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Forecasting Interest Rates: an application for Brazil

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Abstract

Understanding the links between long and short-term interest rates is crucial for monetary policy makers, since Central Banks decide and set short-term interest rates in order to affect indirectly long-term interest rates, which affects aggregate spending. This paper studies whether VAR/VEC models are useful in predicting long-term interest rates for Brazil. The empirical results suggest that these models are useful in building qualitative scenarios for the Term structure of interest rates, but do not provide good forecasts in terms of accuracy. Furthermore, models that assume that the future path of short-term interest rates (target interest rates) is known by forecasters do not perform better in terms of both directional and forecasting accuracy.

JEL Classification: E42; E43.
Keywords: monetary policy; short and long-term interest rates; expectations theory of interest rates; transmission mechanism.

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1. Introduction

The development of forecasting models for short and long-term interest rates has been in the research agenda for the past years and is crucial for policy modeling, portfolio and risk management and for macroeconomists (See Fletcher and Gulley, 1996). The dynamics of interest rates have important implications for the economy and its forecasts are necessary for almost all economic activities. Furthermore, long-term interest rate forecasts are useful as economic agents consider them to make decisions regarding investment and savings levels.

It is consensus in the economics literature that monetary policy matters for explaining movements in real output (short run) and inflation (long run). However, the transmission mechanism through which monetary policy affects the economy is more controversial.

Central banks define short-term interest rates in the conduct of monetary policy, but it is generally accepted that aggregate-spending decisions are more closely related to long-term interest rate behavior. In other words, central banks set up short-term interest rates, which affect longer-term interest rates, which by its turn influences aggregate-spending decisions affecting real output and inflation. For this reason, understanding the relationship between short and long-term interest rates is crucial for macroeconomic modeling and the conduct of monetary policy.

In this paper we study the relationship between short and long-term interest rates for Brazil[1]. To accomplish this purpose we estimated a vector autoregression (VAR) and a vector error correction (VEC) between the short-term interest rate SELIC[2], which is determined by the Monetary Policy Committee (COPOM), and the medium-term interest rate, performing out-of-sample forecasts of these variables. We then compared the forecasts from these models with the results presented by a random walk to evaluate their accuracy[3].

[1] See Tabak and Andrade (2003), Tabak (2004), and Garcia and Didier (2001) for a discussion on the behavior of interest rates in Brazil.

[2] SELIC is a system for custody of Public bonds issued by the Brazilian Treasury and the Central Bank. The SELIC interest rate is determined in the secondary market and calculated by the Central Bank of Brazil.

[3] A similar methodology has been adopted by Lo *et al.* (1995) for Euroyen and domestic yen interest rates, and the evaluation of different forecasting models of real interest rate has been previously done by Bidarkota (1998). Recent examples of interest rate forecasting also include Byers and Nowman (1998), Fletcher and Gulley (1996) and Ferreira (2005).

The main contribution of the paper is to evaluate whether simple VAR and VEC models can be helpful in forecasting medium-term interest rates. Besides, differently from previous literature, we test whether knowledge of the future path of short-term interest rates is useful in forecasting medium-term interest rates. It is widely perceived that central banks wish to smooth interest rates and therefore determine paths for short-term interest rates. We test whether knowledge of this future path may improve forecasting. Additionally, we test for both predictive and directional accuracy. Our main results suggest that such models perform poorly in terms of predictive accuracy but are helpful in terms of directional accuracy. Therefore, they are helpful in building qualitative scenarios for policy modeling.

The rest of the paper will be structured as follows: In section 2 we present a brief review of the literature, section 3 describes the data we used in our estimations, section 4 is the methodology, in 5 we present the empirical results and, finally, section 6 concludes the paper.

2. Brief literature review

The link between short and medium-term interest rates is given by the Expectations Hypothesis (EH) which suggests that monetary policy affects medium-term interest rates by directly influencing short-term rates and by altering market expectations of future short-term rates. This hypothesis is important since the term structure is one of the most relevant channel of the transmission of the monetary policy.

