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THE YIELD CURVE INFORMATION UNDER UNCONVENTIONAL MONETARY POLICIES*

LA INFORMACION EN LA ESTRUCTURA DE TASAS BAJO POLITICAS MONETARIAS NO CONVENCIONALES

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Abstract

This paper attempts to address the question of how unconventional monetary policies affected the market expectations regards the expected path of the monetary policy rate and economic growth in countries where some kind of unconventional monetary policies were applied. The approach used is to compare the implicit expectations in the yield curve with market surveys (for the expected path pf monetary policy rate) and econometric models (for economic growth) and evaluate the accuracy of each forecast at different horizons. We conclude that in the period where unconventional monetary policies were applied, the yield curve provided relevant additional information to forecast the monetary policy rate and economic growth, especially in developed economies.

Keywords: *Yield curve, unconventional monetary policies, economic forecasting.*

JEL Classification: *E43, E44, E47, E58.*

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Resumen

Este artículo intenta abordar la interrogante sobre cómo las políticas monetarias no convencionales afectaron las expectativas de mercado sobre la trayectoria esperada de la tasa de política monetaria y el crecimiento económico en países donde algún tipo de política monetaria no convencional fueron aplicadas. El enfoque utilizado en este trabajo compara las expectativas implícitas de la curva de rendimiento con encuestas de mercado (para la tasa de política monetaria) y modelos econométricos (para el crecimiento económico) y así evaluar la precisión de cada una para proyectar a diferentes horizontes. Se concluye que en dicho periodo donde se aplicaron políticas no convencionales, la curva de rendimiento entregó información relevante a la hora de proyectar tanto la tasa de política monetaria como el crecimiento, especialmente en países desarrollados.

Palabras clave: *Estructura de tasas, políticas monetarias no convencionales, proyección económica.*

