Term Structure Fitting, Regime Change and the Expectation Hypotheses: A Study for Brazil

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This is the first Expectation Hypothesis (EH) study to address the problem of term structure fitting. We also test the effect of different economic regime. The overall results does not reject REH for the period before 1999 where the regime was a fixed foreign exchange rate, but strongly rejected for the period with floating exchange rate. In both cases we find predictability for short term rates and time varying risk premium. Other studies got an imprecise result and are unable to reject REH. We show that the foreign exchange rate regime does have a great impact in the result.

1. Introduction

This is the first Expectation Hypothesis (EH) study to address the problem of term structure fitting. We also test the effect of different economic regime. We test the Rational Expectation Hypothesis (REH) using two term structure fitting models: flat forward and Nelson Siegel and split the sample between the fixed and floating exchange regime

Two REH tests for Brazil have been done by Tabak and Andrade (2003) and Brito et all (2004). Regarding other countries, several studies have been done. Mankiw and Miron (1986) was valid before the creation of the FED reserve bank in 1913 but no longer valid after that. Hardouvelis (1994) found some support to REH in countries other than US. Gerlach and Smets (1997) find evidence of weaker predictability (lower beta) in some countries coincidentally with strong exchange control. In general those studies reject REH but do find some predictability in most countries, although, few of them, do not reject the REH.

In the second section we revise the REH theory, in the third section we explain the term structure fitting models used, in the forth section we explain the data used, in the fifty we presented the results and at the sixty section we conclude.

2. The Framework of Expectation Hypotheses

To test the joint hypotheses of EH plus rational expectations (REH), consider the strategy of buying a long bond and finance this purchase with very short term interest rate. This strategy is known as "carry trade," and the expected excess return embedded in this trade is the risk premium defined by:

$$\lambda_t^n = R_t^n - \left(\frac{1}{n}\right)\sum_{j=0}^{n-1} E_t\left(r_{t+j}\right) \tag{1}$$

where λ_t^n is the one-period risk premium embedded in a n periods bond;

R_t^n is the one-period return on a (long) bond maturing in *n* periods evaluated at date *t*;

and $E_t(r_{t+j})$ is the expected short term return in *t+j* evaluated at date *t*.

All rates are continuously compounded. Rearranging equation (1) and subtracting the current short term rate, we have:

$$\sum_{j=1}^{n-1}\left(1-\frac{j}{n}\right)\left[E_t(r_{t+j})-E_t(r_{t+j-1})\right]=(R_t^n-r_t)-\lambda_t^n \tag{2}$$

Assuming a constant risk premium, we have $\lambda_t^n=\lambda$. Assuming rational expectations, we also have $E_t(r_{t+j})=r_{t+j}+\tilde{v}_{t+j}$ where v_{t+j} is a white noise, therefore we end up with the following process for the short term interest rate:

$$\sum_{j=1}^{n-1}\left(1-\frac{j}{n}\right)\left[r_{t+j}-r_{t+j-1}\right]=-\lambda+(R_t^n-r_t)-\left(\frac{1}{n}\right)\sum_{j=1}^{n-1}\tilde{v}_{t+j} \tag{3}$$

If EH plus rational expectations are valid, the short term rate differential should be related to the return differential between the current (date *t*) long term rate and the short term rate. To check if it is valid, a regression can be done taking the one period weighting changes in short rate against the long term rate plus a constant:

$$\sum_{j=1}^{n-1}\left(1-\frac{j}{n}\right)\left[r_{t+j}-r_{t+j-1}\right]=\alpha+\beta(R_t^n-r_t)+\varepsilon_t \tag{4}$$

where $\alpha=-\lambda;$ *and* $\varepsilon_t=-\left(\frac{1}{n}\right)\sum_{j=1}^{n-1}\tilde{v}_{t+j}$ is MA(n-2) process.