The equation for the EH is presented below:

$$R_t^n = \frac{1}{k}\sum_{i=0}^{k-1} E\left[R_{t+im}^m\right] + \varphi_{n,m}$$

where $n > m$, n and m stand for long and short-term, $k = n/m$ is an integer, R_t^n is the n-period interest rate and $\varphi_{n,m}$ is a term premium.

The EH implies that the expected return on different maturity bonds, over any holding period, should be equalized. Therefore, the equation can be rearranged into:

$$R_t^n = E_t\left[\frac{1}{n}\sum_{i=1}^{n-1} r_{t+i}\right] + E_t\phi_t^n$$

where ϕ_t^n is an average risk premium. Hence, the *n*-period medium rate equals a weighted average of expected future short rates r_{t+i} plus the average risk premium on the *n*-period bond, ϕ_t^n.

Given that medium rates R_t and short rates r_t are found to be I(1), ΔR and Δr are I(0) by construction. A weak test of the Pure Expectations Hypothesis[4] and Rational Expectations implied by the 'future-short-rate' or 'long-rate' equations is that R_t and r_t are cointegrated with a cointegration parameter of unity. Alternatively, the EH implies that the spreads ($R_t - r_t$) should be I(0).

A natural way to test the EH is to perform a VEC analysis on short and medium term interest rates and test for the parameters restrictions implied by the EH.

In the international literature, Cuthbertson (1996) using Johansen cointegration analysis found that data for the UK interbank market is consistent with the EH at shorter maturities but when 6 and 12-months interest rates were used the EH was rejected.

Engsted and Tanggaard (1994) also used Johansen cointegration techniques to test for the cointegration implications of the EH on a sample of US discount yields and found evidence suggesting that cointegration implications of the EH generally seem to hold. Dominguez and Novalez (2000) analyze the EH on Euro-Rates using cointegration analysis and found that the restrictions of the EH on the cointegrating relationships are not rejected. However, it is not clear if the EH holds for emerging markets.

Other important empirical papers in the financial literature testing the EH using different techniques include: Mankiw (1986), Mankiw and Miron (1986), Stambaugh (1988), Froot (1989), Shiller and McCulloch (1990), Campbell and Shiller (1991), McFadyen *et al.* (1991), Taylor (1992), Longstaff (2000) and Thornton (2000), among many others.

Gamber and Hakes (2005) created a model to evaluate the importance of monetary policy for forecasting real growth and inflation. They also incorporated

[4] The Pure Expectations Hypothesis (PEH) assumes that the expected excess return is zero and that the term premium is zero for all maturities.

information into their model and found that smaller monetary policy forecast errors do not imply significantly smaller growth and inflation forecast errors. However, they do imply smaller variance of growth and inflation forecast errors.

Roley and Sellon (1995) used a model that captures the tendency of market rates to anticipate policy actions and found evidence of strong and persistent response of long-term rates to policy actions. Their main conclusions were that the average effect of monetary policy on long-term rates is positive and that much of the impact of policy actions on market rates appears to come from the reaction of forward rates.

Byers and Nowman (1998) used continuous time term structure models and compared the forecasting performance of different one-factor interest rate models for the UK and US. Ferreira (2005) found that the VEC model of Bollerslev *et al.* (1988) was the best model to forecast the comovements of spot interest rates. Also, Fletcher and Gulley (1996) extended the in-sample forecasting technique of Mishkin (1984) by calculating out-of-sample one-period ahead forecasts of real interest rates using an updated regression, a rolling regression and an ARMA model.

Here we try to evaluate if short-term rates help predict medium-term rates and if the assumption that forecasters have information of the future path of short-term interest rates is of any assistance in the accuracy of the forecasts.

3. Description of the data

The variables regressed in our model were the time series of the SELIC and the 6-months interest rate[5]. In this contract a party pays a fixed rate over an agreed principal and receives a floating rate over the same principal, the reverse occurring with his counterpart. There are no intermediate cash flows, and the contract settles on maturity. The floating rate is the overnight interbank deposits rate, which tracks very closely the average rate in the market for overnight reserves at the Central Bank. The fixed rate, negotiated by the parties, is the one used on this paper[6].

