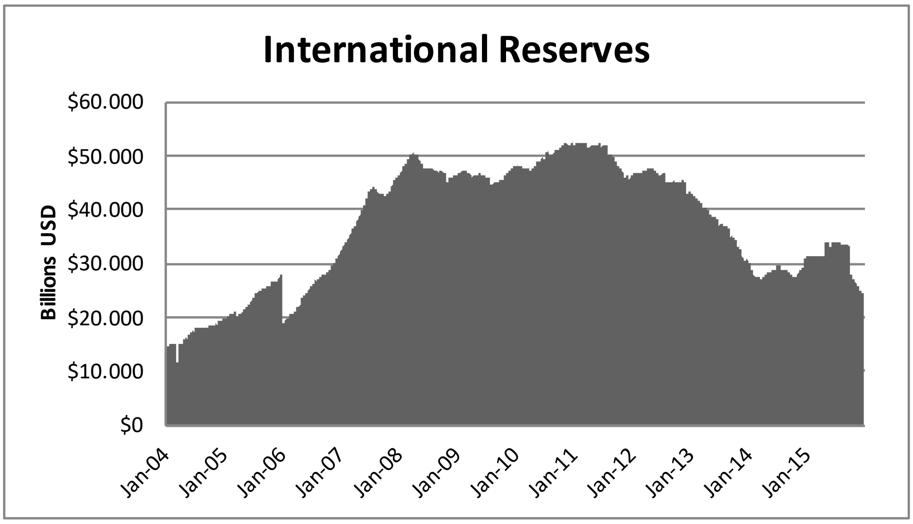


Figure 19: foreign currency reserves

Robustness and goodness of fit of the Model

The robustness and goodness of fit of the CCA model and its risk indicators are tested against the information available in the market. In order to do this, the historical series obtained from the CCA model is compared with the historical market series of the 5 year Credit Default Swap (CDS).

Correlation with the Market

If the outputs of the model are good, then the distance to stress (D2D) should be negatively correlated with the series of sovereign credit spread. As the distance to stress increases, the credit risk should decrease reflecting a lower end of the Credit Default Swap. Figure 20 shows the relationship between the distance to stress (inverted on the right axis) and the historical quotes of the 5 year CDS of Argentina[15]. On the other hand, it would be expected that the RNS and the EMBI + index are positively correlated. Figure 21 shows this relationship[16].

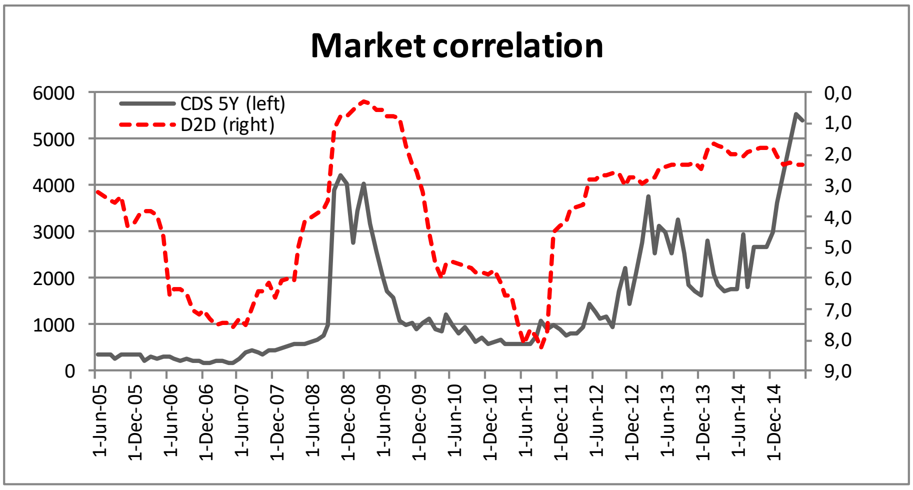


Figure 20: CDS 5Y and D2D correlation

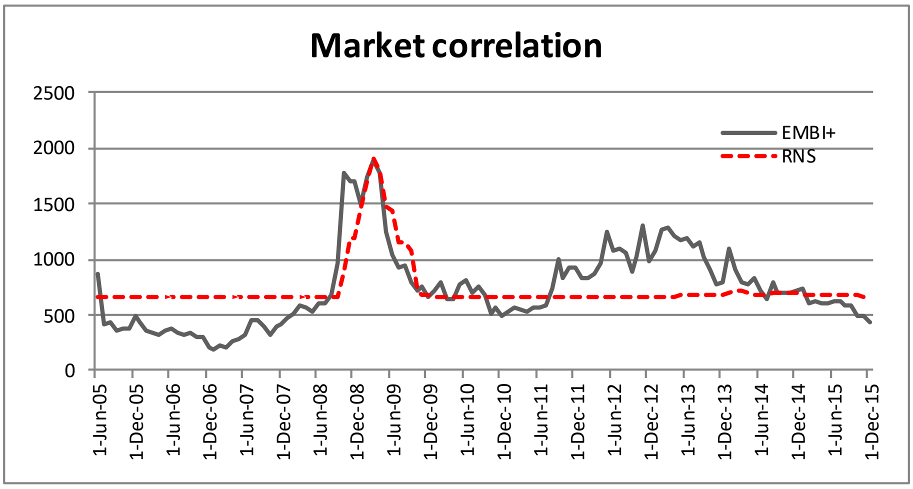


Figure 21: EMBI+ and RNS correlation

Table 3 and Figure 22 show the correlation between D2D and CDS, D2D and EMBI+, RNS and EMBI+ and finally RNS and CDS. The estimated correlation is Spearman's instead of the conventional one. The latter would be inappropriate given that it assumes a linear relationship between variables which contradicts the non-linear relationships established throughout the CCA model, while the Spearman coefficient does not assume linearity between the variables.

[15] The historical series available are between June 2005 and May 2015 (interpolating January-March 2015) due to the fact that New York Judge Thomas Griesa, ordered Argentina to pay the holdouts and Thomson Reuters has no information about the CDS since Argentina was considered to be in Default.