3. Term Structure Fitting

The interest rates used above should be free of reinvestment risk, therefore should be collected from zero coupon bonds in what is called spot rates. Unfortunately most of the bonds in the market have coupon payments and, to get rid of the reinvestment risk, researchers and practitioners impose some functional form for term structure of spot rates. Even if the original market data comes from zero coupon bonds or derivatives (futures or Swaps), some sort of function should be adopted to get spot rates for fixed maturities (which we call term structure fitting) because it will be extremely rare to see everyday trading for these maturities.

Several different functions forms have been tested (Bliss, 1997). Two largely used and also very different ones are the flat forward (Coleman *et all* 1992) and Nelson Siegel (Nelson and Siegel, 1987) functions, which is can be thought as a smooth forward.

Flat forward

This model treats the forward rates between two observable spot rates as constant:

$$P(t) = e^{-(f_0 t_0 + f_1(t_2 - t_1) + \ldots + f_k(t - t_k))} \qquad for\ t_k < t < t_{k+1} \tag{5}$$

where $P(t)$ in the bond price,

f_k is forward rate in the interval[i] (t_k, t_{k+1}):

$$f_k = \frac{t_{k+1} i_{k+1} - t_k i_k}{(t_{k+1} - t_k)} \tag{6}$$

and i_k is the spot for maturity t_k (node t_k).

This model is largely used by practitioners in Brazil and even by the Central Bank (Banco Central do Brasil 2000).

Nelson-Siegel (NS)

This model has a smooth functional form for the forward rate:

$$f(t) = \beta_1 + \beta_2 \underbrace{e^{\left(-t/\tau\right)}}_{Factor2} + \beta_3 \underbrace{\left[\left(t/\tau\right) e^{\left(-t/\tau\right)}\right]}_{Factor3} \tag{7}$$

where $\{\beta_1, \beta_2, \beta_3, \tau\}$ are model parameters and $\{f_1, f_2, f_3\}$ are factor values,

Integrating this function between the current date and the maturity of the desired spot rate and then dividing by the term, we get the spot rate term structure:

$$i(t) = \beta_1 + \beta_2 \frac{\left[1 - e^{\left(-t/\tau\right)}\right]}{\left(t/\tau\right)} + \beta_3 \left\{ \frac{\left[1 - e^{\left(-t/\tau\right)}\right]}{\left(t/\tau\right)} - e^{\left(-t/\tau\right)} \right\} \tag{8}$$

where i is the spot rate (continuously compounded) for the maturity t,

$\{\beta_1, \beta_2, \beta_3\}$ are the factor loadings and

τ is the parameter that regulates the factors intensity.

This model allows a very flexible term structure fitting the several forms common in the market. It allows monotonically increasing or decreasing spot rates and term structure with flexible curvature. Parameter β_1 defines the interest rate level and is interpreted as the long term component (from (7) when $t \rightarrow \infty$). Parameters β_2 and β_3, define the slope and curvature, respectively. The first factor is flat and represents the level and a long term factor. The second factor starts at 1 and has an exponential decay, rapidly reaching zero. It represents the slope and can be interpreted as a short term factor. The third factor starts at zero and reaches a maximum (in the point defined by λ) and decreases to zero. It represents the curvature and can also be interpreted as a medium term factor. To estimate the parameters vector $\{\beta_1, \beta_2, \beta_3, \lambda\}$, we used the same procedure originally suggested in Nelson and Siegel (1987), whereby we fix the value of λ at a pre-defined value and compute the factor loadings by ordinary least square (OLS) for each day.

These models provide quite different results although they are used for the same purpose of getting spot rates from coupon bonds or interpolating observable spot rates. The former assumes that forward rates are flat between observable spot rates and the latter assumes smooth forwards.

