The yield curve dynamics in a small emerging economy and its interactions

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Abstract

This paper contributes to the literature on the relationship between the yield curve, macroeconomic variables and the unexplored interactions with the U.S. yield curve movements by focusing on an emerging market: Brazil. We incorporate factors for the U.S. yield curve and domestic macroeconomic variables into the Dynamic Nelson Siegel Model to exterminate co-movements with the Brazilian yield curve. The empirical results suggest that both American and macroeconomics components have explanatory power to the latent factors of the term structure, especially for the level U.S. factor high predictive power over Brazilian level, slope and curvature of the term structure.

Resumo

Esse trabalho contribui com a literatura sobre a relação entre a curva de juros brasileira, variáveis macroeconômicas e os movimentos da curva de juros americana. Incorpora-se os fatores da curva dos EUA e fatores macroeconômicos domésticos em um modelo de Nelson-Siegel dinâmico para avaliar os co-movimentos existentes com a curva de juros do Brasil. Os resultados demonstram que tanto os fatores americanos como macroeconômicos tem poder explicativa sobre os fatores da estrutura a termo da taxa de juros brasileira, principalmente o nível da curva dos EUA apresentou relevante poder preditivo para o nível, inclinação e curvatura da curva brasileira.

Key-words: yield curve, cross-country co-movement, emerging market, macro-finance.

Palavras-chave: curva de juros, co-movimento entre países, mercado emergente, macro-finanças.

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JEL Classification: C58, E43, G12, G15.

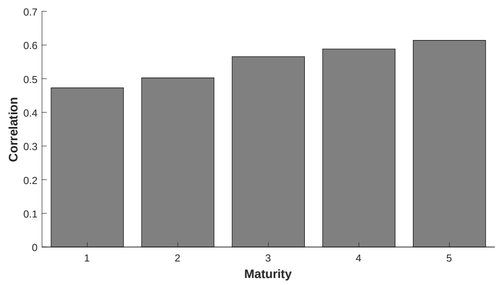
1 Introduction

Many studies have analyzed the term structure of interest rates and macroeconomic variables jointly, considering both unidirectional and bidirectional linkage (Ang and Piazzesi, 2003; Diebold, Rudebusch, and Aruoba, 2006; Hördahl, Tristani, and Vestin, 2006; Aguiar-Conraria, Martins, and Soares, 2012, among others). At the same time, another key issue in the literature is the co-movements across different yield curves. Jotikasthira, Le, and Lundblad (2015) find out that U.S. yield level helps to explain covariance of yields at all maturities for Germany and the United Kingdom. Similarly, Lange (2014) demonstrates that the U.S. yield curve accounts for a relevant variation of the movement in the Canadian term structure factors.

A number of recent studies have centered their attention on the effects of U.S. term structure of interest rates on the yield curve of small and emerging economies. Kulish and Rees (2011) argue that long-term interest rates in a number of inflation-targeting small open economies is strongly correlated with those of the United States. Bowman, Londono, and Sapriza (2015) investigate the effect of U.S. monetary policy shocks on the sovereign bond yields in emerging market economies (including Brazil) and figure that these sovereign bonds responds strongly to U.S. monetary policy announcements. Besides its relevant conclusions, there are still few studies analyzing this connectedness between developing and developed markets yield curves.

Figure (1) shows the patter of interest rate correlations at different maturities on the yield curve for Brazil with the U.S. The long-term rates are highly correlated with their U.S. counterparts and usually more than rates at shorter maturities. The high interest rate correlations between the yield curve for Brazil with the U.S., and the recent research evidence about the impact of global factors on the domestic yield curve motivates the present study.

Figure 1: **Cross correlations with U.S. interest rates.**



The main purpose of this paper is to evaluate the impact that the U.S. yield curve and macroeconomic variables have on the Brazilian curve, extending the Diebold, Rudebusch, and Aruoba (2006) framework. We follow Lange (2014) by assuming that term structure of a small open economy will be affect by the U.S. curve, but not the other way around. We contribute to the literature of a yield curve cross-country iteration, such as Diebold, Li, and Yue (2008), Lange (2014) and Jotikasthira, Le, and Lundblad (2015). Furthermore, we shed lights on an emerging economy, observing its financial market openness, and also expanding an underdeveloped literature.

The paper proceeds as follows. Section 2 lays out the model with U.S. yield curve states and macroeconomic variables. Section 3 presets the empirical results and compares the effects of foreign variable in the model. Section 4 concludes the paper.