[16] For the estimation of the correlation between EMBI+ and SNR, the historical series available was from June 2005 to May and December 2015 for the D2D and the SNR respectively

	D2D vs		RNS vs	
	CDS 5Y	**EMBI+**	**CDS 5Y**	**EMBI+**
Rho Spearman:	-79.72%	-64.56%	79.83%	64.30%
Degree of freedom:	118	125	118	125
P-value:	1.26E-27	2.52E-16	9.37E-28	3.64E-16

Table 3: Summary Spearman's Correlation

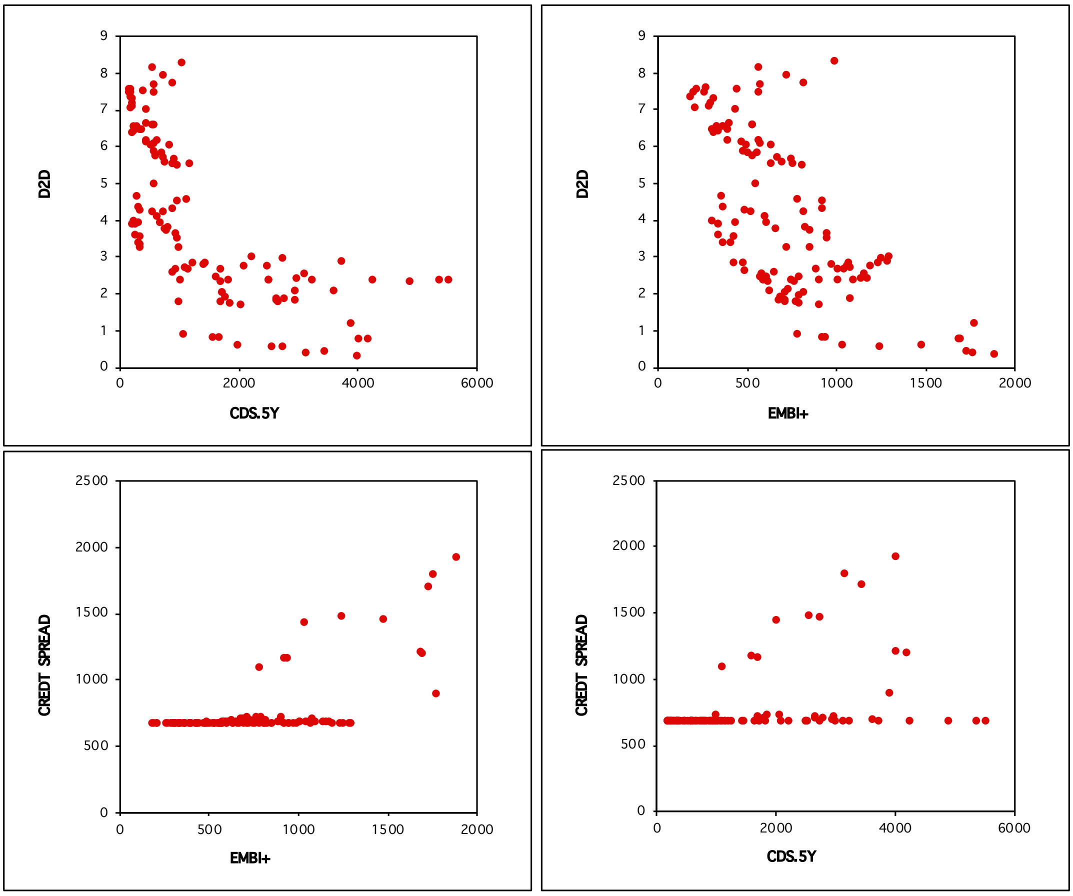


Figure 22: Spearman's correlation

Regression analysis

In order to estimate the relationship between the RNS and the sovereign spread of EMBI+, a simple regression analysis of the EMBI+ with respect to RNS is carried out. This allows us to map the risk neutral spread (RNS) towards the observed market spreads. This estimation methodology is important since the RNS frequently tends to underestimate the observed market spreads. In our regression model we used the EMBI+ as a dependent variable and the RNS as an explanatory variable. The result of the model yields the following equation and goodness of fit as can be seen in Table 4:[17]

$$EMBI_{+} = \beta_0 + \beta_1 RNS + \mu$$

$$EMBI_{+} = 667,9246 + 3,8237 RNS + \mu$$

In the Figures 23 and 24 below we can see the evolution of implied assets and the distress barrier, and the evolution of the implied asset volatility. It is evident that the model captures the 2008 shock mention above.

[17]We also estimated an Elasticity model, that is, a log-log regression analysis, the results of which were nearly the same.

Coefficients	Estimate	Std. Error	t value	Prob (> t)	Sig.
Intercept	667,9246	26,4139	25,287	<2e-16	0%
RNS	3,8237	0,4315	8,861	6,64e-15	0%
Residual standar error	283,8				
R squared	0,3858				
Adjusted R squared	0,3809				
F statistic	78,53				
p value	6,642e-15				

Table 4: Summary linear regression model

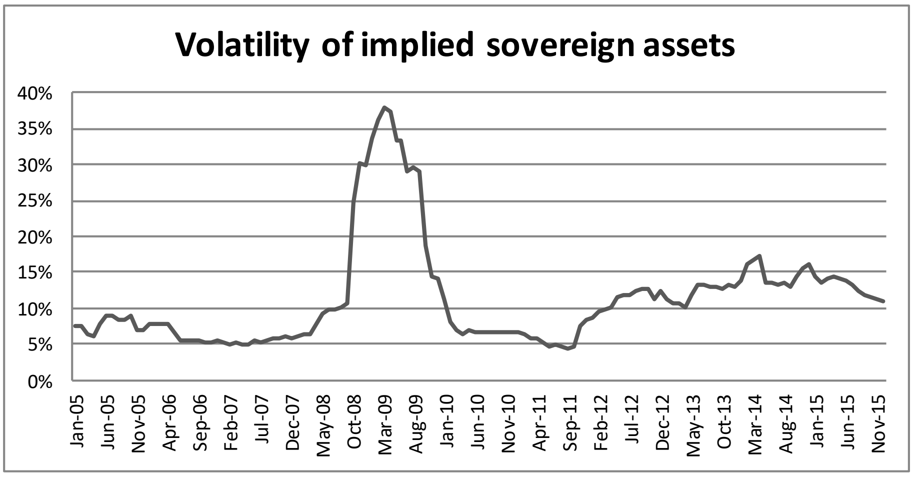


Figure 23: Implied sovereign assets volatility

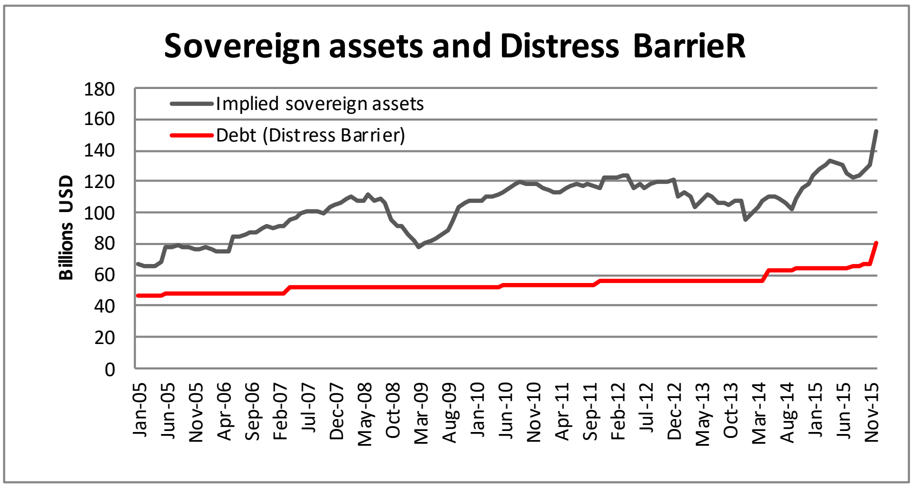


Figure 24: Evolution of Sovereign assets and Distress Barrier

Credit Risk and Sustainability

Credit Risk and Sustainability entail an explicit distinction between the process of sovereign risk premium estimation of local currency denominated debt and the sovereign risk premium estimation of foreign currency denominated debt.This distinction is important because, when covering expected losses in local currency debt, the government can choose to print more money (causing inflationary pressure) or force the dilution of debt via issuance of new sovereign bonds. Nevertheless, these kinds of options are not available in the case of foreign currency debt, as they are limited by the amount of foreign currency reserves and the generation of foreign currency.