4. Data

The data available in Brazil to generate the term structure with high credit quality are (i) interest rate future contract traded at Bolsa Mercantil e de Futuros (BM&F); (ii) Local Brazilian Government bonds (LBGB), and (iii) Swap traded at BM&F. The first one is this future contract known as DI-Futuro, and it is the main reference and main interest rate derivative instrument used in Brazil, it has several outstanding maturities, with 3 to 6 extremely liquid, and has no coupon whatsoever. The second one could be the LTN (with no coupon) or NTNF (with coupon) and are much less liquid and market to market prices are more difficult to get and less precise. The last type of data, Swaps rates, is very easy to collect, although used in several academic articles (Tabak and Andrade 2003, Brito et all 2004), it is also extremely illiquid. Nevertheless, these rates are announced everyday for dozens maturities BM&F as indicative rates. These rates are calculated based on DI futures prices and interpolated by BM&F.

In fact swap rates announced by BM&F are simply indicative rates and do not represent actual trading. LBGB's are also quite illiquid and until 2000, prices[ii] were not available. Until 1999 the outstanding maturities were lower than one year. After that table 1, shows the outstanding maturities, which are very short:

as of	1 year	1-2 years	2-3years	3-4 years	4-5 years	>5 years
dez/99	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%
dez/00	96.7%	3.3%	0.0%	0.0%	0.0%	0.0%
dez/01	96.7%	3.3%	0.0%	0.0%	0.0%	0.0%
dez/02	96.8%	3.2%	0.0%	0.0%	0.0%	0.0%
dez/03	86.0%	13.7%	0.0%	0.0%	0.3%	0.0%
dez/04	90.3%	8.3%	0.1%	1.2%	0.0%	0.0%
dez/05	54.9%	34.0%	9.5%	0.2%	0.8%	0.6%
dez/06	52.9%	32.2%	6.6%	4.8%	0.3%	3.1%
dez/07	44.7%	26.1%	17.1%	2.5%	6.5%	3.1%

Table 1. Percentage of outstanding LBGB per maturity.

In case of DI future, liquidity is extremely high and this contract is the base for all other announced and traded interest rates. For this reason, this study will use only DI futures rates to test the expectation hypotheses.

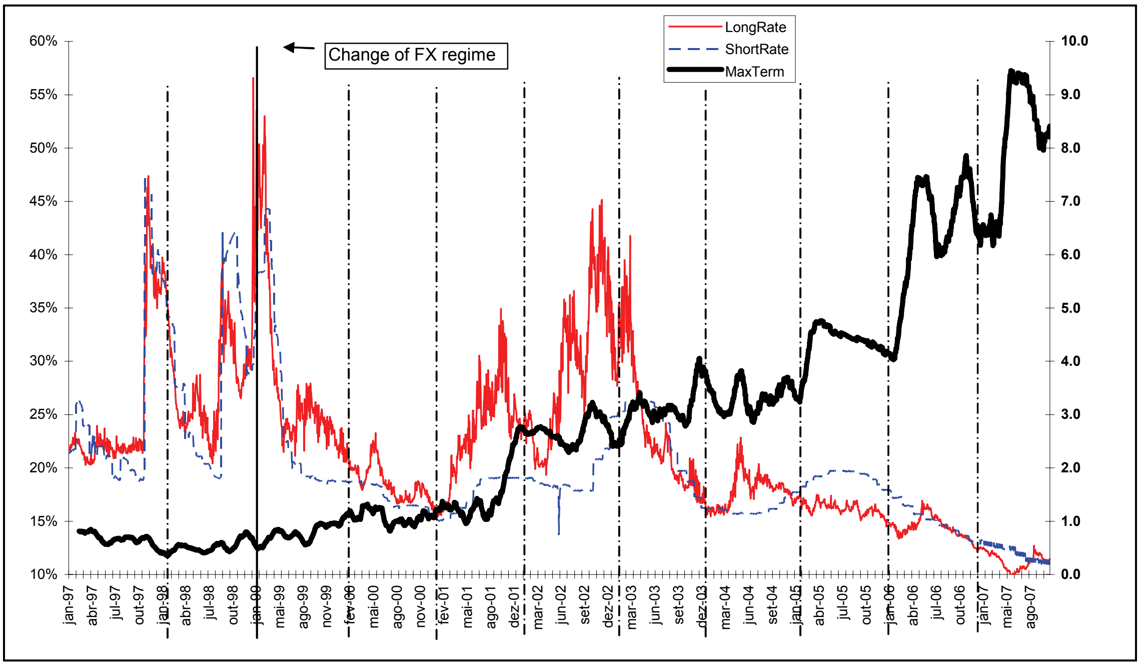
To construct the term structure we use daily interest rates quotes obtained from DI futures contracts. As explained in Varga (2004) these contracts simulated a cash and carry deal with a zero coupon type of instrument and are guaranteed by the exchange. Therefore its embedded rate is a spot rate with high credit quality. The data sample ranges from 1/2/1997 to 10/19/2007 with approximately ten years and ten months of daily data, totaling 2678 observations.