[5] We used the 6-month interest rate because a longer-term rate, with a large time span, does not exist and also, it is the most liquid maturity.

[6] It is important to notice that the 6-month interest rate is used in the current macroeconomic modeling of the Banco Central do Brasil. The 6-months interest rate swap enters the IS specification (see Bogdanski *et al.*, 2000).

Our data consists on the period from January 1995 to November 2005. Both series were taken from Bloomberg and consisted of daily observations. In this study we employ monthly observations. We obtained the average monthly value of the time series, which reduced our input sample to 131 observations.

4. Methodology

We obtained our forecasts by estimating an Unrestricted VAR, based on OLS estimates, where the short and medium-term interest rates are the endogenous variables. As an important disadvantage of this model is the possible over-parameterization it was essential to choose a proper lag length, which in our case was done using the Akaike (AIC) and Schwartz Information Criterion (SIC). In addition, it is important to mention that we have selected models that are free of autocorrelation between the residuals.

The forecasting benchmark for comparisons between our models will be the random walk. The random walk hypothesis asserts that the random natures of the variables in question do not reveal trends and therefore current values are no guide to future values. The short-term unpredictability of factors means that they appear to walk randomly on a chart, and the best guide to the value of a variable in time $t+1$ is it's value in time t. Therefore, according to this theory, every new change is explained by new information.

We consider that in order to perform a real forecast, it is necessary that the model be designed to predict out-of-sample values and, therefore, we tag along Fletcher and Gulley's (1996) extension of the methodology adopted by Mishkin (1984). This way, the parameters are estimated inside the sample and, based on these results, a forecast of the value a step forward from the last value of the sample is made. Considering this, our three and six month forecasts were made out-of-sample and using a rolling window so we could correctly evaluate the performance of the models.

The EH of interest rates implies a medium-run relationship between medium and short-term rates. This relationship was estimated by means of cointegration tests. In our case, we performed these tests using the approaches of Engle-Granger (1987), Johansen (1988,1991) and a vector error correction model.

The estimated VAR model was the following:

$$\Delta r(t)=\alpha_1+\sum_{i=1}^{4}\alpha_{12}(i)\Delta r_{t-i}+\sum_{i=1}^{4}\alpha_{12}(i)\Delta R_{t-i}+\varepsilon_{r(t)} \quad (1a)$$

$$\Delta R(t)=\alpha_2+\sum_{i=1}^{4}\alpha_{21}(i)\Delta r_{t-i}+\sum_{i=1}^{4}\alpha_{22}(i)\Delta R_{t-i}+\varepsilon_{R(t)} \quad (1b)$$

where *r(t)* and *R(t)* are the short- and long-term interest rates, respectively.

The vector error correction model was:

$$\Delta r_{rt}=a_{10}+\alpha_r(r_{Rt-1}-\beta r_{rt-1})+\sum a_{11}(i)\Delta r_{rt-i}+\sum a_{12}(i)\Delta r_{Rt-i}+\varepsilon_{rt} \quad (2a)$$

$$\Delta r_{Rt}=a_{20}-\alpha_R(r_{Rt-1}-\beta r_{rt-1})+\sum a_{21}(i)\Delta r_{rt-i}+\sum a_{22}(i)\Delta r_{Rt-i}+\varepsilon_{Rt} \quad (2b)$$

where $(r_{Rt-1}-\beta r_{rt-1})$ is the linear combination of interest rates, meaning, the cointegration element.

The forecasts were made using rolling windows of fifty elements, this approach implicates calculating the parameters inside a window, being the number of lags equal to 4, and then making a three step ahead out-of-sample forecast. After the forecast was made, it would be included in the sample, adjusting the following window. This was done iteratively until we reached the end of the sample.

Our first estimates involved a three step forward forecast of the series, later we also estimated six step forward forecasts. The second battery of estimates included the hypothesis that the Central Bank smoothes interest rates, meaning, forecasters have some knowledge of the future path of short-term interest rates. We consider this hypothesis the privileged information in our model. Therefore, VAR-naive will be the first model and VAR-information the model estimated assuming that forecasters know the future path of short-term interest rates. Also, since a VEC was performed for each model, they will also be identified as VEC-naive and VEC-information.