The term "Debt Sustainability" means that the market value of debt remain above a certain threshold given a confidence level and maturity. That is, the risk premium and the expected loss must be below a certain threshold. When this level is accomplish then we can say that the debt is sustainable. For example, Basel

Committee[18] set a threshold about 0,5% of probability of default for debt whose maturity is one year. This percentage and maturity correspond to a BBB agency rating[19] (see Table 5 below[20]). Knowing that credit spread may vary according to the recovery rate and the liquidity level, a default probability of 0,5% usually corresponds to a spread between 50 to 100 basis points. This can be directly translated into the cost of new issuance or restructuring of debt and, from the point of view of the threshold, translates into potential limits at the time of borrowing (roll-over of the risk).

Rating	1 Year (%)	5 Years (%)	10 Years (%)
A	0,00	1,55	5,77
BBB	0,00	2,11	2,83
BB	0,59	4,73	10,60
B	2,53	13,28	23,60
CCC/CC	26,46	51,57	68,44
Investment Grade	0,00	0,91	2,02
Speculative Grade	2,65	10,98	19,25
All Rated	0,90	4,30	7,54

Table 5: Default probability per Rating

Simulation Methodology

In order to carry out analysis on different types of shock (stress) and policies, we will work under two methodologies. The first is commonly called "Scenario Analysis", in this methodology we will configure a "base" scenario that corresponds to the last period covered by the analysis (December 2015). An "adverse" scenario, which we will call scenario 1, represents the potential negative effects caused by a capital outflow. And a "favorable" scenario, which we will call scenario 2, represents the potential benefits of capital inflows (Figure 25).

The main objective of the scenario is to perform a static-comparative analysis, which allows us to estimate the effects of changes in economic condition and their impact on sovereign credit risk as compared to the "base" scenario. This way, we can appreciate the different non linear relationships between the different risk indicators and sovereign assets.

The "Scenario Analysis" can be complemented by the implementation of a method called "Montecarlo Simulation". This methodology allows us to obtain a large number of macroeconomic scenarios and achieve a probability distribution for each risk indicator. This method uses as input random data extractions on simulated samples of the 12-month future exchange rate and the Badlar domestic interest rate. To achieve a robust model, we proceed to simulate 10,000 possible scenarios through which we obtain sample distributions of the main risk indicators and main variables and, therefore, confidence intervals. These confidence intervals allow us obtaining "stress test" measures on sovereign risk levels with respect to risk indicators (D2D, PD, RNS, etc.). This type of measure called VaR (Value at Risk) can be defined, in summary, as the upper limit on the amount of gains or losses on the implicit value of sovereign assets for market risk.

Analysis of scenarios

Base scenario: The values are from December 2015 (last simulated month). During this period, the estimated stress barrier reached $80 billion (comprising 100% of short-term debt maturing within a year, plus 50% of long-term debt maturing after one year both issued in foreign currency, plus interest). The value and volatility of sovereign assets reached $153 billion and 22% respectively (volatility includes the average observed during 2015 and the average of the 2008-2009 stress period). Finally, the BCRA's reserve level of foreign currency amounted to $26 billion.

Credit Risk Indicators: distance to stress (D2D), in number of standard deviations is 1.24. The risk neutral default probability is 11%. Likewise, the value at risk of the debt issued in foreign currency is $72 billion and the spread for credit risk reached 831 basis points. Finally, the present value of the expected loss on the

[18] Basel Committee for Risk Management of Financial Institutions (Van Deventer and Imai, 2003).

[19] Gray, Lim, Loukoianova and Malone, (2008).

[20] Source: S&P Global Ratings. RatingsDirect. Default, Transition, and Recovery (2015) Annual Sovereign Default Study And Rating Transitions. Sovereign Foreign-Currency Cumulative Average Default Rate With Rating Modifiers (1975 - 2015) and Moody's Sovereign Default and Recovery Rates, 1983-2015. Issuer-Weighted Cumulative Default Rates, 1983-2015.

value of risky debt issued in foreign currency (implicit put option) is \$2 billion. This value arises from the difference between the distress barrier's present value discounted (using the 5-year US sovereign risk free rate of 1.76%) and the implicit market value of the foreign currency debt.

Sensitivity measures: we analysed the effect of 1% change in the implicit market value of the sovereign assets and their volatility. For example, if the value of the assets decreases by 1% (see Table 4) then this will cause a drop of 0.02 standard deviations in the D2D (i.e. from 1.24 to 1.22), the risk neutral default probability increases by 0.38 percent. The risk-neutral credit spread increases by 7 basis points and finally the expected loss (EL) of foreign currency debt increases by \$0.07 billion.

As we discussed earlier, this type of scenario sensitivity analysis framework allows us to capture the non-linearity in the CCA model. A specific example of this type of relationship can be seen in Figure 25 below[21] through the relative increase in the sovereign spread, rising from 831 to 1,212, as the implicit value of the assets approaches the distress barrier (scenario 1). While the sensitivity of RNS subject to a decrease in 1% in the value of assets goes from 7 basis points to 15.

Scenario 1: we assume (generally speaking) a deteriorating economy with decreasing country confidence and capital flight. Usually the outflows of capital can be associated with a combination of phenomena such as: depreciation of the local currency, a consequent fall in the prices of domestic debt (possibly associated with an increase in local interest rates) and an increase in the volatility of the exchange rate and of debt in general.

The final impact of the outflow of capital always depends on the political measures carried out. The general assumption used in this scenario is that those responsible implement certain policies against shocks, whose effects cannot be totally mitigated. These policies can include loss of foreign reserves held by the BCRA, an adjustment to interest rates and an increase in net fiscal tax assets. Under this scenario, the value of the assets is assumed to fall by \$20 billion, foreign reserves decrease by \$5 billion and the volatility of the assets increases by 5%. As a result of this scenario, the outflow of capital causes a deterioration in the sovereign credit risk indicators and an increase in the exposure to risk. This translates into a decrease of D2D of the order of 0.57 standard deviations (from 1.24 to 0.67) and an increase of 15 percentage points (i.e. from 11% to 25%) in the default probability and an increase of the order of 381 basis points (reaching 1212) in the credit spread.