Clasificación JEL: *E43, E44, E47, E58.*

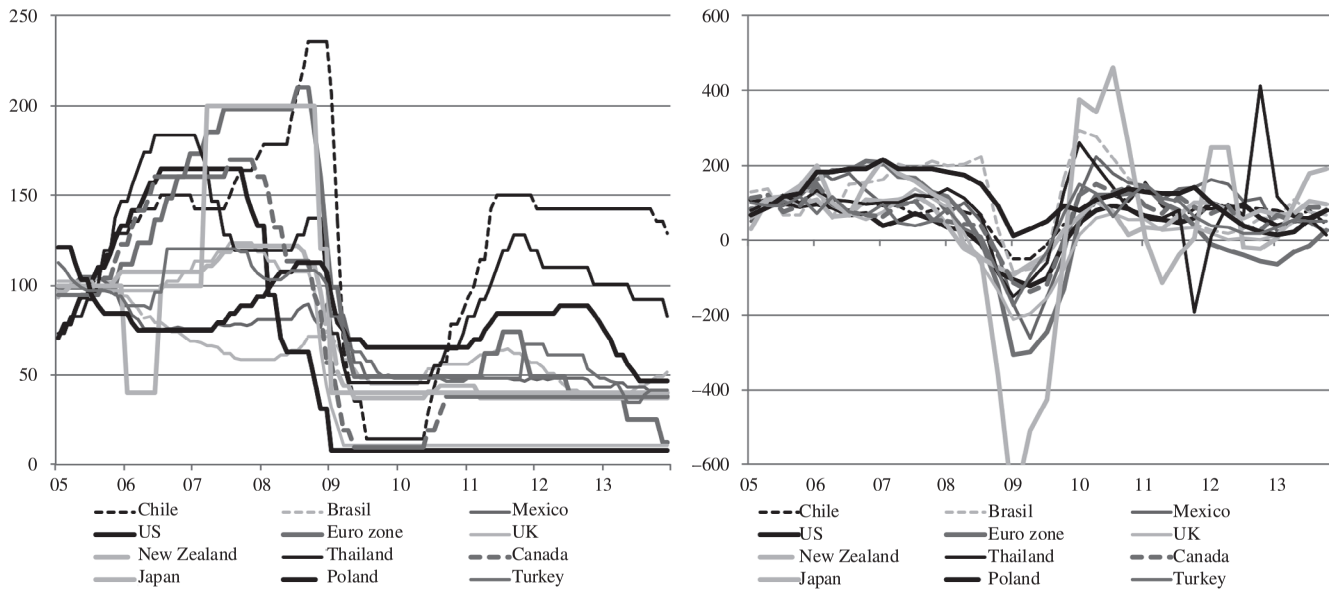
1. INTRODUCTION

The conventional monetary policy (understood as changes in the level of the monetary policy interest rate) seeks to influence the expectations of market participants about the future path of interest rates, affecting asset prices and therefore the level of output in the economy. The transmission mechanism can be summarized in two processes. The first process involves the propagation of changes in monetary policy through the financial system. Therefore movements in the monetary policy rate (MPR) lead to changes in asset prices (i.e. bond and bank loans) affecting the spending decisions of individuals and firms. The second process is related to the propagation of the MPR from financial assets to the real economy in both aggregate output and prices.

However, after the onset of the financial crisis in 2008 caused by the subprime mortgage crisis in the US, conventional monetary policy described above gave way to a new form of so-called unconventional monetary policy. During this period different economies experienced a contraction of output while some countries reached a lower bound for the monetary policy rate as Figure 1 illustrates for a selected group of countries that applied unconventional monetary policies. Also during this period, some governments took actions to provide liquidity in foreign currency and monetary markets, and additional unconventional policies were adopted to reinforce the credibility of announcements that the monetary policy rate would be kept low for a long time. All the financial turmoil exhibited during that period might have affected the information derived from bonds related to the future path of the MPR and therefore future economic growth.

FIGURE 1

MONETARY POLICY RATE AND GDP GROWTH



Left chart correspond to monthly monetary policy rate expressed as index (2005 = 100). Right chart correspond to quarterly Gross Domestic Product growth expressed as index (2005 = 100).
Sources: Centrals Banks and Bloomberg.

The different unconventional policies adopted by various central banks, especially during the period 2008-2009[1] can be grouped into (1) liquidity and exchange rate easing, (2) credit and quantitative easing, and (3) forward guidance as Ishi *et al.* (2009) and IMF (2013) enumerates. For example, Moessner (2013) studied the effect of explicit policy rate guidance. It is important to remark that the last two types of unconventional policies affected directly the structure of interest rates, and therefore, the information regarding the future path of the MPR and economic growth.

The aim of this study is to assess whether the information contained in the structure of interest rates (in particular whether the adoption of unconventional monetary policies) affected expectations of future MPR path and activity derived from bonds. We evaluate and compare the expectation of MPR and economic growth for a group of countries that applied unconventional monetary policies based on interest rates, and other benchmarks as surveys (for the MPR) and autoregressive models (for economic growth). Those countries are characterized by having adopted some type of unconventional monetary policy in the period 2005-2013.

Our approach relies in the accuracy of the yield curve to predict the short-term interest rate path and economic growth up to 12 months in different monetary policy regimes. Most research reveals that the term spread helps to predict economic growth in the short-term horizon and it has been employed mainly in US such as Rudebusch & Williams (2009), Liu & Moench (2014), Saar & Yagil (2015a) among others[2]. For other economies, Saar & Yagil (2015b) find evidence that government and corporate bonds predict economic growth for some European and Asian economies.

However, our approach differs from previous studies due we focus and compare how the relative performance between expectations based on the yield curve respect to alternative sources changed in the sample where the unconventional monetary policies were implemented.

Our findings suggest that the forecast of the short-term interest rates in most countries have same predictive power between the expected interest rate derived from bond yields and market-based surveys, so the expectations derived from bond was not affected in such period. Also, we evidence for the economic growth evaluation, that the inclusion of the yield curve information outperformed alternative models, especially in developed countries.

The paper is organized as follows. Section 2 presents the methodology used to compute the expected short-term interest rate and forecast future economic growth. Section 3 presents the data description, in section 4 we present the empirical results and finally the section 5 concludes.

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1 For instance, Céspedes *et al.* (2011) compile a list of fifty-six policy announcements regarding unconventional policies, in the period from September 2008 to October 2009, for a group of thirteen central banks.