The forecasts made using the informed model were performed assuming that the forecasters know the true realized path of short-term interest rates. Therefore, we plug the realized path of short-term interest rates in the forecasting equations and forecast medium-term interest rates.

To compare the results of the estimated models and identify the most efficient we calculated the Mean Squared Error, and also the Mean Absolute Error, and compared the results of the first and second VAR and VEC and the random walk. Our evaluation of the results consisted in applying two statistical tests, that of Diebold and Mariano (1995) to compare the differences among the MSE results and a second test, Pesaran and Timmermann (1992), was implemented in order to obtain directional accuracy.

5. Empirical Results

This section presents the results from the estimation of VAR and VEC models with and without the assumption of privileged information in which forecasters are assumed to know the future path of short-term interest rates and therefore the only variable that should be estimated is the medium-term interest rates. Results the parameters of the VAR and VEC and cointegration vectors are not shown to conserve space and to focus on the forecasting properties of these models. However, it is worth mentioning that the short and medium-term interest rates cointegrate.

In order to compare forecasts made from these models we implement the directional accuracy (DA) statistic, which is given by:

$$DA = \frac{SR - SRI}{\sqrt{\text{var}(SR) - \text{var}(SRI)}} \overset{a}{\sim} N(0,1), \tag{3}$$

where SR (Success Ratio) = $\frac{1}{m}\sum_{j=1}^{m} I_j$, $m =$ number of periods, I_j is an indicator for correct sign and SRI (Success Ratio under Independence) $= P.\hat{P} - (1-P).(1-\hat{P})$ given that $P = \frac{1}{m}\sum_{j=1}^{m} I_j^{true}$ and $\hat{P} = \frac{1}{m}\sum_{j=1}^{m} I_j^{pred}$ represent the realized and predicted means.

Table 1 presents results for DA for all the estimated models. It is worth noting that incorporating information regarding the future path of short-term interest rates has an insignificant impact on the directional accuracy and success ratio. Furthermore, the VAR model performs very similarly to the VEC model, therefore, the error correction term does not help much in terms of forecasting medium-term interest rates one and two quarters ahead, although it is statistically significant in the VEC formulation.

Table 1

	MSE	MAE	SR(%)	DA	p-value
Panel A:					
VAR-naive	0.004355	0.046366	0,69863	33,065*	(0,000472)
VAR-information	0.004451	0.046027	0,69863	33,065*	(0,000472)
VEC-naive	0.004878	0.050768	0,69863	34,522*	(0,000278)
VEC-information	0.005059	0.05024	0,64384	24,141*	(0,007887)
Random Walk	0.003322	0.043058			
Panel B:					
VAR-naive	0.009338	0.075769	0,67143	2.7985*	(0,0025668)
VAR-information	0.008545	0.075227	0,64286	2.367*	(0,0089657)
VEC-naive	0.010056	0.079088	0,67143	2.8544*	(0,0021562)
VEC-information	0.010511	0.081898	0,67143	2.8544*	(0,0021562)
Random Walk	0.008818	0.07368			

In Table 1, Panel A presents the Mean Squared (MSE) and Absolute (MAE) Error, Success Ratio (SR), Directional Accuracy statistic and the p-value for the three steps ahead forecasts. Panel B refers to the six steps ahead forecasts. We performed a Pesaran-Timmerman test to obtain these results and its possible to observe that we can reject the null hypothesis that the Success Ration is statistically non-significant for all models. In this case, the higher the value of the DA statistic the larger is the rejection of the H_0.

* Significant at 1%.

We compare the forecasting performance of these models using the modified Diebold-Mariano statistic, which is given by:

$$DM = \frac{\bar{d}}{\sigma_d} \overset{a}{\sim} N(0,1), \qquad (4)$$

where $\bar{d}$ is the sample mean loss differential and σ_d is the variance of the loss differential, with a correction for serial correlation (Newey-West, 1987 covariance estimator).

