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## Journal of Banking &amp; Finance

journal homepage: [www.elsevier.com/locate/jbf](http://www.elsevier.com/locate/jbf)

# Modelling sovereign credit spreads with international macro-factors: The case of Brazil 1998–2009

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## ARTICLE INFO

## Article history:

Received 1 September 2011

Accepted 7 August 2012

Available online 23 August 2012

## JEL classification:

G12

F41

F34

E43

## Keywords:

Affine term structure model

Macro-finance

Sovereign credit spread

International spillover

Macroeconomic volatility

## ABSTRACT

This paper develops a macro-finance model of the Brazilian economy and its sovereign debt markets that allows for domestic and international macroeconomic influences as well as swings in investor confidence. It finds significant evidence of common trends in the US and Brazilian economies and bond markets as well as spillover effects from US inflation and business cycles to the Brazilian economy. The US Fed Funds rate influences Brazilian sovereign spreads, as do Brazilian inflation and policy rates. The Brazilian confidence factor dominates the behavior of the spreads during periods of crisis and we find that it also has a powerful effect on the level and volatility of macroeconomic variables. These results suggest that the macro-finance approach could throw light upon the behavior of other economies that are troubled by sovereign risk.

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## 1. Introduction

This paper develops a macro-finance model of the US and Brazilian economies and the markets for US Treasury bonds and Brazilian sovereign debt (US dollar-denominated Brazilian government bonds) over the period November 1998 to December 2009. This was a period of economic and political stability under the Cardoso and Lula governments, when Brazil (along with the other 'BRICs', Russia, India and China) emerged as a leading world economy. It followed the emerging market crisis of 1998 but included the Brazilian crises of 1999 and 2002 as well as the global financial crisis of 2008. We also use the model to assess the performance of Brazil during the recovery phase, 2010–2011.

There is a large outstanding literature on the effects of macroeconomic and financial factors on sovereign spreads (the differences between yields on sovereign bonds and US Treasuries). Most of these studies analyze the effect of domestic macroeconomic and external liquidity conditions on these spreads (Eichengreen and Mody, 1998; Min, 1998; Ferrucci, 2003; Baek et al., 2005). Others

find that contagion spillovers from other emerging markets (Mauro et al., 2002; Ciarlone and Trebeschi, 2009; IMF, 1999; Claessens and Forbes, 2001) as well as global financial factors (Masson and Mussa, 1995; Arora and Cerisola, 2001) are also significant, often dominating the effect of macroeconomic variables. However, these studies do not use the arbitrage-free pricing approach found elsewhere in the finance literature. Nor do they consider the possible feedback effects of swings in investor confidence on the domestic economy.

In this paper we use an arbitrage-free macro-finance framework that allows bond yields to reflect macroeconomic variables as well as latent variables representing spillovers from other emerging markets, global influences and other financial market factors. It also allows these factors to influence the domestic economy. This approach was pioneered by Ang and Piazzesi (2003) and has been developed by Rudebusch and Wu (2003), Jiang and Yan (2009), Dewachter et al. (2006), Joyce et al. (2010), and Fan and Johansson (2010) and many others in a closed economy setting. Some macro-finance models allow bond yields to reflect macroeconomic variables using a jump diffusion for the spot rate (e.g. Jiang and Yan, 2009). However, this paper follows the KVAR approach which augments the usual macro Vector Autoregression (VAR) model with Kalman filter latent variables to capture changes in the underlying rate of inflation (reflected in inflation, nominal interest rates and

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bond yields). We allow the nominal trend ( $f_t^*$ ) to affect both US and Brazilian economies and bond markets.

These macro-finance studies employ a closed economy model, but we follow Spencer and Liu (2010) by developing an open economy model that allows for global trends, external contagion effects and macroeconomic spillovers from the US to the Brazilian economy and sovereign debt spreads. We use a reduced-form framework<sup>1</sup> to model these spreads. This approach treats default as an unexpected event that occurs with a hazard rate  $h(t)$ , which can be modelled like the spot rate  $r(t)$  in a standard affine term structure model. It has successfully replicated the size of credit spreads in the corporate markets (Jarrow et al., 1997; Lando, 1998; Duffie and Singleton, 1999). Liquidity, counterparty and other market-specific risks can be handled in a similar way. Duffie et al. (2003) and Pan and Singleton (2008) use this framework to model sovereign spreads. However, these reduced-form models all use latent variables that can only be interpreted as confidence indicators or perhaps by ex post alignment with macroeconomic variables. Our model also incorporates macroeconomic variables explicitly, allowing us to distinguish their effects from those of unobservable 'confidence' and other effects.