Scenario 2: Analogously, a capital inflow scenario can be illustrated. The inflow of capital can be explained (in a simplified manner) through the joint result of an appreciation of the exchange rate, an improvement in domestic debt prices and a decrease in market volatility. Likewise, the inflow of capital allows the increase of foreign reserves, which may require sterilization operations. The impact of this type of scenario projects an increase of the sovereign assets by \$20 billion, a fall in the volatility of 2%, an increase in the reserves of \$5 billion and an increase in dollar terms of the debt issued in currency domestic due in part to sterilization and partly to the appreciation of the exchange rate.

[21] Based on the IMF WP/05/155[1].

Risk Indicators Dashboard

	Scenario 1	Dec' 2015	Scenario 2
Contingent Claim Sovereign Balance Sheet		*(USD billions)*	
Value of sovereign assets (implied)	**$133**	**$153**	**$173**
Foreign reserves (observed value) 1/	$21	$26	$31
Sovereign asset less reserves (implied)	$112	$127	$142
Value of risky foreign currency debt	$69	$72	$73
Distress barrier 1/	$80	$80	$80
PV of distress barrier 1/	$74	$74	$74
PV of expected losses (= implict put option)	$5	$2	$1
Value of local currency liabilities 1/	$64	$81	$100
Volatility of asset (implied)	27%	22%	20%
Credit Risk Indicators			
Distance to distress (D2D) 2/	0,67	1,24	1,68
Risk-neutral default probability (RNDP)	25%	11%	5%
Risk-neutral spread (RNS) 3/	1212	831	724
Sensitivity Measures 4/			
Change in distance to distress / 1% change in assets 2/	-0,017	-0,020	-0,022
Change in distance to distress / 1% change in asset vol. 2/	-0,05	-0,08	-0,10
Change in RNDP / 1% change in assets	0,53	0,38	0,22
Change in RNS / 1% change in assets 3/	15	7	3
Change in RNS / 1% change in asset vol. 3/	59	34	18
Change in PV expected loss / 1 % change in assets	0,14	0,07	0,03
Change in PV expected loss / 1 % change in asset vol.	0,53	0,32	0,17

1/ Model inputs. Remainder are model outputs.
2/ In standard deviation of sovereign asset value.
3/ Spread in basis points.
4/ Based on a 1 percent change in sovereign asset value (e.g. from 152.64 to 151.12) and sovereign asset volatility (e.g. from 22 percent to 23 percent).

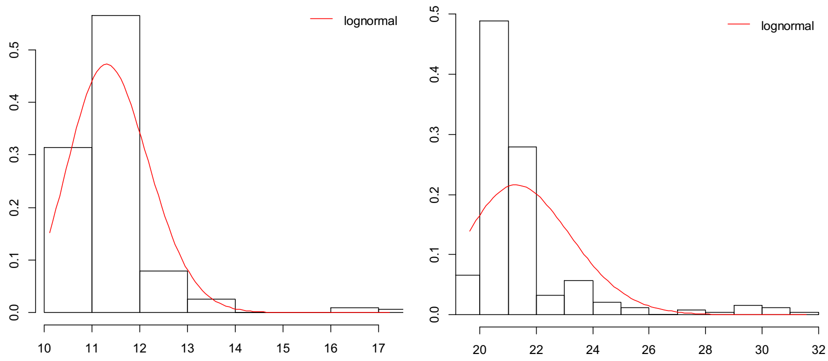
Figure 25: Risk indicator dashboard

Montecarlo Simulation

In the previous section we develop three estimation points for the credit risk indicators, the first arises from the "base" scenario and the other two from both "scenario 1" and "scenario 2". Although this type of work is useful when examining a specific type of event, it is also limited, given that only a few adverse market combinations can be considered. For this reason, Montecarlo Simulation methodology is advantageous to deal with multiple (several thousand) scenarios. Through this methodology we can obtain a probability distribution of the sovereign credit risk indicators and, as we mentioned above, measures of value at risk (VaR).

VaR measures are commonly used in Risk Management framework for credit risk, market risk, interest rate risk, operational risk, etc. From the Sovereign Balance Sheet point of view, we can define VaR as the market value of gains and losses of the Sovereign Assets due to market risk. And, just as an asset manager is required to maintain capital reserves to protect the institution from market or credit losses; Governments often identify the need to maintain a minimum cushion of foreign reserves to protect the economy against adverse market events.

The Montecarlo Simulation process is built on 10,000 random samples of two variables: the future 12 month FX and the domestic interest rate (Badlar). Through a goodness of fit analysis, we have been able to approximate the empirical distributions of the aforementioned variables towards a univariate logarithmic distribution with a certain confidence level, as shown in the graphs below (Figure 26).



(a) FX 12 months histogram (b) Badlar histogram

Figure 26: Empirical distributions aproximation

The empirical adjustment process of both variables was performed by maximum likelihood estimation. That is, once the parametric distribution $f(\cdot|\theta)$ is selected (with parameter $\theta \in \mathbb{R}^d$) it can be adjusted to the set of empirical data. Under the assumption that the sample follows a process i.i.d., the distribution of the parameters θ is estimated by maximizing the likelihood function defined as:

$$L(\theta) = \prod_{i=1}^{n} f(x_i|\theta)$$

Where x_i is the n observation of X variable and $f(\cdot|\theta)$ is the density function of the parametric distribution[22].

The simulation starting point process takes data from December 2015, where the 12 month future exchange rate was taken as \$17.23 (Argentine Pesos) while the domestic interest rate (Badlar) was taken as 27.25%. Through the estimated volatility and the correlation between both variables (it is 0.83, that is, a depreciation of the exchange rate usually leads to an increase in the domestic interest rate) a covariance matrix is obtained. Finally, through a well-known process called "Cholesky decomposition", we use this covariance matrix and obtain the following distributions (Figure 27):