2 A complete revision is made by Wheelock & Wohar (2009).

2. METHODOLOGY

2.1. The yield curve

We can compute three factors of the yield curve defined as the level, slope and curvature (see Diebold & Li (2006) for a detailed revision) and use them to analyze their relation with the rest of the economy. To compute the factors of the yield curve, we employed the Nelson & Siegel (1987) model which according to the BIS (2005) is one of the most used models by different central banks due to its easy computation and good fit to observed interest market rates. The model can be written as:

$$y_t^{\tau} = \beta_{0,t} + \beta_{1,t}\left[\left(1 - e^{-\lambda\tau}\right) / \lambda\tau\right] + \beta_{2,t}\left\{\left[\left(1 - e^{-\lambda\tau}\right) / \lambda\tau\right] - e^{-\lambda\tau}\right\} \quad (1)$$

where y_t^{τ} corresponds to the interest rate observed at maturity τ in time t. The model (1) calibrates parameters $\{\beta_0, \beta_1, \beta_2, \lambda\}$, such that the error between the market rates and the estimated rates derived from the model are minimized.

In order to obtain the parameters from (1), we proceed to fix the λ parameter of the model[3] for two reasons: (a) When this parameter is fixed, the model is linear and can be estimated by OLS for each date, generating a time series for each factor, and (b) changes in the parameters (factors) in (1) can be interpreted as changes in the level, slope and curvature of the yield curve, and those are the relevant elements to take into account when analyzing its importance in the economy.

2.2. Monetary policy rate expectations

To assess the MPR forecast, we consider two sources of information. The first refers to the expected MPR implicit in the yield curve based on the forward rate structure proposed by Nelson & Siegel (1987) denoted in (1). Thus, the expected forward rate at maturity τ in period t $\left(f_t^{\tau}\right)$ is denoted as:

$$f_t^{\tau} = \beta_{0,t} + \beta_{1,t}e^{-\lambda\tau} + \beta_{2,t}\lambda\tau e^{-\lambda\tau} \quad (2)$$

This information corresponds to the expectations that the market has regarding future changes in the MPR. The second source is the estimation of analysts and investment banks in each economy reported by Consensus Forecast Survey (CF). The latter reflects the MPR's expected future path based on a survey. In both cases we

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[3] The parameter calibrated ranges from 0.07 to 0.12 for different countries. Different values of this parameter do not change our results qualitatively. Note that Diebold & Li (2006) as well as for example Dolan (1999) and Fabozzi *et al.* (2005) first fix λ to a pre-specified value and then proceed with analyzing the three-factor model.

consider the forecast horizon at three and twelve months (the periods for which we have available data for CF). Thus, we proceed to compute the forecast error measured as:

$$e_t^j = MPR_{t+h} - E_{t+h}^j(MPR) \tag{3}$$

where MPR_{t+h} denotes the effective monetary policy rate at horizon $t+h$, $E_{t+h}^j(MPR)$ indicates the expectation in time t for MPR h months ahead based on forecast source j (either bond prices or CF). In each case, we estimate the model and produce forecasts for both horizons (three and twelve months ahead), evaluating the accuracy of the forecast as:

$$d_t = g\left(e_t^{bond}\right) - g\left(e_t^{CF}\right) \tag{4}$$

where $g(\bullet)$ is the loss function represented by the squared error, as is usual in the literature.

Then using the series generated in (4), we run a Diebold & Mariano (1995) test using the small sample correction proposed by Harvey *et al.* (1997) and evaluate the accuracy of each forecast at different horizons.

An important issue with this framework is the assumption that the expected path of the short-interest rate is fully characterized by (2), so the expectation hypothesis holds for any maturity and the long-term interest rates correspond to an average of future path of short-term interest rates and the term premium is equal to zero. However, many authors have argued that the term premium play a relevant role in the behavior and dynamic of interest rates. For instance, Wright (2011) document the term premium for several developed countries, and Blake *et al.* (2015), Ceballos *et al.* (2015) and Espinosa *et al.* (2014) for other LATAM economies. However, our analysis focus on the expected short-term interest rate up to 12 months ahead, which has been documented by some authors to exhibit a term premium is close to zero (Ceballos *et al.* (2015) for the Chilean market and Adrian *et al.* (2013) for US market). Additionally, we follow the standard approach used by many Central Banks described in BIS (2005), in which the computation of expected interest rate follows mostly non-parametric model fitting observed interest rates in the money and bond markets and no derivation neither identification of term premium is carried out.