Table 2 presents the results of a Diebold-Mariano test to evaluate the performance of the models two-by-two. We found that in the three steps ahead forecasts both VEC models performed better than the random walk, in the six steps ahead forecasts only the VEC with information presented better results. Therefore, in terms of forecasting accuracy a VAR/VEC framework performs poorly.

Table 2

	VAR-naive	VAR-information	VEC-naive	VEC-information
Panel A				
VAR-information	0.16066			
	(0,43618)			
VEC-naive	-1.3009	-1.2373		
	(0,90336)	(0,89202)		
VEC-information	-1.2028	-1.2942	0.30105	
	(0,88546)	(0,9022)	(0,38169)	
RW	1.0001	0.7681	1.6175**	1.4716**
	(0,15864)	(0,22121)	(0,052884)	(0,07057)
Panel B				
VAR-information	2.1666			
	(0.015133)			
VEC-naive	0.32978	-0.2934		
	(0.37078)	(0.61537)		
VEC-information	-1.5094	-2.4641	-2.1646	
	(0.93441)	(0.99313)	(0.98479)	
RW	1.1629	-0.227	0.2708	3.4175**
	(0.12244)	(0.58977)	(0.39326)	(0.00031605)

This table presents the results of a diebold-mariano test of the forecast errors of each model and provides p-values in parenthesis. In Panel A are the results for the three steps ahead forecasts while in Panel B are those for the six steps ahead forecasts.

** Significant at 10%.

6. Final Considerations

This paper studies a VAR/VEC model to forecast medium-term interest rates for the Brazilian economy. We focus on two variants of the model: one in which forecasters do not have information regarding short-term interest rates, and another, in which we assume that forecasters know the future path of short-term interest rates. This assumption seems reasonable since the Central Bank has short-term interest rates as the main instrument to conduct monetary policy, leading to some degree of predictability of short-term interest rates.

The empirical results obtained suggest that VAR/VEC models perform poorly in forecasting movements in interest rates in terms of forecasting accuracy. However, these models prove to be valuable as they help predict the direction of movements in medium-term interest rates.

The use of VAR/VEC models in monetary policy modeling seems to be useful as it can help policymakers to create scenarios for the term structure of interest rates in the future, and assess what would be the impact on macroeconomic variables in these scenarios. Additional research could study models that allow for changes in regimes.

References

Bidarkota, P.V. (1998) The Comparative Forecast Performance of Univariate and Multivariate Models: an Application to Real Interest Rate Forecasting. Internacional Journal of Forecasting, 14(4), 457-468.

Bogdanski, J., Tombini, A.A., Werlang, S.R.C. (2000) Implementing Inflation Targeting in Brazil. Banco Central do Brasil Working Papers Series, n. 1.

Bollerslev, T., Engle, R.F., Wooldridge, J.M. (1988) A Capital Asset Pricing Model with Time-Varying Covariances. The Journal of Political Economy, 96(1), 116-131.

Byers, S.L., Nowman, K.B. (1998) Forecasting U.K. and U.S. Interest Rates Using Continuous Time Term Structure Models. Internacional Review of Financial Analysis, 7(3), 191-206.

Campbell, J.Y., Shiller, R.J. (1991) Yield Spreads and Interest Rate Movements: A Bird's Eye View. Review of Economic Studies, 58(3), 495-514.

Cuthbertson, K. (1996) The Expectations Hypothesis of the Term Structure: the UK Interbank Market. Economic Journal, 106(436), 578-592.

Diebold, F.X., Mariano R.S. (1995) Comparing Predictive Accuracy. Journal of Business and Economic Statistics, 13(3), 253–263.

Domínguez, E., Novales, A. (2000) Testing the Expectations Hypothesis in Eurodeposits. Journal of Internacional Money and Finance, 19(5), 713-736.

Engsted, T., Tanggaard, C. (1994) Cointegration and the US Term Structure. Journal of Banking and Finance, 18(1), 167-181.

Engle, R.F., Granger, C.W.J. (1987) Co-integration and Error-correction: Representation, Estimation and Testing. Econometrica, 55(2), 251-276.

