Sovereign spreads, currency crises, and fundamentals: A non-linear analysis

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1 The issue

- Growing market size of emerging countries' bonds after the debt crisis of mid-eighties.

- Sovereign spreads: excess return of emerging markets debt instruments over comparable US Treasury bonds interest rate.

- Understanding spreads dynamic behaviour important for portfolio allocation and debt management...

$\Rightarrow$ large literature on fundamental determinants of sovereign spreads: Edwards (1984, 1986), Fernàndez Arias (1996), Kamin and Kleist (1999), Jostova (2006).

BUT Ferrucci (2003): non-fundamental factors play a more important role $\longrightarrow$ over financial and currency crisis periods relationship between spreads and fundamentals breaks down $\longrightarrow$ is this evidence of market inefficiency?

2 This paper

- THEORETICAL CONTRIBUTION: using Boschi and Goenka (2007) show that relationship between sovereign spreads and fundamentals weakens as pressure exerted by investors in foreign exchange markets increases.

- METHODOLOGICAL CONTRIBUTION: show how to bring to data a class of "second generation" models of financial/currency crises using a Markov-switching VAR framework $\Rightarrow$ extension to a MULTIVARIATE analysis of Jeanne and Masson (2000).

3 The model

- The representative international investor maximizes expected utility over time.

$$U_t = E_t \left\{ \sum_{s=t}^{\infty} \beta^{s-t} u(C_s) \right\} \tag{1}$$

- E_t = expectation operator;

- $\beta \in (0, 1)$ = constant subjective time-preference factor;

- $u(\cdot)$ = period utility function.

- Period-by-period budget constraint:

$$B^{*f}_{s+1} + \sum_{m=1}^{M} x^{*m}_{s+1} B^{*m}_{s} + \sum_{m=1}^{M} x^{m}_{s+1} \frac{B^{m}_{s}}{e^{m}_{s}} =$$
$$(1 + r^{*f}_{s}) B^{*f}_{s} + \sum_{m=1}^{M} x^{*m}_{s} (I^{*m}_{s} + B^{*m}_{s})$$
$$+ \sum_{m=1}^{M} x^{m}_{s} \left(\frac{I^{m}_{s} + B^{m}_{s}}{e^{m}_{s}} \right) - C_s \qquad (2)$$

- B^{*f}_{s} =risk free asset purchased at time s

- $x^{*m}_{s+1}, x^{m}_{s+1}$ = fractions of country m's security held

- B^{*m}_{s}, B^{m}_{s} = market value of country m's dollar- and local currency debt

- r_s^{*f} = risk free interest rate

- I_s^m =dividend/coupon of country m's security

- C_s = consumption.

  - Maximizing (1) subject to (2) with respect to x_{s+1}^{*m}, x_{s+1}^m, and B_{s+1}^{*f}, gives the Euler equations at every date s for each asset.

  - Manipulate the Euler equations; approximate through a Taylor expansion;

  - We obtain:

$$E_t(r^{*m}_{t+1}) - r^{*f}_{t+1} \approx$$
$$(1 + r^{*f}_{t+1})\beta \left(\frac{-C_t u''(C_t)}{u'(C_t)} \right) Cov \left\{ \frac{C_{t+1}}{C_t}, r^{*m}_{t+1} \right\}. \quad (3)$$

If we assume a decreasing relative risk aversion then a negative relationship between risk premium and aggregate consumption is established.

- Using a log-linear approximation to the budget constraint:

$$c_t - E_{t-1}c_t = (E_t - E_{t-1}) \sum_{j=0}^{\infty} \eta^j r^{*w}_{t+j} \quad (4)$$

- This provides the needed link between the risk premium and the probability of devaluation of country m' currency.

- If $\pi_{t+1}^{m} \uparrow, \Longrightarrow E_t(r_{t+1}^{*m}) \downarrow \Longrightarrow E_t r_{t+1}^{*w} \downarrow$.

- $c_t - E_{t-1} c_t \downarrow \Longrightarrow$ pure wealth effect.

- Finally $\rho_{t+1}^{m} \uparrow$ through increased risk aversion.

- Build on a second generation model of currency crises in the spirit of Jeanne (1997).

- Emerging economy will take any decisions about either maintaing the peg or not by minimizing the following loss function:

$$L_{t+1} = (u_{t+1})^2 + (\Delta d_{t+1})^2 + \delta \Gamma_{t+1} \qquad (5)$$

- $u_{t+1} =$ unemployment rate.

- Δd_{t+1} = growth in government real debt proportional to GDP.

- δ = dummy variable equal to 1 if devaluation occurs and 0 if the peg is mantained.

- Γ_{t+1} = exogenous cost of devaluing.