Finally, we could consider alternative models attempting to measure the expected path of short-term interest rates as affine models, structural models, among others. However, we consider that most of alternative models suffers from (1) real-time error estimation, which occurs when the model-parameter are re calibrated once the new information arrives or even when first releases of economic data (as CPI, activity, etc.) are changed, and (2) in the zero-lower bound framework that most developed countries have experienced the last years, such models have performed significantly worse than alternative models (see Bauer & Rudebusch (2015)). Furthermore, Gürkaynak *et al.* (2014) have argued that market-based measures of monetary policy expectation

(derived from different financial instruments) provide forecast superior to alternative standard time series models.

2.3. Economic growth expectations

Following the literature (Estrella & Hardouvelis (1991) and Hamilton & Kim (2000) among others), we use the slope factor of the yield curve to predict output growth at different horizons. To do this, we estimate regressions of the $t + h$ periods ahead year-on-year growth rate of industrial production on a set of regressors in time t. For parsimony, we follow Estrella & Hardouvelis (1991) and Hamilton & Kim (2000), among others, and estimate the following model:

$$y_{t+h} = \alpha_0 + \sum_{i=1}^{p} \beta_i y_{t-i} + \gamma \Delta i_t^{6m} + \delta slope_t + \varepsilon_t \tag{5}$$

where y_{t+h} is the monthly growth of industrial production h periods ahead, Δi_t^{6m} is the change in the nominal short-term interest rate (specifically the 6-month interest rate) between period t and $t\text{-}1$ and $slope_t$ is the slope of the yield curve denoted by β_1 in model (1). Finally the lag-order p is set equal to three[4]. We evaluate the forecasting power of the slope, comparing model (5) with a modified version given by the following expression:

$$y_{t+h} = \alpha_0 + \sum_{i=1}^{p} \beta_i y_{t-i} + \gamma \Delta i_t^{6m} + \varepsilon_t \tag{6}$$

Equation (6) is the same as equation (5) but imposing the constraint $\delta = 0$. The specification (5) attempts to capture the additional information contained in the interest rates of bonds through the slope factor of the yield structure. Our procedure is recursive[5], so we first estimate both models in monthly frequency for the period January 2005-November 2007. Then the models incorporate new observations and are re-calibrated in order to make a forecast h-steps ahead. Finally, to evaluate the relative performance of each model, we compute the modified Diebold & Mariano (1995) test described in the previous section. The horizons taken in consideration are three, six, and twelve months ahead.

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[4] We test with different lag-order (1 to 6) and results are robust. Also we evaluate an alternative specification considering the annual growth rate of industrial production and we evidence similar results.

[5] However, as a robust exercise, we evaluate a rolling specification which leads similar results, which is reported in Appendix B.

3. DATA

The empirical work considers 12 developed as well developing economies. In particular, we follow the IMF's country classification and consider two categories: (1) developed economies and (2) emerging economies. The first group is related to the major advanced economies and corresponds to the largest in terms of GDP. The second group considers six emerging countries. The Table 1 shows the countries considered and other variables used in this work.

TABLE 1

DATA DESCRIPTION

Country	Classification	Economic growth	Frequency	Source
Brazil	EME	Industrial Production	Monthly	Bloomberg
Canada	DEV	Monthly GDP estimation	Monthly	Bloomberg
Chile	EME	Economic activity (IMACEC)	Monthly	Bloomberg
Euro Zone	DEV	Industrial Production	Monthly	Bloomberg
Japan	DEV	Industrial Production	Monthly	Bloomberg
Mexico	EME	Industrial Production	Monthly	Bloomberg
New Zealand	DEV	Business Performance Manufacturing index	Monthly	Bloomberg
Poland	EME	Industrial Production	Monthly	Bloomberg
Thailand	EME	Industrial Production	Monthly	Bloomberg
Turkey	EME	Industrial Production	Monthly	Bloomberg
UK	DEV	Industrial Production	Monthly	Bloomberg
US	DEV	Industrial Production	Monthly	Bloomberg

This table shows the interest rate data and economic activity proxy used.