Brazil has recovered from a large period of hyperinflation and only after 1994 inflation has gone down for good. Therefore the term structure is a relatively new object in the Brazilian financial market. As a matter of fact, at the sample beginning, the maximum maturity was no longer than a year and only at the end of the sample period, it has reached approximately 4 years. Table 2 shows a daily DI future maturity summary.

Year	Average	Maximum
1997	0.50	0.90
1998	0.40	0.99
1999	0.58	1.04
2000	0.81	2.03
2001	1.02	2.90
2002	2.02	4.06
2003	2.25	3.77
2004	2.73	5.40
2005	4.16	6.04
2006	6.03	9.12
2007	8.09	9.93

Table 2. The second column shows the annual average of the maximum daily maturity and the third column shows the maximum maturity traded each year.

During this period the interest level has gone down from something around 25% to 12%. It has also suffered from several crises that eventually pushed the rates up, even doubled the rates in some cases. For instance: the Asian crisis in October 1997; Russian crisis in September 1998; Real crisis (Brazilian devaluation) in January 1999 and the Mark-to-Market crisis of June 2002. All those events where accompanied by the central bank increasing the overnight rate (except the last one) and the long term rate also going up. Despite all those crises the traded maturity has increased and the volatility has gone down for the entire period as shown in graph 1.



Graph 1. Daily interest rates (not continuous), from January 1997 to October 2007. The left axis shows the rates and the right axis shows the maturity in annual terms.

The available market data was interpolated using flat forward and Nelson Siegel to get rates for maturities of 1, 2,3 and 6 months and 1, 2, 3, 4, 5 and 6 years. All calculations were done based on a 252 business day year. Contracts with less than 5 tradings in a day were excluded from the sample.

Brazil had in January of 1999 a FX regime change moving from fixed to full floating exchange rate. This fact had a major impact in the yield curve statistics, therefore we divided the sample in two parts—before (which comprises 1997 and 1998) and after the regime change (after January 1999). Tables 3 and 4 shows some term structure statistics for both periods.

For the fixed FX rate period, table 3 shows a higher volatility for the short term rates than for long term rates. Among the empirical factors level, slope and curvature, the volatility is the highest for the level (4.73%) followed by slope (2.44%) and curvature (2.12%). The average rates show, an atypical inverted yield curve and a negative curvature.