2 The Model

The popular yield curve model developed by Nelson and Siegel (1987, henceforth NS) provides a flexible and parsimonious approach to fit the cross-section of yields. Diebold and Li (2006, henceforth DL) reinterpreted the NS model as a dynamic factor model

$$y_t(\tau) = \beta_{1,t} + \beta_{2,t}\left(\frac{1-e^{-\lambda\tau}}{\lambda\tau}\right) + \beta_{3,t}\left(\frac{1-e^{-\lambda\tau}}{\lambda\tau} - e^{-\lambda\tau}\right) + \epsilon_t(\tau), \tag{1}$$

where $\beta_{1,t}$, $\beta_{2,t}$ and $\beta_{3,t}$ are time-varying parameters referred as level (L_t), slope (S_t) and curvature (C_t) factors of the yield curve.

The DL generalization of the NS model can be expressed in state space form

$$y_t(\tau) = \Lambda f_t + \epsilon_t, \quad \epsilon_t \sim N(0, \Omega),\ t = 1, \ldots, T, \tag{2}$$

$$(f_t - \mu_f) = \Upsilon(f_{t-1} - \mu_f) + \eta_t, \quad \eta_t \sim N(0, \Sigma_\eta), \tag{3}$$

where (2) and (3) are the measurement and transition equations, respectively. In (2), y_t is a vector of N yields with maturities τ, Λ is the loading matrix, f_t is the vector of latent dynamic factors, where we can include the yield curve factors level, slope and curvature. Our purpose is to also include macroeconomic variables and the U.S. yield curve factors in the f_t vector, aiming to evaluate its impacts on the Brazil yield curve. μ_f is the mean vector, Υ is the autoregressive matrix, which we will take a closer look soon. The disturbance vector, ϵ_t, is normally distributed with diagonal variance matrix Ω.

The structure for the loading matrix Λ is inherited from the NS model and is identified by setting the predetermined loadings, so

$$\Lambda = \left[1, \left(\frac{1-e^{-\lambda\tau}}{\lambda\tau}\right), \left(\frac{1-e^{-\lambda\tau}}{\lambda\tau} - e^{\lambda\tau}\right)\right], \tag{4}$$

where λ is a decay parameter and the only parameter to be estimated. The dimension of Λ could be generalized as a $N \times k$ matrix, of which the first three columns include the loadings on the three yield factors and the $k-3$ columns on the right contain only zeros, so that the yields still load only on the yield curve factors, as the original DL model.

A model with macroeconomic variables and/or foreign yield curve factors would increases the f_t and, consequently, most of elements in the equations (2) and (3). Dealing with the curse of dimensionality, some restrictions will be imposed, so we can estimate three models specifications, which are briefly described in the section 3.2.

3 Empirical Application

3.1 Data

The Brazilian yields for the estimations consists of end-of-month yields of Brazilian interbank deposit future contracts (DI-futuro) collected on a monthly basis. The data set were obtained from the Brazilian Mercantile and Futures Exchange (BM&FBovespa), which is the entity that offers DI-futuro contracts and determines the maturities with authorized contracts. Our sample range from January 30th, 2004 to November 30th, 2016, with a monthly frequency, and consider the following 14 maturities: 3, 6, 9, 12, 15, 18, 21, 24, 30, 36, 42, 48, and 60 months. This choice provides us with a panel of 165 monthly observations on 14 different yields.[1] At the same time, we took advantage of the Gurkaynak, Sack, and Wright (2007) resulting estimates to compute the U.S. yield curve for the same fixed maturities used by Diebold, Rudebusch, and Aruoba (2006).[2]

For the macroeconomic variables, we used the industrial capacity utilization (uci_t), the 12-month percentage change in the Broad National Consumer Price Index ($ipca_t$), the measure used as the inflation target in Brazil, and the Selic interest rate ($selic_t$), which is equivalent to the U.S. federal funds rate, as the instrument of monetary policy. All three variables are public available on the Brazil Central Bank and the Institute for Applied Economic Research (IPEA) databases.

3.2 Estimation Procedures

We follow Diebold, Rudebusch, and Aruoba (2006) estimation procedures, initializing the Kalman Filter[3] with the parameters obtained by the DL two-step method computed with $\lambda = 0.077$. We maximize the likelihood by iterating Nelder-Mead and BFGS algorithms[4], with a convergence criterion of 10^{-6}. As a standard procedure, we optimize the Cholesky factor of matrix Σ_η, shrinking the number of parameters to be estimate from $k \times k$ to $k(1+k)/2$, and ensuring that this matrix will be symmetric and positive definite.