For the construction of nominal yield curve we consider quoted local currency government bond reported at daily frequency by Bloomberg in both monetary market for maturities shorter than one year, and transaction quotes in the bond market for maturities longer than one year. The maturities considered are 3, 6, 12, 24, 60 and 120 months[6].

For the evaluation of the expected monetary policy rate we use the Consensus Forecast information as the Survey-based forecast evaluation. In particular, we consider the expected nominal short-term interest rate expected at three and twelve months ahead in each economy. Also, for the economic growth evaluation, we consider different proxies for monthly economic growth instead to use directly GDP

[6] The Appendix A summarizes the financial instrument used to calibrate the yield curve in each economy.

indicator. We follow this approach due to consider data with monthly frequency instead a lower frequency[7].

4. EMPIRICAL RESULTS

Besides analyzing market expectations in the whole period, we take into consideration two subsamples which were characterized by different expectation disruptions as a way to get robust results. The first subsample, spanning December 2007 to July 2009, was characterized by historical increase in the risk indicators, episodes of turbulence in financial markets, significant slowdown in production and a decrease to the lowest MPR level in each economy. Also during this period the first types of unconventional monetary policies aimed to normalize the functioning of financial markets and stimulate the economy began being implemented. The second subsample, spanning August 2009 to December 2013, was characterized by decreases in the risk levels as well as a gradual recovery of output in most countries. Table 2 presents the Diebold-Mariano tests over the MPR forecast based on interest rates and those reported by CF taking into consideration different subsamples.

The evidence suggests that for most developed economies, the information of the yield curve have no marginal extra information regards the future path of the short-term interest rate shown in Table 2. Thus, in Canada, and New Zealand there is no gain to use the information embedded in the yield curve. The opposite occurs in Japan and UK, in which the yield curve have a better predictive power of the yield curve regarding the market-based survey. In the Eurozone and US the yield curve provides no improvement in forecast the short-term interest rates. In the case of emerging economies, only Turkey shows that the information derived from bonds allows a better forecast of the MPR in both short and long horizon considering the total sample. However, by considering the first subsample, there is no evidence that information contained in bond interest rate leads an accuracy estimation of future MPR movements. In fact, a lower forecast error based CF in the three-month horizon is evidenced in the Poland case. Meanwhile, when considering the second subsample shows that there is no gain from yield curve except for Poland.

In the economic growth forecasting evaluation presented in Table 3, we find evidence of predictive ability of the slope on output growth in most of the countries. As shown in the table, we find some cases when the forecast of the alternative model (equation 6) is more accurate, as Japan economy. In contrast, we report several cases when the performance of the slope is relevant to predict output growth, and these are statistically significant. For instance, in developed countries as Eurozone, New Zealand and US there are marginal gains considering bond information depending horizon, as well in emerging countries as Mexico, Poland, and Turkey.

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[7] In fact, there is a high correlation between the quarterly economic activity indicator and the GDP growth which registers a correlation of 0.93 and varies from 0.76 to 0.99 depending the country.