	Flat forward - Before 1999									
	1 month	2 months	3 months	6 months	1 year	2 year	3 year	4 year	5 year	6 year
Mean	23.6%	23.4%	22.9%	20.8%	NA	NA	NA	NA	NA	NA
Median	21.1%	21.3%	21.2%	19.6%	NA	NA	NA	NA	NA	NA
Maximum	40.8%	39.6%	39.6%	29.4%	NA	NA	NA	NA	NA	NA
Minimum	17.6%	17.7%	17.9%	18.5%	NA	NA	NA	NA	NA	NA
Std. Dev.	5.7%	5.3%	4.9%	2.5%	NA	NA	NA	NA	NA	NA
Skewness	0.85	0.92	1.18	1.72	NA	NA	NA	NA	NA	NA
Kurtosis	2.42	2.60	3.31	5.12	NA	NA	NA	NA	NA	NA
Observations	500	498	459	142	0	0	0	0	0	0
	After 1999									
Mean	16.6%	16.7%	16.8%	16.9%	16.8%	15.8%	14.3%	13.1%	12.2%	11.5%
Median	16.8%	16.9%	16.9%	16.7%	16.5%	15.7%	14.2%	13.4%	12.4%	11.2%
Maximum	30.1%	28.5%	27.4%	26.1%	28.5%	33.6%	34.3%	24.1%	17.0%	15.6%
Minimum	10.5%	10.5%	10.4%	10.4%	10.2%	9.8%	9.6%	9.5%	9.4%	9.3%
Std. Dev.	3.1%	3.2%	3.2%	3.5%	4.2%	4.3%	3.4%	2.0%	1.6%	1.4%
Skewness	0.60	0.41	0.28	0.28	0.67	1.56	2.32	0.04	0.10	0.58
Kurtosis	4.13	3.44	3.02	2.69	2.97	6.29	12.69	3.15	1.96	2.43
Observations	2122	2122	2120	2003	1556	1202	808	596	366	248

Table 3. Term structure descriptive statistics calculated with the flat forward model. All rates are annual spot rates. The first group contains data ranging from January 1997 to January 1999. The second one ranges from February 1999 to October 2007.

For the current regime (floating FX – after 1999) table 3 shows higher term, lower volatility and lower interest rate level than the fixed exchange regime. Comparing to the fixed FX period (before 1999), the volatility decreases with term but the skewness goes up with the term.

	Nelson Siegel - Before 1999									
	1 month	**2 months**	**3 months**	**6 months**	**1 year**	**2 year**	**3 year**	**4 year**	**5 year**	**6 year**
Mean	23.6%	23.1%	22.9%	20.7%	NA	NA	NA	NA	NA	NA
Median	21.0%	21.0%	21.1%	19.6%	NA	NA	NA	NA	NA	NA
Maximum	40.5%	40.6%	39.7%	29.4%	NA	NA	NA	NA	NA	NA
Minimum	17.6%	17.7%	17.9%	18.5%	NA	NA	NA	NA	NA	NA
Std. Dev.	5.7%	5.2%	4.9%	2.5%	NA	NA	NA	NA	NA	NA
Skewness	0.85	1.09	1.17	1.77	NA	NA	NA	NA	NA	NA
Kurtosis	2.38	3.04	3.30	5.48	NA	NA	NA	NA	NA	NA
Observations	500	462	456	142	0	0	0	0	0	0
After 1999	**NSM01**	**NSM02**	**NSM03**	**NSM06**	**NSM12**	**NSY02**	**NSY03**	**NSY04**	**NSY05**	**NSY06**
Mean	16.6%	16.7%	16.8%	16.9%	15.6%	15.8%	14.3%	13.1%	12.2%	11.5%
Median	16.8%	16.8%	16.9%	16.7%	15.8%	15.6%	14.2%	13.4%	12.4%	11.2%
Maximum	30.2%	28.6%	27.4%	26.2%	28.7%	33.3%	34.0%	23.9%	16.9%	15.6%
Minimum	10.4%	10.4%	10.4%	10.4%	10.2%	9.8%	9.6%	9.5%	9.4%	9.4%
Std. Dev.	3.1%	3.1%	3.2%	3.5%	3.5%	4.2%	3.3%	2.0%	1.6%	1.4%
Skewness	0.64	0.40	0.27	0.27	1.00	1.54	2.29	0.02	0.11	0.58
Kurtosis	4.28	3.47	3.03	2.70	4.60	6.20	12.50	2.95	1.95	2.45
Observations	2122	2119	2119	2002	1202	1202	808	596	366	248

Table 4. Term structure descriptive statistics calculated with Nelson Siegel model. All rates are annual spot rates. The first group contains data ranging from January 1997 to January 1999. The second one ranges from February 1999 to October 2007.

There are no noticeable differences when comparing the basic statistics produced by the two fitting models.