We estimated three models specifications, named: Yields-Macro, Yields-UScurve and Yields-US-Macro. The main difference among them is the composition and size of the Υ matrix. The Yields-Macro is the baseline model. It has the same specification introduced by Diebold, Rudebusch, and Aruoba (2006), with $f_t = (L_t, S_t, C_t, uci_t, selic_t, ipca_t)$, where Υ is a full 6×6 matrix.

In the Yields-UScurve, the f_t vector is composed by the three unobserved Brazilian yield curve factors and the empirical factors of the U.S. curve[5], so $f_t = (L_t, S_t, C_t, usl_t, uss_t, usc_t)$. We can summarize the matrix Υ into four 3×3 blocks:

$$\Upsilon = \begin{bmatrix} \Upsilon_1 & \Upsilon_2 \\ \Upsilon_3 & \Upsilon_4 \end{bmatrix}. \tag{5}$$

The effects of legged U.S. factors on the Brazilian curve are incorporated in the sub-matrix Υ_2. At the same time, as the opposite effect is very unlikely, the Υ_3 block is composed of zeros, in a way that lagged Brazilian factors have no effect on the U.S. curve.

The Yields-USc-Macro specification includes both U.S. curve empirical factors and macroeconomic variables, in that order. This time, the Υ matrix can be summarized into six 3×3 blocks:

$$\Upsilon = \begin{bmatrix} \Upsilon_1 & \Upsilon_2 & \Upsilon_3 \\ \Upsilon_4 & \Upsilon_5 & \Upsilon_6 \\ \Upsilon_7 & \Upsilon_8 & \Upsilon_9 \end{bmatrix}. \tag{6}$$

The sub-matrix Υ_4 is equivalent to the Υ_3 block in (5), and so is composed of zeros. Similarly, Υ_8 and Υ_6 are also formed of zeros, assuming that lagged U.S. factors have no effect on Brazilian macroeconomic variables, and the other way around.

[1] Additional details about this data set and the DI-futuro contract can be found in Caldeira, Moura, and Santos (2016).

[2] The authors follow the framework developed by Svensson (1994), an extension of the form proposed by Nelson and Siegel (1987), using yearly maturities.

[3] We applied the procedures developed by Jungbacker and Koopman (2015) due to gains in efficiency.

[4] The second algorithm is a gradient quasi-Newton method with BFGS update of the estimated inverse Hessian, konwn as the csminwel.m routine by Christopher A. Sims. The interaction of both algorithms avoid the optimization stuck in a cliff edge, once we perturb the initial values of the parameter vector while not converged.

[5] The empirical proxy for level, slope and curvature are $usl_t = (y_t(3) + y_t(24) + y_t(120))/3$, $uss_t = y_t(3) - y_t(120)$ and $usc_t = 2y_t(24) - y_t(3) - y_t(120)$, respectively.

3.3 Results

We now discuss the correlation between empirical and estimated factors, comparison of decay parameters (λ) and the Y matrix with VAR parameters for the three models. In general, the models fits well the term structures in all three specifications, with a high correlation between the empirical and the estimate factors, as presented in Table 1, and small measurement errors in the parameters estimates. The λ for the Yield-Macro, Yield-UScurve and Yield-US-Macro model is 0.0928, 0.0913 and 0.0899, respectively, which implies that the loading on the curvature factor is maximized approximately at 18 and 21 months, a consistent result with the literature and the fixed maturities used.

Table 1: Correlation between empirical and estimate factors

	L_t	S_t	C_t
Yield-Macro	0.8187	0.9664	0.8968
Yield-UScurve	0.8251	0.9658	0.8689
Yield-US-Macro	0.8236	0.9651	0.8686

Table 2 presents the Υ matrix of estimated parameters for the Yields-Macro model. All variables presents significant persistence. As already pointed out by Sekkel and Alves (2010), lagged macroeconomic variables have important effects on Brazilian yield curve factors. The bidirectional linkage between term structure factors and macroeconomic variables is presented, with the latent factors been more significant for the future macroeconomic factors, indicating a capability of the market to anticipate economic movements.

The lagged monetary instrument, the $selic_{t-1}$ interest rate, presents a negative effects for all yield factors. Even thought the level parameter is not significant, the negative effect of monetary instrument on level and slope factors is quite unusual in the literature analyzing developed countries and is inconsistent with the expectations hypothesis, since an increase in the interest rates turns the yield curve more positively sloped. Regressing each maturity on the policy interest rate, we can observe that its effects on the slope factor are mainly related to changes in the shorter end of the term structure. This result could be related to historical high-inflation episodes in Brazil, once we also observe positive effect of lagged factors on the inflation. In this sense, a higher interest rate is mainly associate with the focus on inflation control by the monetary authorities. Since the central bank seems to be accurate on this objective, as express by the significant parameter for lagged $selic_t$ on the inflation, the markets reacts through the yield curve in an opposite direction.