TABLE 2

MONETARY POLICY RATE FORECAST EVALUATION

	Full sample		Subsample A		Subsample B	
	h=3	h=12	h=3	h=12	h=3	h=12
Brazil	1.02	0.91	1.42	0.69	–0.33	–0.33
	0.31	0.36	0.17	0.50	0.75	0.75
Canada	–1.10	–1.02	–1.16	–0.56	–0.60	–0.59
	0.27	0.31	0.26	0.58	0.55	0.56
Chile	–0.74	–0.68	–0.47	–0.23	–0.28	–0.35
	0.45	0.50	0.65	0.82	0.78	0.73
Euro Zone	–0.16	–0.25	–1.50	–0.73	5.85	4.30
	0.87	0.80	0.15	0.48	0.00	0.00
Japan	–4.21	–4.26	–5.22	–2.53	–2.95	–2.30
	0.00	0.00	0.00	0.02	0.00	0.03
Mexico	0.99	0.94	1.17	0.57	0.79	1.29
	0.33	0.35	0.26	0.58	0.44	0.20
New Zealand	1.61	1.50	1.48	0.72	0.60	0.28
	0.11	0.14	0.16	0.48	0.55	0.78
Poland	–0.93	–0.87	2.61	1.26	–0.75	–0.26
	0.35	0.39	0.02	0.22	0.45	0.79
Thailand	–1.10	–0.78	–1.15	–0.56	–1.44	–0.31
	0.27	0.44	0.26	0.58	0.16	0.76
Turkey	–4.66	–4.21	–0.43	–0.21	–5.34	–3.36
	0.00	0.00	0.67	0.84	0.00	0.00
UK	1.03	1.00	1.60	0.78	–3.88	–3.30
	0.31	0.32	0.13	0.45	0.00	0.00
US	1.77	1.74	2.38	1.15	1.24	1.63
	0.08	0.09	0.03	0.26	0.22	0.11

The table reports the modified Diebold-Mariano test and *p*-values. Under the null, both models have the same predictive power, while under the alternative is different. When the Diebold-Mariano statistic is negative and statistically significant, this represents evidence in favor of the predictive power of model based bond interest rates. Full sample corresponds to December 2007 to December 2013, Subsample A corresponds to December 2007 to July 2009 and Subsample B corresponds to August 2009 to December 2013.

TABLE 3

ECONOMIC GROWTH FORECAST EVALUATION

	Full sample			Subsample A			Subsample B		
	h=3	h=6	h=12	h=3	h=6	h=12	h=3	h=6	h=12
Brazil	–1.45	–0.57	–0.01	–1.32	0.21	–0.70	–0.99	–0.60	0.88
	0.15	0.57	0.99	0.20	0.83	0.49	0.33	0.55	0.38
Canada	0.67	–0.64	–0.59	1.00	–0.22	–0.37	–0.01	–0.83	–0.28
	0.51	0.53	0.56	0.33	0.83	0.72	0.99	0.41	0.78
Chile	–0.66	–0.82	0.23	–0.96	–0.42	–0.24	–0.15	–0.55	0.88
	0.51	0.41	0.82	0.35	0.68	0.81	0.88	0.58	0.38
Euro Zone	–1.99	–0.73	0.26	–0.71	–1.83	–1.38	–1.96	0.11	1.71
	0.05	0.47	0.79	0.49	0.08	0.18	0.06	0.91	0.09
Japan	3.10	1.67	0.56	1.25	–1.12	–0.22	4.60	2.68	1.99
	0.00	0.10	0.58	0.22	0.28	0.83	0.00	0.01	0.05
Mexico	0.74	–2.19	–1.84	1.01	–0.13	–0.60	–0.14	–2.34	–1.21
	0.46	0.03	0.07	0.33	0.90	0.55	0.89	0.02	0.23
New Zealand	–1.12	–1.48	–1.39	–1.76	–0.34	–0.74	0.29	–1.51	–1.13
	0.27	0.14	0.17	0.09	0.74	0.47	0.77	0.10	0.26
Poland	–1.10	–1.79	–1.48	–1.05	–1.13	–1.02	–0.51	–1.26	–0.06
	0.28	0.08	0.14	0.31	0.27	0.32	0.61	0.21	0.95
Thailand	–1.34	–0.38	–0.05	–1.08	–0.08	–0.16	–0.94	–0.46	0.43
	0.18	0.71	0.96	0.29	0.94	0.87	0.35	0.64	0.67
Turkey	–2.05	–2.19	–1.84	–1.45	–1.07	–0.99	–1.46	–1.49	–1.05
	0.04	0.03	0.07	0.16	0.30	0.34	0.15	0.14	0.30
UK	0.69	–0.53	–0.50	0.81	–1.23	–0.29	–0.70	0.25	–0.06
	0.49	0.60	0.62	0.43	0.23	0.77	0.49	0.81	0.95
US	–2.32	–1.41	–1.76	–0.16	–0.07	0.16	–2.78	–1.40	–2.12
	0.02	0.16	0.08	0.88	0.94	0.88	0.01	0.17	0.04

This table reports the modified Diebold-Mariano test and *p*-values. Under the null, both models have the same predictive power, while under the alternative is different. When the Diebold-Mariano statistic is negative and statistically significant, this represents evidence in favor of the predictive power of model based bond interest rates. Full sample corresponds to December 2007 to December 2013, Subsample A corresponds to December 2007 to July 2009 and Subsample B corresponds to August 2009 to December 2013.