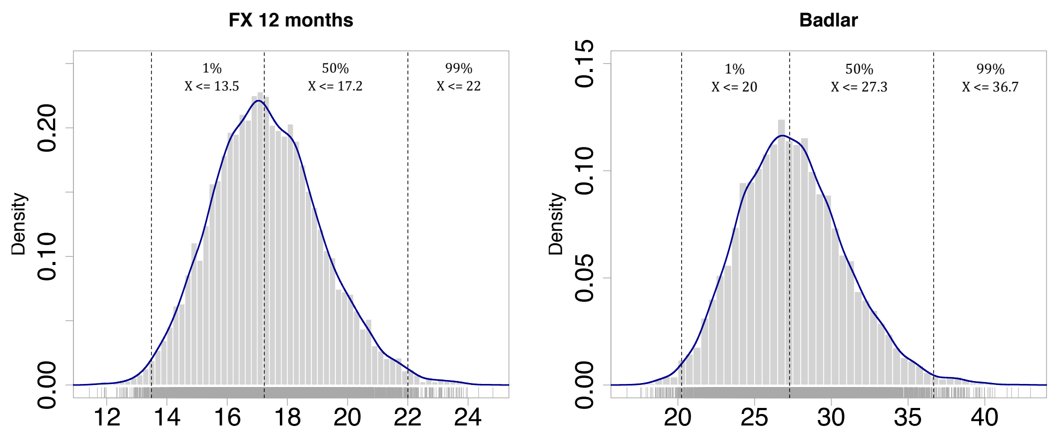


Figure 27: Montecarlo Simulation

We simulated 10,000 scenarios for both variables, the 12 month future exchange rate and the domestic interest rate (Badlar). The 12 month future exchange rate variable impacted directly on the sovereign balance sheet through the revaluation of the implicit value of sovereign assets and liabilities in domestic currency, expressed in USD, as of December 2015 (last month of analysis). The domestic interest rate (Badlar) variable however, impacted indirectly on the sovereign balance sheet. That is, the Badlar simulation was applied to the debt in local currency for a period of 3 years, and it is assumed to have a rate of return of 27.25% (that is, a cost equivalent to the expected Badlar). If the simulation results are higher than the expected Badlar rate of 27.25%, the discounted marginal incremental cost of the interest rate is subtracted from the value of the sovereign assets in order to reflect the increase in debt servicing. Alternatively, if the result of the simulation yields a lower rate

[22] fitdistrplus: An R Package for Fitting Distributions

than the one established, the discounted marginal differential is positively imputed to the implicit value of the sovereign assets.

Once the Montecarlo Simulation process is executed, it is possible to obtain univariate distributions for each of the sovereign risk indicators, that is: the Distance to Distress (D2D), the Risk Neutral Probability of Default (RNPD), and the Risk Neutral Spread (RNS). It is also possible to obtain a distribution of the implicit value of the sovereign assets. Below are the figures corresponding to each distribution (see Figure 28).

The Distance to Distress or D2D (in standard deviations units) average distribution is 1.24, the lower boundary at 5% probability is 0.77, while the upper boundary at 95% probability is 1.68. The Risk Neutral Spread or RNS (in basis points units) average distribution is 833, the lower boundary at 5% probability is 726, while the upper boundary at 95% probability is 1057. The Risk Neutral Default Probability or RNDP average distribution is 11% the lower boundary at 5% probability is 4.5%, while the upper boundary at 95% probability is 22%. Finally, the Implied Sovereign Assets (in USD billions) average distribution is \$152, the lower boundary at 5% probability is \$121, while the upper boundary at 95% probability is \$190.

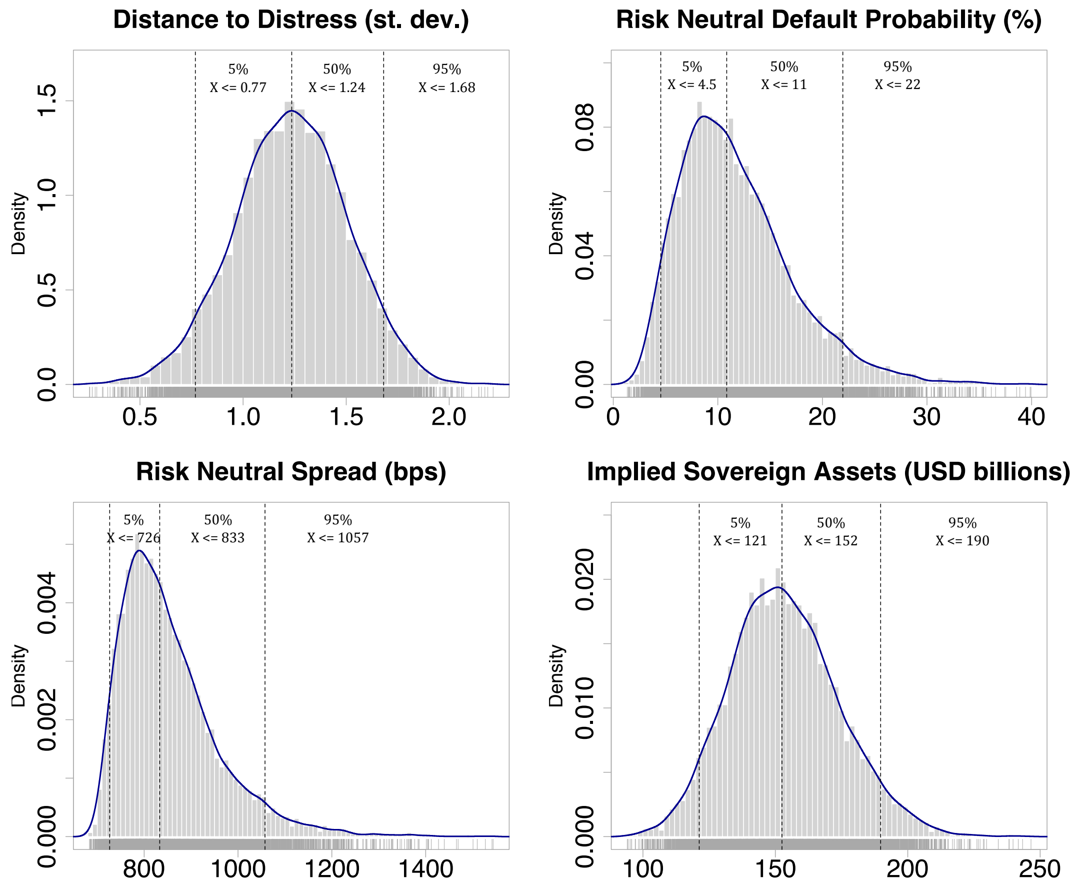


Figure 28: Sovereign Risk Indicators Distributions

Policy Design evaluation

Policy Design

Based on the distributions obtained from the Montecarlo simulation process we can evaluate or test the quantitative effect of implementing different kinds of policies. These may include, among others, changes in the level of foreign reserves, changes in debt structure, the use of mitigating risk instruments such as insurance contracts, etc. Regardless of the policy implemented, those executions have a direct impact on the sovereign balance sheet and, therefore, we will obtain a new probability distribution of the aforementioned credit risk indicators. In our paper, we present three types of policy administration: one linked to "Indebtedness", another linked to levels of "foreign reserves" and a third, a type of policy that combines the previous ones, which we shall call "Assets and Liabilities".

Debt structure management: Figure 29 illustrates an example where political management seeks to analyse the effect of reducing exchange rate exposure. To achieve this objective, it mainly focuses on exchanging $10 billion of debt issued in foreign currency (which is part of the distress barrier) for the same amount of debt in local currency. As a result, the distress barrier falls by that amount, while the debt in domestic currency increases. The Montecarlo simulation shows us how all the distributions of the credit risk indicators improve with respect to the base distribution.