We show the Yield-UScurve parameter estimates in the Table 3. As the Yield-Macro model, all parameter persistence are significant, with very similar results for the latent factors. The parameters for the U.S. curve are close to the literature, where the main distinguish is the slope persistence, which presents a higher result than other estimations.[6] The main result to be observed in this specification is the effects of lagged U.S. empirical factors on the latent Brazilian factors, where most parameters are significant.

There is an indicative of co-movement between the American and the Brazilian yield curve, expressed by the same factors relations, in the second 3×3 block of the Y matrix diagonal. The usc_{t-1} and C_t parameter, for example, highlights the predicative power of the American factors for the Brazilian curve. Moreover, the cross-factors relations also demonstrates de importance of U.S. curve, mainly the usl_{t-1} and uss_{t-1}. An increase in the U.S. level factor raises the curvature and reduce the slope of the yield curve in Brazil. At the same time, a positive change in the American slope factor lead to

[6]Such as Diebold, Rudebusch, and Aruoba (2006) and Laurini and Caldeira (2016).

Table 2: Yields-macro model parameter estimates

	L_{t-1}	S_{t-1}	C_{t-1}	uci_{t-1}	$selic_{t-1}$	$ipca_{t-1}$	μ
L_t	**0.97**	**0.13**	-0.01	**0.02**	-0.08	0.01	-0.59
	(0.52)	(0.03)	(0.02)	(0.01)	(0.04)	(0.04)	(0.36)
S_t	**0.20**	**0.96**	**0.08**	**-0.02**	**-0.10**	0.05	0.12
	(0.04)	(0.41)	(0.03)	(0.01)	(0.04)	(0.05)	(0.43)
C_t	**0.47**	**0.38**	**0.96**	0.00	**-0.47**	**-0.20**	**1.19**
	(0.14)	(0.15)	(0.23)	(0.01)	(0.17)	(0.07)	(0.57)
uci_t	0.02	-0.03	-0.02	**0.99**	0.01	**-0.05**	**0.34**
	(0.05)	(0.04)	(0.01)	(0.77)	(0.05)	(0.02)	(0.15)
$selic_t$	**0.36**	**0.31**	**0.07**	**0.01**	**0.62**	0.02	**-0.32**
	(0.02)	(0.02)	(0.01)	(0.01)	(0.00)	(0.01)	(0.12)
$ipca_t$	**0.15**	**0.12**	**0.05**	**0.01**	**-0.17**	**1.00**	**-0.37**
	(0.03)	(0.03)	(0.01)	(0.00)	(0.03)	(0.86)	(0.12)

Note: Bold and underline entries denote parameter estimates significant at the 5% and 10% level, respectively. Standard errors appear in parentheses.

Table 3: Yields-UScurve model parameter estimates

	L_{t-1}	S_{t-1}	C_{t-1}	usl_{t-1}	uss_{t-1}	usc_{t-1}	μ
L_t	**0.90**	**0.12**	-0.02	**0.18**	**-0.35**	-0.07	0.30
	(0.23)	(0.03)	(0.02)	(0.08)	(0.13)	(0.16)	(0.28)
S_t	**0.15**	**0.85**	**0.10**	**-0.30**	**0.32**	0.20	-0.56
	(0.04)	(0.10)	(0.03)	(0.10)	(0.16)	(0.19)	(0.34)
C_t	**-0.18**	-0.11	**0.82**	**0.38**	**-0.61**	**0.62**	**1.13**
	(0.07)	(0.06)	(0.10)	(0.16)	(0.25)	(0.28)	(0.52)
usl_t				**0.99**	**-0.06**	**0.12**	**0.07**
				(0.84)	(0.01)	(0.02)	(0.03)
uss_t				-0.01	**0.93**	**0.14**	**0.10**
				(0.01)	(0.22)	(0.03)	(0.03)
usc_t				-0.02	0.00	**0.98**	0.01
				(0.01)	(0.01)	(0.81)	(0.03)

Note: Bold and underline entries denote parameter estimates significant at the 5% and 10% level, respectively. Standard errors appear in parentheses.

a decrease in the level factor, due to reduce of the yields on the shorter end of the curve and a loosing international risk perception on the market.