Ferreira, M.A. (2005) Forecasting the Comovements of Spot Interest Rates. Journal of Internacional Money and Finance, 24(5), 766-792.

Fletcher, D.J., Gulley, O.D. (1996) Forecasting the Real Interest Rate. North American Journal of Economics & Finance, 7(1), 55-76.

Froot, K. A. (1989) New Hope for the Expectations Hypothesis of the Term Structure of Interest Rates. Journal of Finance, 44(2), 283-305.

Gamber, E.N., Hakes, D.R. (2005) Is Monetary Policy Important for Forecasting Real Growth and Inflation? Journal of Policy Modeling, 27(2), 177-187.

Garcia, M.G.P., Didier, T. (2001) Very High Interest Rates and the Cousin Risks: Brazil during the Real Plan. mimeo.

Johansen, S. (1988) Statistical Analysis of Cointegration Vectors. Journal of Economic Dynamics and Control, 12(2-3), 231-254.

Johansen, S. (1991) Estimation and Hypothesis Testing of Cointegration Vectors in Gaussian Vector Autoregressive Models. Econometrica, 59(6), 1551-1580.

Lo W-C., Fung, H-G., Morse, J.N. (1995) A Note on Euroyen and Domestic Yen Interest Rates. Journal of Banking and Finance, 19(7), 1309-1321.

Longstaff, F.A. (2000) The Term Structure of Very Short-Term Rates: New Evidence for the Expectations Hypothesis. Journal of Financial Economics, 58(3), 397-415.

Mankiw, N. G. (1986) The term structure of interest rates revisited. Brooking Papers on Economic Activity, 1, 61-110.

Mankiw, N.G., Miron, J. A. (1986) The Changing Behavior of the Term Structure of Interest Rates. The Quartely Journal of Economics, 101(2), 211-228.

McFadyen, J., Pickerill, K., Devaney, M. (1991) The Expectation Hypothesis of the Term Structure: More Evidence. Journal of Economics and Business, 43(1), 79-85.

Mishkin, F.S. (1984) The Real Interest Rate: A Multi-Country Empirical Study. The Canadian Journal of Economics, 17(2), 284-311.

Muinhos, M.K., Nakane, M.I. (2006) Comparing Equilibrium Real Interest Rates: Different Approaches to Measure Brazilian Rates. Banco Central do Brasil Working Papers Series, n. 101.

Newey, W.K., West, K.D. (1987) A Simple, Positive Semi-Definite, Heteroskedasticity and Autocorrelation Consistent Covariance Matrix. Econometrica, 55(3), 703-708.

Pesaran, M.H., Timmermann, A. (1992) A Simple Nonparametric Test of Predictive Performance. Journal of Business and Economic Statistics, 10(4), 461-465.

Roley, V.V., Sellon, G.H. Jr. (1995) Monetary Policy Actions and Long-Term Interest Rates. Economic Review, Federal Reserve Bank of Kansas City, fourth quarter, 73-89.

Shiller, R.J., McCulloch, J.H. (1990) The Term Structure of Interest Rates. Handbook of Monetary Economics, chapter 13.

Stambaugh, R.F. (1988) The Information in Forward Rates: Implications for Models of the Term Structure. Journal of Financial Economics, 21(1), 41-70.

Tabak, B.M. (2004) A Note on the Effects of Monetary Policy Surprises on the Brazilian Term Structure of Interest Rates. Journal of Policy Modeling, 26(3), 283-287.

Tabak, B.M., Andrade, S.C. (2003) Testing the Expectations Hypothesis in The Brazilian Term Structure of Interest Rates. Revista Brasileira de Finanças, 1, 19-45.

Taylor, M.P. (1992) Modelling the Yield Curve. The Economic Journal, 102(412), 524-537.

Thornton, D.L. (2000) The Bias in the Conventional Test of the Expectations Theory: Resolving the Anomalies at the Very Short End of the Term Structure. Federal Reserve Bank of Saint *Louis Working Paper Series*, n. 3A.

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