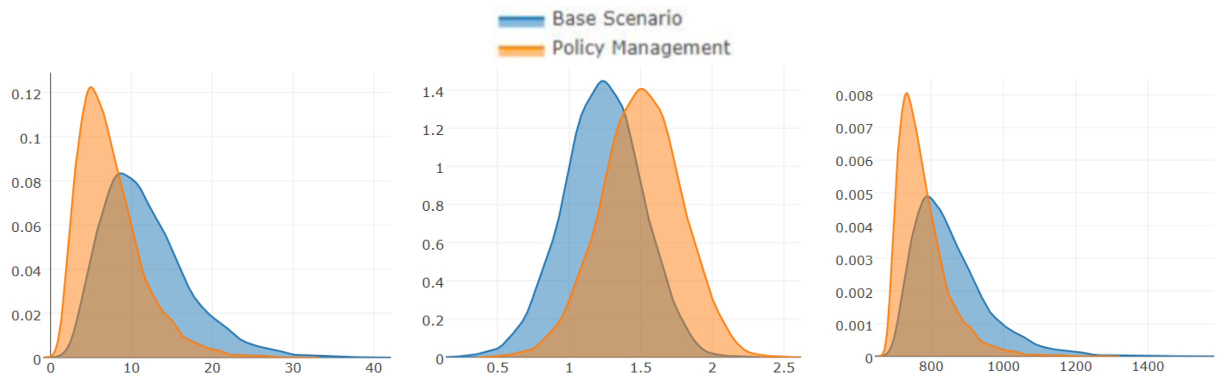
Foreign reserves management: Figure 30 shows the example of an increase in foreign reserves financed mainly by issuing domestic debt. This way Sovereign assets (including foreign reserves) and liabilities in local currency both increase by $10 billion. This scenario can be seen as a proactive strategy of reserve accumulation or capital flow incomes, and therefore, an increase in domestic debt as a consequence of sterilization. As with the debt policy, "foreign reserves management" improves all distributions of credit risk indicators. However, if we analyse the improvement in 1% of the probability distribution, we find that this policy is less effective than the results obtained through the management policy on the debt structure.

Asset and Liability management: Figure 31 illustrates a management policy on foreign reserves and debt structure simultaneously (that is the sum of previous examples). Although the conjunction of both policies generates an improvement in the risk indicators, it is less than the individual sum of each of the policies, reflecting, once again, the non-linearity of the model. Finally, Table 6 shows the impact on the quantiles of each risk indicator for the scenarios proposed.

Notwithstanding the successful demonstration of the implementation of the aforementioned policy strategies, it is necessary to carry out a systemic analysis and its respective trade-offs in each case. That is, the positive effect of each of the three policies carried out on the distribution of risk indicators is evident, but this improvement must be balanced against the negative aspects from the point of view of sovereign balance sheet management (such as the increase of debt in local currency and the interest rate).

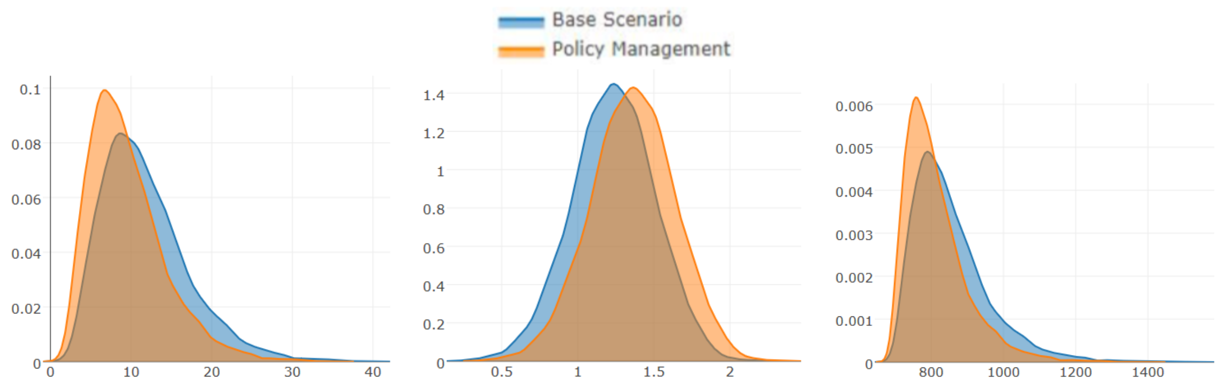
Policy Management	Credit Risk Indicator	5% quantile	50% quantile	95% quantile
	PD (%)	2,40	6,70	15,20
Indebtedness	D2D (st. dev.)	1,02	1,50	1,96
	RNS (bps)	697	760	914
	PD (%)	3,40	8,60	18,50
Foreign Reserves	D2D (st. dev.)	0,89	1,36	1,81
	RNS (bps)	710	794	982
	PD (%)	1,80	5,00	12,50
Asset and Liabilities	D2D (st. dev.)	1,15	1,63	2,09
	RNS (bps)	688	736	861
	PD (%)	4,50	10,80	21,90
Base Scenario	D2D (st. dev.)	0,77	1,24	1,68
	RNS (bps)	726	833	1057

Table 6: Policy design evaluation summary



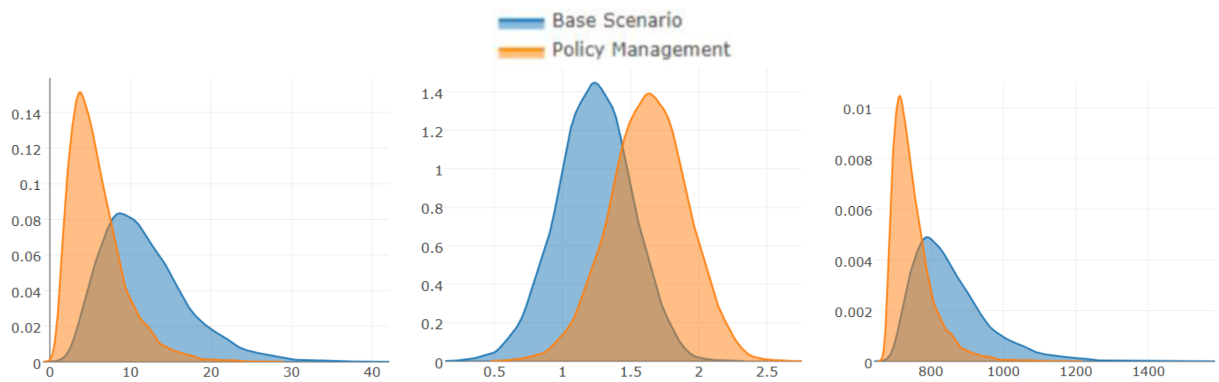
(a) PD (%) (b) D2D (st. dev.) (c) RNS (bps)