In our lest specification, we include U.S. factors and Brazilian macroeconomic variables. The results on Table 4 are similar to previous cases with regard to the persistence. Comparing with the Yield-UScurve model, lagged U.S. factors have a smaller relevance, with only the usl_{t-1} factor being significant for the Brazilian factors. Conversely, the macroeconomic parameters are comparable in significance, in the same way that capacity utilization turn into a pertinent variable both predicting as being predicted by latent factors.

The co-movement between the level factors of U.S. and Brazil curves is stronger than the one observed in the Yield-UScurve model. The impact of U.S. level factor on slope maintains, but it has an opposite sign and more substantial shock on curvature. The result of Yield-UScurve indicates that a rise in the U.S. level factors decreases the slope and increase the curvature, with higher effect on the short and medium term maturities. However, Table 6 give us a different perception, suggesting a smaller reaction of mid-maturities in favor of longer end of the term structure, since there is a negative relation between shocks on usl_{t-1} and the curvature factor.

Table 4: Yields-US-Macro model parameter estimates

	L_{t-1}	S_{t-1}	C_{t-1}	usl_{t-1}	uss_{t-1}	usc_{t-1}	uci_{t-1}	$selic_{t-1}$	$ipca_{t-1}$	μ
L_t	**0.85**	**0.09**	-0.03	**0.37**	-0.28	-0.33	**-0.02**	**0.04**	**0.14**	0.68
	(0)	(0.02)	(0.03)	(0.08)	(0.15)	(0.27)	(0.01)	(0.01)	(0.05)	(0.53)
S_t	**0.21**	**0.88**	**0.13**	**-0.33**	0.25	0.41	**0.04**	**-0.11**	0.01	**-3.07**
	(0.04)	(0.02)	(0.04)	(0.15)	(0.28)	(0.31)	(0.01)	(0.04)	(0.11)	(0.6)
C_t	**-0.43**	-0.29	**0.87**	**-0.91**	-0.40	0.89	0.11	**0.68**	**-0.78**	-5.07
	(0.11)	(0.34)	(0.05)	(0.29)	(0.72)	(0.72)	(0.07)	(0.29)	(0.14)	(2.51)
usl_t				**0.98**	**-0.06**	0.12				0.09
				(0.09)	(0.02)	(0.07)				(0.05)
uss_t				-0.02	**0.92**	**0.14**				0.08
				(0.05)	(0.01)	(0.05)				(0.18)
usc_t				-0.03	-0.01	**0.97**				0.00
				(0.02)	(0.02)	(0.51)				(0.12)
uci_t	-0.23	**-0.26**	**-0.05**				**0.93**	0.28	-0.04	**5.28**
	(0.13)	(0.09)	(0.02)				(0.04)	(0.17)	(0.03)	(0.25)
$selic_t$	**0.26**	**0.23**	**0.06**				**0.02**	**0.72**	0.06	**-2.00**
	(0.06)	(0.05)	(0)				(0.01)	(0.1)	(0.01)	(0.63)
$ipca_t$	**0.11**	0.06	0.01				-0.01	-0.08	**0.94**	**0.67**
	(0.04)	(0.04)	(0.01)				(0)	(0.07)	(0.05)	(0.14)

Note: Bold and underline entries denote parameter estimates significant at the 5% and 10% level, respectively. Standard errors appear in parentheses.