As we have mentioned, the implementation of unconventional monetary policies had a direct impact on interest rate through the purchases of government bond. So we focus in how the yield curve information outperformed the survey-based expectation and alternative autoregressive models for output growth, especially during the second sample (August 2009 to December 2013) respect the prior sample. When we evaluate the predictive performance for the short-term interest rate path, we find that in those countries where the yield curve provided relevant information in the first sample, it was also hold during the second sample (Japan). For the other economies (except Eurozone, Poland and US), the relative performance between the yield curve and market-based survey had no differences. Finally, in Poland and US, the best performance of market-based surveys in the first sample changed in the second sample where both yield curve and survey provided similar information. Thus, we conclude that in almost all countries the yield curve information did not deteriorate the information implicit in interest rates regard other sources in the period where UMP was implemented.

A more notorious result we evidence in the economic growth exercise. For most emerging countries (except Mexico), there is no marginal gain considering yield curve information in both subsamples. In contrast, in Mexico and US, the slope component generated an accurate forecast of economic growth in the second subsample, whereas in the first sample the inclusion of the yield curve slope did not produce better forecast.

To sum up, we observe that the inclusion of the yield curve information to forecast the short-term interest rate and economic growth, in most cases did not impact negatively the expectations for those variables, and the opposite was observed, specially forecasting economic growth for developed countries. Thus, the implementation of unconventional monetary policies did not alter market expectation implicit in financial instrument (in our case bond yields).

5. CONCLUSIONS

After the onset of the financial crisis in 2008 caused by the sub-prime mortgage crisis in the US, different economies implemented unconventional policies in order to reinforce the idea that the monetary policy rate would be kept low for a long time and stimulate the economic growth. Thus, the information embedded in the yield curve (interest rates from government bonds) may be affected for the implementation of UMP.

In this paper we evaluated the expectation derived from the yield curve regards future path of the short-term interest rates as well as forecasting economic growth for several developed and emerging economies in the period 2005-2013. For measuring the expected path of interest rates we rely in the forward interest rates under the model proposed by Nelson & Siegel (1987) which is one of the most common methodologies employed by other Central banks according to BIS (2005) and compared such forecast with market-based survey (Consensus Forecast) for three and twelve month ahead. We evaluate the performance of each source using the Diebold-Mariano test considering the small sample correction proposed by Harvey *et al.* (1997). A similar exercise if

carried out for economic growth evaluation, based on a time series model following Hamilton & Kim (2000) where the yield curve expectation is measured for the slope component.

We compared the relative performance between expectations based on the yield curve respect to alternative sources changed in the sample where the unconventional monetary policies (UMP) were implemented. Thus, we focus on the sample prior the implementation of UMP (before middle 2009) and the period of time which consider July 2009 to December 2013.

Our findings suggest that the forecast of the short-term interest rates in most countries have same predictive power between the expected interest rate derived from bond yields and market-based surveys, so the expectations derived from bond was not affected in such period. Also, we evidence for the economic growth evaluation, that the inclusion of the yield curve information outperformed alternative models, especially in developed countries.

REFERENCES

ADRIAN, T.; R. CRUMP and E. MOENCH (2013). "Pricing the term structure with linear regressions", *Journal of Financial Economics* 110 (1), pp. 110-138.

BAUER, M. and G. RUDEBUSCH (2015). "Monetary Policy Expectations at the Zero Lower Bound", Federal Reserve Bank of San Francisco, Working Paper 2013-18.

BIS (2005). "Zero-coupon Yield Curves: Technical Documentation", *BIS Papers* 25.