Figure 29: Indebtedness



(a) PD (%) (b) D2D (st. dev.) (c) RNS (bps)

Figure 30: Foreign Reserves



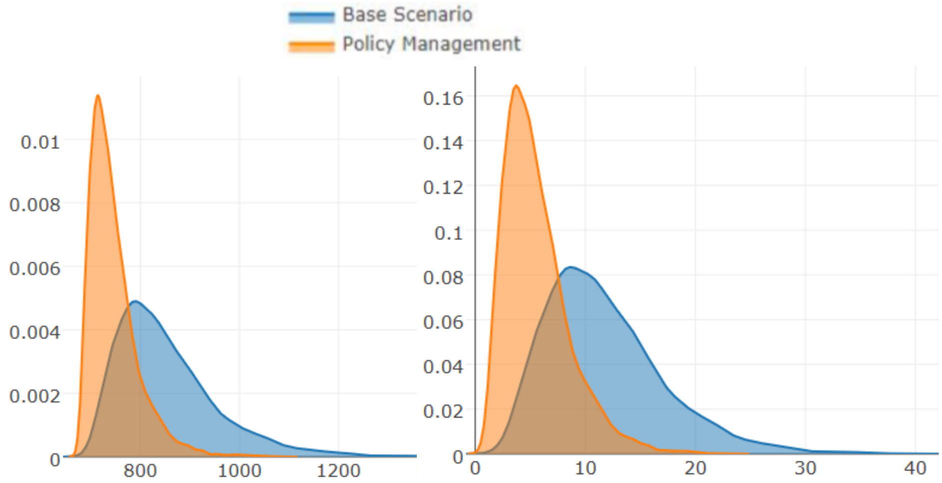
(a) PD (%) (b) D2D (st. dev.) (c) RNS (bps)

Figure 31: Asset and Liabilities

A closer view of Foreign Reserve Management

Under the methodology presented in this paper, we can set an optimal level of foreign Reserves held by the Monetary Authority such as to minimize the distress through the credit risk indicators. For example, we can set an adequate level of reserves that holds the D2D (or DP) above 95 percent confidence level based on the historic foreign exchange process. Moreover we can set a group of credit risk indicators as a target that maintains a minimum of foreign reserves. For example we can develop a set of credit risk indicator distributions for an hypothetical capital-inflow scenario that allows foreign reserves to increase by the sum of USD 34,000 million (a total stock of USD 60,000 million), with a roll-over of foreign currency denominated debt in the long term (i.e. a change in the term debt composition of USD 15,000 million) and finally, and increase in domestic currency denominated debt trough the sterilization process.

The final impact of this scenario on the initial state of sovereign debt is shown in Figures 32 and 33. The first graph shows the parallel distribution movement and the last figure shows the percentile impact. At this point it is important to mention that these kinds of simulations and policies are not always direct o straightforward, that is, a capital-inflow scenario is much more complex and may generate externalities that the government would need to manage.



(a) RNS (bps)

(b) PD (%)

Figure 32: Sovereign Risk Indicators. Parallel distribution movement

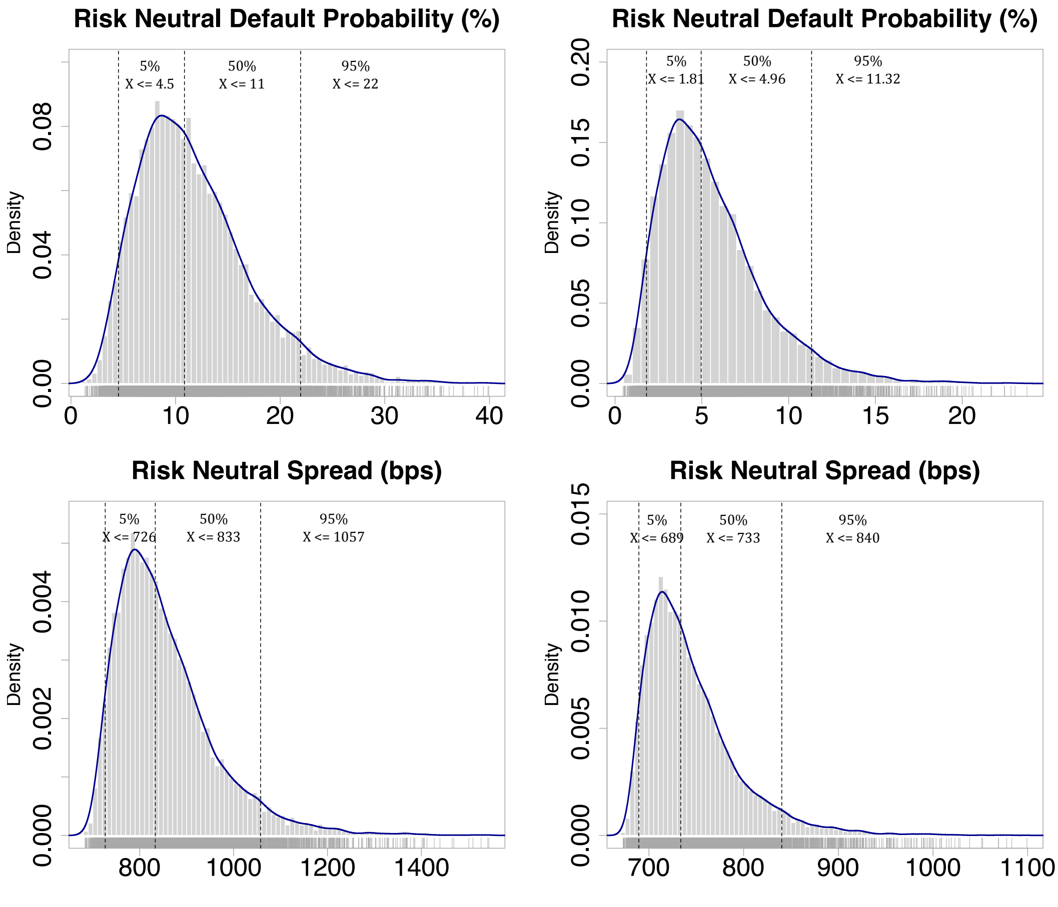


Figure 33: Sovereign Risk Indicators Distributions

Taking again Moody's and S&P ratings and their default probabilities (Table 6) we can observe that the initial DP state is approximated 11% with a potential increase to 22% (with a 95% confidence level). This DP range is equivalent to a "B" rating. After implementing the foreign reserve accumulation policy the estimated

DP is around 5% with a potential increase to 11% (with a 95% confidence level). This new distribution is within an equivalent rating of “BB”. In addition to the impact on DP and, consequently, on the rating, there is another kind of positive externality in this type of foreign reserve accumulation policy. In our hypothetical scenario we can observe that the interest rate risk premium is 8.33% (833 basis points) over the risk free interest rate. After the foreign reserve policy implementation the interest rate risk premium reached 7.33% (733 basis points). This decrease of 100 basis points has a significant impact on sovereign debt cost, both in terms of issuance of new debt or debt roll-over. Simplifying the analysis, in 2015 Argentina was paying an interest rate risk premium [23] of 9.3% (see Figure 34)[24]. If we compare this sovereign interest risk premium with other emerging countries we can see easily that Chile, Peru, Colombia and Greece (among others) were “paying”: 2,9%, 3,8%, 5,5%, and 16% respectively[25]. Except Greece, all the emerging countries mentioned above have significantly lower interest risk premium.