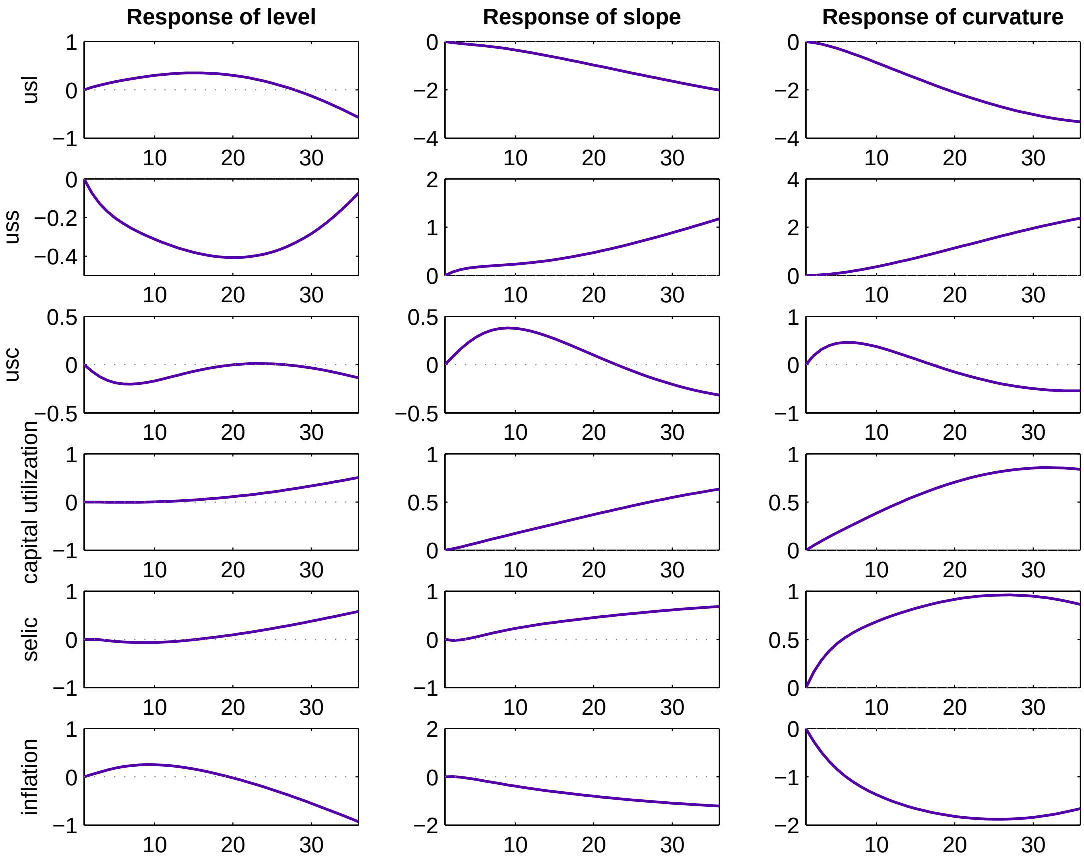
All lagged macroeconomic factors are pertinent for the level factor. An increase in the capacity utilization leads to a small negative change on the level factor. The same could be observed on a decrease of inflation and Selic rate. The negative reaction of slope factor on positive change in the Selic remains, with a greater effect on the curvature. So, an increase in the monetary instrument have the same effect on level factor, mainly because of movements on the short and medium term yield maturities. The inflation give us a comparable analysis, though it is more likely an increase on long instead of medium term rates. When scrutinizing the other direction effects, the main result of lagged factors on macroeconomic variables is related to the slope. Thus, since the slope is negative on average and more related with modifications on the shorter end of the term structure, we can say that a decrease of short term yields have a predicative effect on the expansion of capacity utilization and a decline of Selic rates. Moreover, we highlight the fact that Brazilian yield curvature has link to macroeconomic variables, conversely to the American finding in Diebold, Rudebusch, and Aruoba (2006).

3.4 Yield-US-Macro model Impulse Response functions and Variance Decomposition

To analyze the interaction among variables in the measurement equation we perform impulse-response functions. Figure (2) plot impulse-response functions for the Yield-US-Macro model at horizon of 36 months, in a way we can investigate the counter effect on latent factors to shocks on the U.S. factors and macro variables. On Figure (3) we explore the bidirectional linkage characteristic of this representation, plotting the Brazilian and American yield curve factors on macroeconomic variables. In both cases, we present the response to one standard deviation shock on the variable in the vertical label axis.

The response of level factor to shocks in the U.S. level is positive and hump-shaped, turning negative after around 25 months. Conversely, slope and curvature present a negative response to an increase in the U.S. level curve, which take more than 36 months to dissipate. The magnitude