5. Results

Although all outstanding contracts were collected and there were trading for up to 6 years, the time length allowed only the examination of the term structure up to 2 years.

Before the estimation of equation (4) we test for unit root on the dependent variable. The results are in table 5 and 6 shows

Augmented Dickey-Fuller test statistic - Before 1999							
		FlatForward		obs	Nelson-Siegel		obs
R2M-R1M	with constant	-4.1579	***	495	-2.3706		368
	none	-4.0043	***		-2.3932	**	
R3M-R1M	with constant	-2.2057		382	-2.5440		371
	none	-2.1594	**		-2.6043	**	
R6M-R1M	with constant	insufficient number of observations					
	none						
R1Y-R1M	with constant	insufficient number of observations					
	none						
R2Y-R1M	with constant	insufficient number of observations					
	none						
R3Y-R1M	with constant	insufficient number of observations					
	none						
R4Y-R1M	with constant	insufficient number of observations					
	none						
R5Y-R1M	with constant	insufficient number of observations					
	none						
R6Y-R1M	with constant	insufficient number of observations					
	none						

Table 5. Unit root test for the spread between spot rates of different terms and the one-month spot rate for the period before 1999. The third column shows the Augmented Dickey Fuller (ADF) statistic for null hypothesis of unit root for the flat forward model. In the fifth column the same statistic for the Nelson Siegel Model. *** Reject the null hypothesis with 99% confidence, ** reject with 95% and * reject with 90%.

With the bigger sample, starting in 1999 and shown in table 6, the results are quite similar. Very few independent variables do not reject unit root. In general spurious regression problem will be small.

Augmented Dickey-Fuller test statistic - After 1999							
		FlatForward		obs	Nelson-Siegel		obs
R2M-R1M	with constant	-4.9871	***	2081	-3.7641	***	2063
	none	-4.7329	***		-3.5580	***	
R3M-R1M	with constant	-3.8079	**	2077	-3.2309	**	2063
	none	-3.5719	***		-3.0382	***	
R6M-R1M	with constant	-3.0958	**	1881	-3.6186	***	1891
	none	-3.1717	***		-3.6954	***	
R1Y-R1M	with constant	-2.9624	**	1347	-2.5199		1347
	none	-2.9635	***		-2.5196	**	
R2Y-R1M	with constant	-1.3762		929	0.6625		1030
	none	-1.5785			0.5661		
R3Y-R1M	with constant	-2.4284		740	-2.7766	*	710
	none	-2.1308	**		-1.9778	**	
R4Y-R1M	with constant	-1.9721		547	-2.3507		516
	none	-1.8598	*		-2.4137	**	
R5Y-R1M	with constant	-3.1717	**	318	-3.0073	**	318
	none	-2.8235	**		-2.7041	**	
R6Y-R1M	with constant	-2.3550		188	-0.8088		74
	none	-1.4682			-1.6616	*	

Table 6. Unit root test for the spread between spot rates of different terms and the one-month spot rate for the period after 1999. The third column shows the Augmented Dickey Fuller (ADF) statistic for null hypothesis of unit root for the flat forward model. In the fifth column there are the same statistics for the Nelson Siegel Model. *** Reject the null hypothesis with 99% confidence, ** reject with 95% and * reject with 90%.

To evaluate the Rational Expectation Hypothesis (REH) we estimate equation (4). The estimation is done via Generalized Method of Moments (GMM) to correct for autocorrelation. The instruments used are lagged independent variables and the covariance matrix is corrected for the MA error with the Newey and West (1987) procedure.

The estimation was done for the two different fitting models (flat forward and Nelson Siegel) and two different periods (before and after 1999).