  - Net benefit of the peg: difference between the *devaluation* and *fixed* loss function:

$$\overline{V}_{t+1} = L^{d}_{t+1} - L^{f}_{t+1} \tag{6}$$

  - The decision rule of the policymaker is derived optimally:

$$\phi_{t+1} = E_t\left(V_{t+1}\right) \tag{7}$$

- The international investor formulates rational expectations:

$$\pi_{t+1} = \mathsf{Pr}\left[\overline{V}_{t+1} < 0\right]$$

- Thus:

$$\pi_{t+1} = \mathsf{Pr}\left[\epsilon_{t+1} < \alpha\pi_{t+1} + \varphi\rho_{t+1} - \phi_{t+1}\right] \qquad (8)$$

Under certain conditions eq. (8) may have multiple solutions/equilibria.

4 Empirical illustration

Theory shows a complex interdependence between probability of currency crisis (π_{t+1}) and risk premium (ρ_{t+1}).

This relationship can be linearly approximated to obtain a Markov-switching VAR:

$$y_t = \nu(s_t) + \Pi x_t + \varepsilon_t \tag{9}$$

- $\mathbf{y}_t = \begin{bmatrix} \pi_t \\ \rho_t \end{bmatrix}$;

- $\boldsymbol{\nu}(s_t) =$ intercepts allowed to switch between regimes;

- $s_t =$ UNOBSERVABLE current regime/state $\rightarrow$ follows hidden 2-state Markov chain stochastic process.

- $\mathbf{x}_t$ = vector of relevant economic fundamentals.

I estimate a reduced-form, dynamic generalization of (9):

$$y_t = \nu(s_t) + \sum_{i=1}^{p} A_i y_{t-i} + \sum_{j=0}^{q} \Pi_j x_{t-j} + \varepsilon_t, \quad s_t = 1, ..., n \tag{10}$$

$\Rightarrow$ MSI(2)-VARX(p, q) model.

- Maximum likelihood estimation through *Expectation Maximization* (EM) algorithm.

4.1 Data

- Brazilian economy interesting case $\longrightarrow$ three main periods of financial distress: 1994, 1998, 2001/2003.

- Proxy risk premium, ρ_t, using the Emerging Markets Bond Index + (EMBI+) developed by JP Morgan.

- Term "currency crisis" a strong speculative pressure on country's currency $\Rightarrow$ probability of devaluation, π_t, proxied by an index of the pressure exerted by participants on the foreign exchange market: Exchange Market Pressure Index (EMPI):

$$empi_t = -\frac{\sigma_e}{\sigma_{RES}}\Delta RES_t + \Delta e_t + \frac{\sigma_e}{\sigma_{id}}\Delta id_t$$

- $RES_t =$ foreign exchange reserves;

- $e_t =$ nominal exchange rate;

- $id_t =$ interest rate differential;

- $\sigma_i =$ standard deviation.

  - Exogenous determinants: unemployment, u_t, government deficit, Δd_t, change in trade balance, Δtb_t, real exchange rate, $reer_t$, risk-free real interest rate, r_t^{*f}, rate of change of foreign exchange reserves, Δres_t, rate of inflation, Δp_t, current account balance, ca_t, the rate of change of a broad money aggregate, Δm_t, spread between bank lending and deposit rates, ld_t, rate of change of domestic credit, $\Delta cred_t$, change in local stock market index, Δeq_t.

4.2 Results

Estimate a MSI(2)-VARX(1,1) over the period 1994:1-2005:12.

Table 4. MSI(2)-VARX(1,1) estimation results

	spread	empi
ν(1)	**3.84**	**0.618**
	(1.078)	(0.139)
ν(2)	**5.636**	**0.836**
	(1.201)	(0.152)
spread (-1)	**0.752**	**-0.023**
	(0.036)	(0.005)
empi (-1)	**-1.184**	**0.147**
	(0.480)	(0.063)
Δu	0.285	-0.018
	(0.212)	(0.028)
Δd	**25.006**	1.036
	(12.372)	(1.621)
Δtb	-22.917	0.219
	(21.725)	(2.862)
reer	**-8.922**	**-1.484**
	(1.470)	(0.194)
rf	-1.775	-1.172
	(30.899)	(4.046)
Δp	**-27.182**	-1.020
	(5.975)	(0.788)
Δip	-0.044	*-0.010*
	(0.043)	(0.006)
Δca	24.572	1.412
	(15.226)	(1.990)
Δm	**10.086**	0.341
	(4.961)	(0.655)
ld	**-0.659**	**-0.131**
	(0.271)	(0.035)
Δcred	**11.902**	*0.822*
	(3.807)	(0.495)
Δres	**-12.081**	**-3.191**
	(2.892)	(0.382)
Δeq	**-0.002**	**-0.000**
	(0.000)	(0.000)
trend	*-0.005*	**-0.001**
	(0.003)	(0.000)
σ	0.883	0.117
AIC	2.014 [2.105]	
HQ	2.361 [2.418]	
SC	2.867 [2.876]	
Log-lik	-101.992 [-112.481]	
LR linearity test statitstic	20.977	
DAVIES	[0.0006]**	

Notes: Coefficients in bold (italics) are significant at the 5% (10%) significance level. Standard errors are in parentheses. For the information criteria and the Log-likelihood, the value in square brackets is the corresponding statistics of the linear model.