Figure 2: Inpulse-Response of yield curve factors

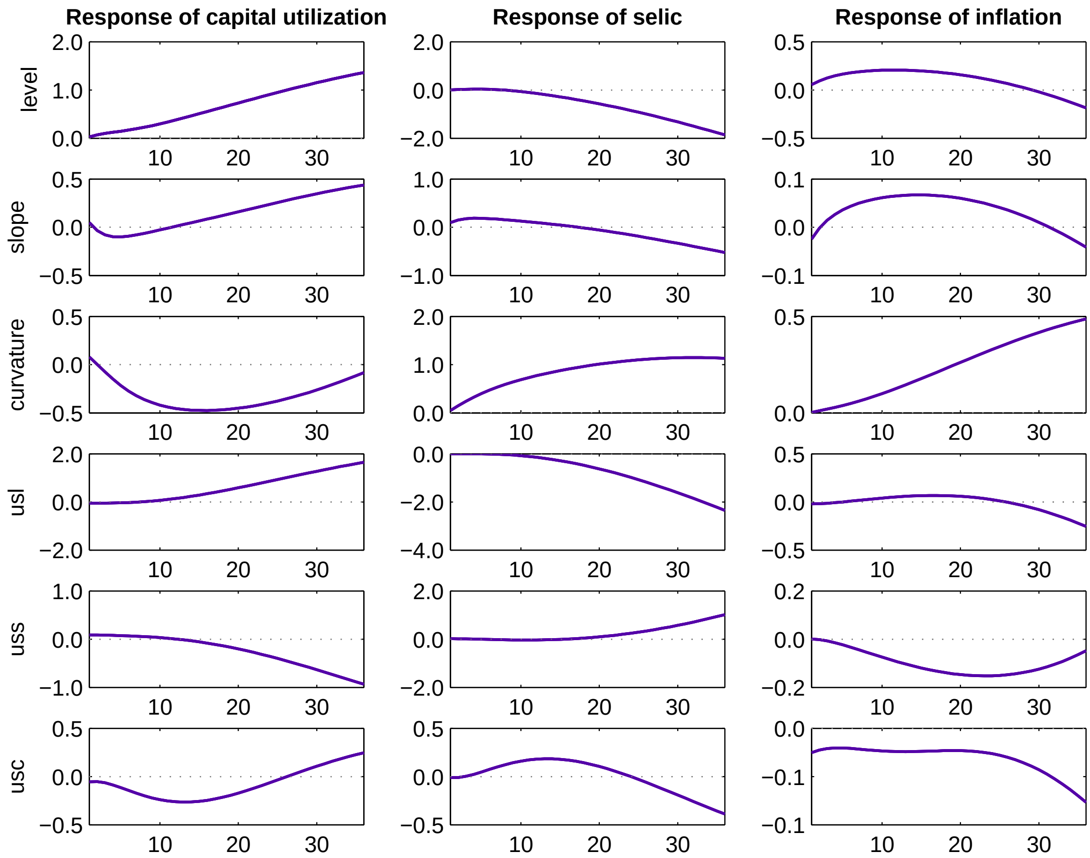


effect of shocks in the U.S. slope and curvature are overall smaller than those observed in the level. Level response to an increase in US yield curve slope, despite its small size, illustrate an inverse connection between then. Our results reinforce the analysis of Jotikasthira, Le, and Lundblad (2015) that U.S. yield factors have power to explain the movements of other countries curves. Moreover, since the authors look to Germany and the UK, we could say that this co-movement is not only between developed economies, but also from an advanced economy to an emerging one.

On the macro variables, an increase in the capital utilization have an slow effect on the level factor, a small but persistent effect on the slope and an almost one-to-one effect with curvature after 30 months. It is interesting to note that curvature factors show higher response to macro variables than the other two factors, in opposition to the empirical results obtained in Diebold, Rudebusch, and Aruoba (2006). Moreover, a positive shock on inflation have the same signal impact for the level, which turns into negative after 20 months, demonstrating the risk perception of the market with an increase in inflation.

Consider now the response of macroeconomic variables to yields curve shocks (see Figure 3). At first, we notice a stronger response of capital utilization and selic interest rate to shocks on the level than the other way around, which might indicate an anticipation behavior of the market. A similar despite smaller effect can be regarded for the slope factor. A positive shock on the slope, with a decrease at short compared with long maturities, indicates a decrease in the Selic interest rate in the long tern, despite a small positive effect on the first ten following months. Note that the effect of Selic indicates a higher response pattern in the curvature, and also shows that capacity utilization responds

Figure 3: Inpulse-Response of Macroeconomic Variables



more intensely to shocks to this variable. A more challenging analysis would be the response of Brazilian macroeconomics to the US yield curve factors, since we already assume that lagged U.S. factors have no effect on it by the restrictions in the Υ matrix in the Yield-US-Macro specification. However, we impose no restriction on the Σ_η variance-covariance matrix in the transition equation of the state-space representation, and thats way Figure (3) shows this effects. This response is related to a global market movement, which worth further research.

The same effect can be observed in the variance decomposition of macro variables. Table 5 provides variance decomposition of the yield factors and macro variables at forecast horizons of 12, 24 and 36 months[7]. It is interesting to notice the importance of U.S. level factor on the variance of capital utilization and Selic interest rate at longer horizons. As we already pointed out, the the term structure interest rates carry information about macroeconomics and expectations. Thus, considering the global importance of the U.S., it is not surprising to observe indirect effect through covariance matrix of our model reflecting consequences on economic activity and monetary policy in Brazil. We can also highlight the influence of domestic factors on macro variables, such as the level on capacity utilization and inflation, or curvature on selic interest rate and inflation. Contrary to the literature, the slope factors has small representation in this decomposition exercise.