Although our estimation period is typical of those for emerging market studies in being short compared to those used in macro-finance studies of developed economies, it is informative about the issues of interest. It begins with a period of high sovereign spreads and macroeconomic volatility, allowing us to assess the effect of confidence factors on both spreads and the domestic economy. The period extends to December 2009, including subsequent observations for which investor confidence in Brazil was high and macroeconomic volatility low, enabling us to identify significant macroeconomic effects on yield spreads and volatility. This data set also encompasses the credit crunch that began in August 2007 and the ensuing US recession. This caused much larger fluctuations in US macroeconomic variables than seen in earlier years, making it easier to estimate their effects on Brazil. Moreover, macro-finance models bring both macroeconomic and financial information to bear on these issues, allowing the linkages between the economy and financial sectors in different countries to be analyzed. Our model uses data on six macroeconomic variables, six US bond yields and five sovereign spreads, giving a total of 2278 observations. Arbitrage and economic restrictions allow us to develop a relatively rich but parsimonious KVAR framework encompassing two macro-financial systems for both the US and Brazil and incorporating a wide variety of linkages between countries and markets that do not feature in single-country stand alone models of economies or bond markets.

The first of these systems is a standard US macro-finance model that uses a central bank model to represent the behavior of the macroeconomy in terms of the US output gap ( $g_t^*$ ), inflation ( $\pi_t^*$ ) and the short term interest rate ( $r_t^*$ ).<sup>2</sup> It also includes bond yields and two latent variables reflecting real ( $z_t^*$ ) and nominal ( $f_t^*$ ) factors, which are interpreted as 'common' or 'global' factors because they can also affect Brazil. The second system models the behavior of the Brazilian economy using a similar central bank model, represented by the output gap ( $g_t$ ), inflation ( $\pi_t$ ) and short term interest rates ( $r_t$ ) as well as its sovereign bond yields. We start by developing three closed economy models, which allow us to analyze the importance of macro-finance links between the Brazilian economy and

sovereign bond market. The first (M0) consists of two separate models: a VAR explaining the macro-variables and a stand alone affine model of the sovereign bond yields. Models M1 and M2 introduce the links running from the bond market to the economy (M1) and then those from the macroeconomy to the bond market (M2), allowing us to see which are significant. This exercise shows that the link from the confidence factor to macro-volatility is particularly important to the working of the model (and arguably the Brazilian economy), one of the key findings of the paper. The confidence factor  $f$  that lies at the heart of the macro-finance models affects both the dynamic behavior and the volatility of the Brazilian economy as well as being priced into the sovereign spreads, binding the macro and bond market models together closely. We then extend the closed economy model M2 to allow for the effect of the common global factors and spillovers from US macroeconomic variables to Brazil, estimating three open economy models (M3–M5). M2 is decisively rejected against these models. The final specification (M3) finds common global trends in real interest rates ( $z_t^*$ ) and nominal variables ( $f_t^*$ ). The latter appears to reflect 'flight to quality' and inflationary oil price shocks influencing international bond markets. In addition to these global effects, the US output gap impacts the Brazil business cycle and there is evidence of an inflationary spillover. The US Fed funds rate affects the sovereign short spreads significantly, as do the Brazilian inflation and policy interest rates.

The paper is organized as follows. Section 2 lists some of the main developments over the estimation period 1998–2009 and then discusses the data and the preliminary tests. Section 3 describes the theoretical framework. Section 4 reviews the empirical results and the performance of the final model (M3) against a more conventional specification (M0) and then looks at the behavior of these economies and markets implied by M3. Section 5 offers our concluding remarks.

## 2. Key developments, data and model design

This section outlines the key political and economic developments seen during our estimation period. It then reports the model data sources and the results of a preliminary specification search, used to inform the macro-finance (MF) model framework in the next section.

### 2.1. Data sources

The model is estimated using monthly macro and yield data for the period November 1998–December 2009, which was an eventful period in Brazil's political and economic history. It began under President Fernando Henrique Cardoso with a move from fixed to floating exchange rates in January 1999 and to inflation targeting in the following July. It includes the periods of uncertainty seen in 1999 and again in 2002 following the Argentinian default and the election of President Luis Inacio Lula da Silva. When Sr. da Silva came to power, Brazil had already received the largest loan ever given by the IMF and the markets expected him to default. However, he tightened fiscal policy instead, making it much tighter than the IMF had demanded. Confidence began to return towards the end of the year, ushering in a period of economic growth and stability. This placed Brazil in a good position to withstand the effect of the credit crunch that began in the US in August 2007, when a liquidity crisis in the Brazilian markets with potentially serious economic consequences was effectively dealt with by a reduction in bank reserve requirements (see Montoro (2011)). Improvements in macroeconomic policy and behavior allowed the country to ride the reduction in world trade relatively well and then to recover remarkably quickly.

<sup>1</sup> The alternative would be to use a structural model in which default is triggered as a solvency variable (like the value of a firm in the case of a corporate borrower) hits a threshold value (Merton, 1974; Leland, 1994; Leland and Toft, 1996; Longstaff and Schwartz, 1995). However, the solvency variable is not well defined for a sovereign borrower and the threshold would be hard to specify. It is also difficult to explain the size of short spreads using the structural approach.

<sup>2</sup> Akram and Eitrheim (2008) evaluate the central bank model against VAR alternatives that include asset prices.

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