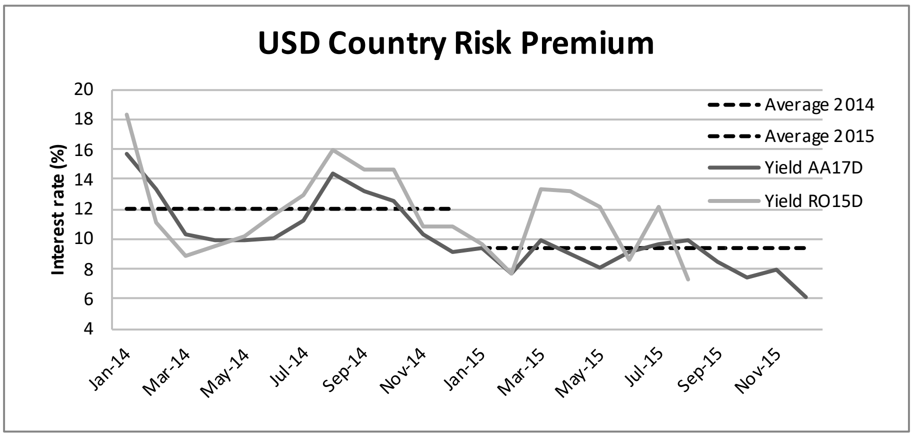


Figure 34: Implied sovereign assets volatility

In Figure 30 above we can observe that the expected RNS (median) of the distribution shifts to the left by 100 basis points. If we take this marginal upturn in the RNS over the issuance of new long term debt of USD 30,000 million (10 years) and assume that the interest rate scheme payment is simple (bullet or at discount, i.e. interest and capital are paid at maturity), this decrease implies a cost reduction (or savings) in present value terms of approximately USD 2,000 million (see Table 7).

Face Value: USD 30,000 Millions			
Year	**Average Yield 2015**	**-100 bps Yield**	**Difference**
1	9.3%	8.3%	USD 277,008,310
2	9.3%	8.3%	USD 255,778,680
3	9.3%	8.3%	USD 236,176,066
4	9.3%	8.3%	USD 218,075,777
5	9.3%	8.3%	USD 201,362,675
6	9.3%	8.3%	USD 185,930,448
7	9.3%	8.3%	USD 171,680,930
8	9.3%	8.3%	USD 158,523,481
9	9.3%	8.3%	USD 146,374,406
10	9.3%	8.3%	USD 135,156,423
Total			**USD 1,986,067,196**

Table 7: Spread impact

This evidence of foreign reserve positive externality is aligned with E. Levy Yeyati’s (2006)[15] article in which he argues that much research on accumulation of foreign reserve policies have “missed” important potentially positive collateral effects. Since the cost of holding foreign reserves (which is typically estimated as the spread between the interest rate on the debt issued in order to accumulate foreign reserves, and the risk free rate at which such reserves are invested) is usually overestimated. This is the case as the accumulation of reserves

[23] This sovereign risk premium comes from discounting the USD nominated debt sovereign bonds: RO15 and AA17 and the 2 year US yield.

[24] It is interesting to note that the sovereign risk premium values are within the “Base SNR distribution model” given that its 99% percentile reaches a spread of 1,163 basis points, but is higher than the expected 750 basis points.

[25] Thomson Reuters Eikon information, constituent of the 2 Year Bond government reference curve.

reduces the probability of default (as demonstrated above), this decrease reduces the margin paid on the stock of sovereign debt, adding to the marginal benefits of reserve accumulation. In another article E. Levy Yeyati (2010)[16] has shown that the expenditures generated by this "insurance" generated by reserves accumulation tends, in part, to be compensated in periods of economic stress, by the tendency of the exchange rate to depreciate. Finally, it is important to note that central banks, unlike commercial banks, do not aim to make a profit. Due to their inherent characteristics central banks can continue to function independently despite generating negative results and / or net worth[26].

[26] The importance of a negative result for these entities is related to the magnitude and persistence of the same and the expectation of compensation via seigniorage or asset valuation gains. For more information see Archer and Moser-Boehm (2013), "Central bank finances", BIS Papers No 71.

Conclusions

Argentina's Risk based DSA model show us that in the last decade (2005-2015) the country does not appear to have been vulnerable against real sovereign debt stress events (defaults). Nevertheless, the 5 years CDS, the EMBI+ and the D2D have been volatile during that period (see Figure 20 and 21). This characteristic shows us that Argentina has not been immune to sudden market shocks or events (sudden drops). Manifesting this through sovereign spread increases and erodes the implicit market value of sovereign assets. A clear example of the level of sovereign exposure arises from the results of the consistent model of the price level, yields (see Figures 4 to 7 and 12), volatility (see Figure 23) and sovereign spread (see Figure 21) during the period between the last quarter of 2008 and the first half of 2009 where the D2D reaches a minimum level of approximately half standard deviation (see Figure 20).

Although Argentina's Risk based DSA model efficiently captures the correlation between D2D, CDS and EMBI+, which allows us to perform sensitivity analysis by creating scenarios and parametric simulation analysis using Montecarlo, there are some aspects about the evolution of the CDS or the EMBI+ not captured by the model. More precisely, we need to perform an adjustment by regression analysis to calibrate the RNS. Despite this weakness, the CCA model is extremely useful when determining the sustainability of a government based on the implicit value and volatility of its assets.

Given that the Risk based DSA model is parsimonious and relatively simple to calculate and capture market expectation, the use of Risk based DSA as an additional tool to the traditional DSA, is highly recommended in the implementation of macroeconomic, fiscal or monetary policies. .

Moreover, the presented model can be extended in order to capture the interrelation between the Sovereign Balance and the different (most important) sectors of the economy. Gray and Malone (2008)[9] present several types of relationship between the Sovereign Balance Sheet and Corporate, Financial and Household balance sheets, complemented by the External Sector. In principle, these CCA balances by sector can be integrated into what is called a General Balance Sheet of the Economy, whose risk exposures between modeled sectors consist of implicit options of puts and calls. Obviously in practice this type of model is subject to the availability and quality of information about the country under analysis. Last but not least, this type of CCA model can be used as an entry variable towards macroeconomic models such as IS-LM (Mundell-Fleming) or DSGE models[27].

[27] For more information see Chapter 14, Gray, D. and S. Malone, (2008).

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