Finally, we interpret the decomposition of domestic yield curve factors. There is a relevant explanatory power among themselves, mainly through level and curvature. The variance decomposition of level factor for a long horizon in mainly explained by the curvature and the inflation. Actually,

[7]We do not analyze shorter horizons because their results tend to show persistence effects only.

Table 5: Forecast Error Variance Decomposition, Yield-US-Macro Model

	Horizon	L_t	S_t	C_t	usl_t	uss_t	usc_t	uci_t	$selic_t$	inf_t
Level Factor	12	0.6409	0.0397	0.0567	0.0747	0.0876	0.0383	0.0001	0.0035	0.0584
	24	0.3628	0.0317	0.2950	0.0958	0.1416	0.0186	0.0077	0.0083	0.0385
	36	0.1847	0.0154	0.4079	0.0676	0.0850	0.0097	0.0428	0.0541	0.1327
Slope Factor	12	0.4220	0.0510	0.2048	0.0680	0.0381	0.0962	0.0167	0.0258	0.0775
	24	0.2921	0.0214	0.1045	0.2306	0.0621	0.0327	0.0354	0.0534	0.1679
	36	0.2477	0.0200	0.0437	0.3255	0.0959	0.0152	0.0388	0.0511	0.1620
Curvature Factor	12	0.2402	0.0396	0.2811	0.0818	0.0138	0.0289	0.0169	0.0614	0.2364
	24	0.2646	0.0274	0.0825	0.2327	0.0648	0.0093	0.0287	0.0586	0.2314
	36	0.2473	0.0258	0.0379	0.3122	0.1202	0.0095	0.0286	0.0449	0.1736
Capital Utilization	12	0.1438	0.0125	0.2732	0.0117	0.0121	0.0871	0.4010	0.0135	0.0451
	24	0.2786	0.0141	0.1611	0.1643	0.0232	0.0377	0.0803	0.0378	0.2029
	36	0.2705	0.0219	0.0522	0.2923	0.0726	0.0130	0.0375	0.0439	0.1961
Selic rate	12	0.0094	0.0639	0.7482	0.0100	0.0013	0.0331	0.0450	0.0559	0.0332
	24	0.1015	0.0104	0.4224	0.1253	0.0050	0.0104	0.0655	0.0825	0.1770
	36	0.1653	0.0120	0.1818	0.2461	0.0335	0.0063	0.0641	0.0797	0.2112
Inflation	12	0.2491	0.0181	0.0433	0.0068	0.0227	0.0042	0.0062	0.0320	0.6176
	24	0.2340	0.0236	0.2595	0.0162	0.0860	0.0043	0.0060	0.0192	0.3513
	36	0.1209	0.0118	0.4405	0.0398	0.0630	0.0065	0.0346	0.0484	0.2344

inflation is the macro variable with most significant explanatory capacity for shorter horizons in curvature and longer in both slope and level. Considering the U.S. factors, around 30% of slope and curvature variance at 36 months horizon is due to American yield curve level, and 12% for of the curvature is due to U.S. slope. Once again, this reinforce our finding about the linkage between the U.S. and Brazil yield curve.

4 Concluding Remarks

This paper compare three specifications of the DNS model, considering the effect of macroeconomic variables and the U.S. yield curve factors. The results reinforce the bidirectional macro-finance linkage of term structure of interest rates. We show that the market tend to anticipate economic movements through changes in the Brazilian yield curve. We also observe controversial effects of lagged monetary instrument for all yield factors, mainly the slope, which indicates an space for further research. Moreover, capacity utilization turn into a pertinent variable both predicting as being predicted by latent factors.

We prove the importance of American factors for Brazil yield curve, even though we should take this analysis further, in order to have a clear comprehension of impacts of American factors movements on the Brazilian term structure forecasting. There is clear evidences of co-movement between factors for the U.S. and Brazil curve, meanly the level factor of both countries, where lagged U.S. factors present a high predicative power of the movements in the Brazilian term structure. The American curve level has also a cross impact on Brazilian slope and curvature, once around 30% of their variance at long horizon is due to American yield curve level movements.

This findings reinforce the literature of co-movements between term structures of different countries and brings and unprecedented result on linking the term structure of an emerging with a developed market. Our result highlight the importance of American curve to forecast movements in the Brazilian yield curve, which may assist fund mangers and policymakers with a batter understand of the magnitude and direction of this activities.

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