Before 1999 - Flat Forward Fitting						
Term	**α**	**β**	**H0: β=1**	**H0: β=1; α=0**	**R2**	**Sample**
2 Months	0.0048	1.3013	0.3032	0.2294	16%	492
	(1.72)	(4.45)				
3 months	0.0091	1.2740	0.3817	0.0926	18%	422
	(2.16)	(4.07)				
6 months	0.0224	1.0940	0.8069	0.0001	27%	49
	(4.50)	(2.86)				
1 year	insufficient number of observations					
2 years	insufficient number of observations					
3 years	insufficient number of observations					

Table 7. Parameters estimated for equation (4) for the flat forward model and data before 1999. In the second column there is the regression constant (with its *t* statistic below). In the third column is its beta coefficient. In the forth column there is the *p*-value for the null hypothesis of beta=1. In fifth column there is the *p*-value for the null hypothesis of beta=1 and constant=0. In the last two columns there are the adjusted R-squared and the number of observations used.

For the first case: flat forward before 1999, table 7 shows that beta=1 hypothesis could not be rejected for any maturity. The risk premium increases with the maturity, the joint hypothesis of beta =1 and risk premium =0 is rejected at 99% for the 6-month maturity. The coefficient of determination increases with the maturity. In general the maturities are very short due to the lack of liquidity in the market.

After 1999 - Flat Forward Fitting						
Term	**α**	**β**	**H0: β=1**	**H0: β=1; α=0**	**R2**	**Sample**
2 Months	-0.0012	0.5826	0.0126	0.0000	20%	2,101
	(3.98)	(3.48)				
3 months	-0.0022	0.5185	0.0000	0.0000	27%	2,074
	(4.77)	(4.38)				
6 months	-0.0048	0.6562	0.0000	0.0000	46%	1,824
	(7.77)	(10.62)				
1 year	-0.0089	0.6400	0.0000	0.0000	41%	1,240
	(6.82)	(11.25)				
2 years	-0.0084	0.5584	0.0001	0.0000	30%	550
	(4.77)	(4.89)				
3 years	insufficient number of observations					

Table 8. Parameters estimated for equation (4) for the flat forward model and data after 1999. In the second column there is the regression constant (with its *t* statistic below). In the third column is its beta coefficient. In the forth column there is the *p*-value for the null hypothesis of beta=1. In fifth column there is the *p*-value for the null hypothesis of beta=1 and

constant=0. In the last two columns there are the adjusted R-squared and the number of observations used.

For the second case: flat forward after 1999, table 8 shows that beta=1 hypothesis should be rejected for any maturity. The risk premium decreases with the term as opposed with the first period and both hypothesis (beta=1, beta=1 with risk premium=0) are rejected. On average coefficients of determination are bigger than the prior period.

Before 1999 - NelsonSiegel Fitting

Term	α	β	H0: β=1	H0: β=1; α=0	R2	Sample
2 Months	0.0033	1.2384	0.4946	0.5353	15%	425
	(1.09)	(3.55)				
3 months	0.0084	1.2635	0.4023	0.1307	16%	416
	(1.98)	(4.02)				
6 months	0.0204	0.8154	0.6150	0.0022	22%	49
	(3.72)	(2.24)				
1 year	insufficient number of observations					
2 years	insufficient number of observations					
3 years	insufficient number of observations					

Table 9. Parameters estimated for equation (4) for Nelson Siegel model and data before 1999. In the second column there is the regression constant (with its *t* statistic below). In the third column is its beta coefficient. In the forth column there is the *p*-value for the null hypothesis of beta=1. In fifth column there is the *p*-value for the null hypothesis of beta=1 and constant=0. In the last two columns there are the adjusted R-squared and the number of observations used.

For the third case: Nelson Siegel before 1999, table 9 shows that the result is qualitatively very similar to the first case. The betas are slightly bigger than in the first case.