Estimated matrix of transition probabilities shows two fairly persistent regimes do exist:

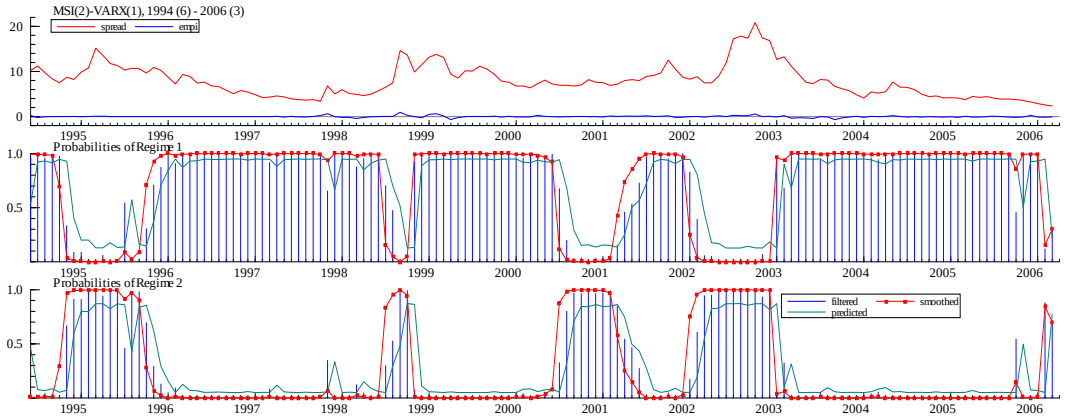
$$\widehat{P} = \begin{pmatrix} 0.9489 & 0.0511 \\ 0.1278 & 0.8722 \end{pmatrix}$$

- Regime 1 corresponds to "tranquil" periods; Regimes 2 represents times of high economic tension $\longrightarrow$ corresponds Mexican devaluation of 1994-1995, Russian default of 1998, Argentinean turmoil of 2001-2002, and pressures on the Brazilian currency surrounding the Presidential elections of 2002.

- Most of fundamental variables (8 out of 13) are statistically significant in either one of the two equations of the model, and have the right signs.

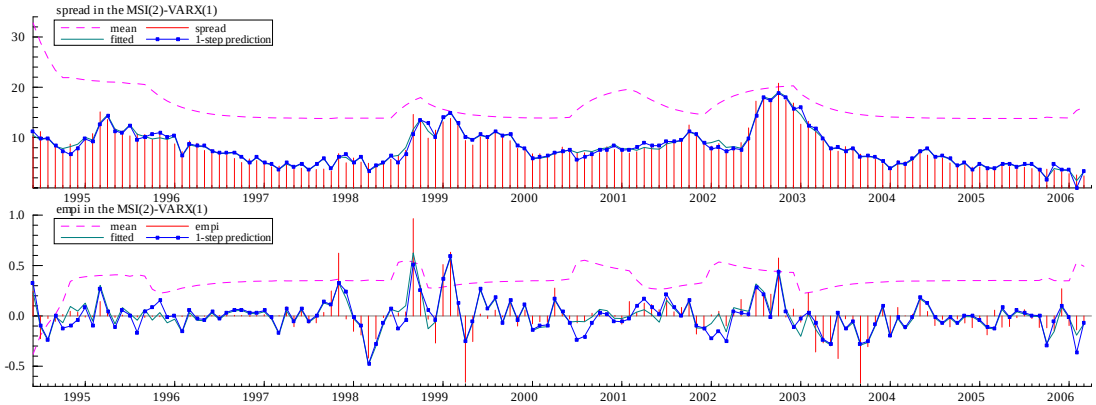
- The model performs better than a linear, i.e. one state, VAR(1) with same specification.

Figure 1: Regime probabilities



- Figure 5 shows the remarkable performance of the MS-VAR model by reporting the fitted and actual values of $spread$ and $empi$.

Figure 2: MS(2)-VAR(1) model: fitted and actual values of Brazil's spreads and empi



5 Conclusion

- Earlier studies highlight that over crisis periods the relationship between sovereign spreads and macroeconomic fundamentals breaks down, suggesting market inefficiency.

- This paper, by contrast, shows that a non-linear relationship between emerging markets spreads and fundamentals can be the outcome of investors' rational maximizing behaviour as they take into account the probability of domestic currency devaluations.

- Tests this hypothesis by developing an empirical version of the theoretical framework based on a Markov-switching regime multivariate model.

- Model outperforms its linear counterpart as well as univariate specifications, both linear and non-linear, of sovereign spreads.