After 1999 - NelsonSiegel Fitting

Term	α	β	H0: β=1	H0: β=1; α=0	R2	Sample
2 Months	-0.0011	0.4511	0.0001	0.0000	19%	2,092
	(3.90)	(3.16)				
3 months	-0.0022	0.4708	0.0000	0.0000	26%	2,071
	(4.74)	(4.22)				
6 months	-0.0048	0.6626	0.0000	0.0000	47%	1,821
	(7.95)	(10.83)				
1 year	-0.0090	0.6377	0.0000	0.0000	42%	1,240
	(6.94)	(11.44)				
2 years	-0.0083	0.6026	0.0007	0.0000	31%	550
	(4.83)	(5.19)				
3 years	insufficient number of observations					

Table 10. Parameters estimated for equation (4) for the Nelson Siegel model and data after 1999. In the second column there is the regression constant (with its *t* statistic below). In the third column is its beta coefficient. In the forth column there is the *p*-value for the null hypothesis of beta=1. In fifth column there is the *p*-value for the null hypothesis of beta=1 and constant=0. In the last two columns there are the adjusted R-squared and the number of observations used.

For last case, Nelson Siegel fitting after 1999, the results are also quite similar to flat forward for the same period.

In all cases betas are statistically positive and different than zero, which suggest that long term rates have predictability power on short rates. The risk premium is also significant and likely time varying. In the fixed regime, it is negative and in the floating regime positive. The R2, in general, increases with the term to maturity.

6. Conclusion

The overall results does not reject REH for the period before 1999 where the regime was a fixed foreign exchange rate, but strongly rejected for the period with floating exchange rate. In both cases we find predictability for short term rates and time varying risk premium. Regarding the use of different term structure fitting model, the results are essentially the same.

Comparing to Tabak and Andrade (2003), since the period they study ranges from 1995 to August 2000, therefore most of then includes the fixed exchange period, it should be expected to have similar result to what we found with regards to the period before 1999 which is the case. The other study (Brito et all 2004) uses a little longer sample (ending in December 2001) gets an imprecise result and is unable to reject REH.

The use of future interest rate as opposed to SWAPs rate (the case of both studies above) apparently does not lead to different results.

We show that the foreign exchange rate regime does have a great impact in the result, as already conjectured by Gerlach and Smets. Any econometric investigation regarding REH should split the sample between the foreign exchange rate regime.

References

BANCO CENTRAL DO BRASIL (2000) Technical note to Circular 2972 in www.bcb.gov.br.

BLISS, R. (1997) "Testing Term Structure Estimation Methods," Advances in Futures and Options Research 9, 197-232.

BRITO, R. D.;GUILLEN, O. T. C.; DUARTE, A. J. M. (2004) Overreaction of yield spreads and movements of Brazilian interest rates. Revista de Econometria, Rio de Janeiro, V. 24, N. 1, P. 1-55.

COLEMAN, T.; L. FISCHER AND R. IBBOTSON (1992) "Estimating the term structure of interest rates from data that include the prices of coupon bonds," The Journal of Fixed Income, September, 85-116.

GERLACH, S. AND F. SMETS (1997) "The Term Structure of Euro-rates: some evidence in support of the expectations hypothesis," Journal of International Money and Finance, Vol. 16, no. 2, 305-321.

HARDOUVELIS, G. A. (1994), "The term structure spread and future changes in long and short rates in the G7 countries", Journal of Monetary Economics 33, 255-83.

MANKIW, N. G. AND J. MIRON (1986), "The Changing Behaviour of the Term Structure of Interest Rates", *Quarterly Journal of Economics* 101(2), 211–228.

NELSON, C. AND SIEGEL, A. (1987) "Parsimonious Modeling of Yield Curves," Journal of Business, vol 60 no. 4, 473-489.

NEWEY, W. AND K. WEST (1987) "A simple positive semi-definite, heteroskedasticity and autocorrelation consistent covariance matrix," econometrica, 55, 703-708.

TABAK, B. M.; ANDRADE, S. C. (2003) Testing the Expectation Hypothesis for Brazilian Term Structure of Interest Rates. Revista Brasileira de Finanças, v. 1, 2003.

VARGA, G. (2004) "Preço e estratégias com futuro de DI e FRA." Resenha mensal da BM&F.

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[i] In Brazil all terms are in business days, assuming 252 business days per year.

[ii] Since 2000, ANDIMA (Brazilian association of open market dealers) have announced daily quotes for LBGB.