BLAKE, A.; G. RULE and O. RUMMEL (2015). "Inflation targeting and term premia estimates for Latin America", *Latin American Economic Review* 24 (3).

CEBALLOS, L.; A. NAUDON and D. ROMERO (2015). "Nominal Term Structure and Term Premia: Evidence from Chile", Central Bank of Chile, Working papers (752).

CESPEDES, L.F.; R. CHANG and J. GARCIA-CICCO (2011). "Heterodox Central Banking", in L. F. Céspedes, R. Chang and D. Saravia, eds., *Monetary Policy Under Financial Turbulence*, Central Bank of Chile.

DIEBOLD, F. and C. LI (2006). "Forecasting the Term Structure of Government Bond Yields", *Journal of Econometrics* 130 (2), pp. 337-364.

DIEBOLD, F. and R. MARIANO (1995). "Comparing Predictive Accuracy", *Journal of Business and Economic Statistics* 13 (3), pp. 253-263.

DOLAN, C. (1999). "Forecasting the Yield Curve Shape: Evidence in Global Markets", *Journal of Fixed Income* 9 (1), pp. 92-99.

ESPINOSA, J.; L. MELO and J. MORENO (2014). "Estimación de la prima por vencimiento de los TES en pesos del gobierno colombiano", *Borradores de Economía* (854).

ESTRELLA, A. and G. HARDOUVELIS (1991). "The Term Structure as a Predictor of Real Economic Activity", *Journal of Finance* 46 (2), pp. 555-576.

FABOZZI, F.; L. MARTELLINI and P. PRIAULET (2005). "Predictability in the Shape of the Term Structure of Interest Rates", *Journal of Fixed Income* 15 (1), pp. 40-53.

GÜRKAYNAK, R.; B. SACK and E. SWANSON (2014). "Market-based measures of monetary policy expectations", *Journal of Business and Economic Statistics* 25 (2), pp. 201-212.

HAMILTON, J. and D.H. KIM (2000). "A Re-examination of the Predictability of Economic Activity using the Yield Spread", *Journal of Money, Credit and Banking* 34 (2), pp. 340-360.

HARVEY, D.; S. LEYBOURNE and P. NEWBOLD (1997). "Testing the Equality of Prediction Mean Squared Errors", *International Journal of Forecasting* 13 (2), pp. 281-291.

IMF (2013). "Global Impact and Challenges of Unconventional Monetary Policies", *IMF Policy Papers.*

ISHI, K., M. STONE and E. YEHOUE (2009). "Unconventional Central Bank Measures for Emerging Economies", IMF WP 09/226.

LIU, W. and E. MOENCH (2014). "What Predicts US Recessions?", *Federal Reserve Bank of New York, Staff Report* (691).

MOESSNER, R. (2013). "Effects of explicit FOMC policy rate guidance on interest rate expectations", *Economics Letters* 121 (2), pp.170-173.

NELSON, C. and A. SIEGEL (1987). "Parsimonious Modeling of Yield Curves", *The Journal of Business* 60 (4), pp. 473-489.

RUDEBUSCH, G. and J. WILLIAMS (2009). "Forecasting Recessions: The Puzzle of the Enduring Power of the Yield Curve", *Journal of Business and Economic Statistics* 27 (4), pp. 492-503.

SAAR, D. and Y. YAGIL (2015a). "Corporate yield curves as predictors of future economic and financial indicators", *Applied Economics* 47 (19), pp. 1997-2011.

SAAR, D. and Y. YAGIL (2015b). "Forecasting growth and stock performance using government and corporate yield curves: Evidence from the European and Asian markets", *Journal of International Financial Markets, Institutions and Money* 37 (0), pp. 27-41.

WHEELOCK, D. and M. WOHAR (2009). "Can the Term Spread Predict Output Growth and Recessions? A Survey of the Literature", *Federal Reserve Bank of St. Louis Review* (91), pp. 419-440.

WRIGHT, J. (2011). "Term premia and inflation uncertainty: Empirical evidence from an international panel dataset", *American Economic Review* 101 (4), pp. 1514-1534.

APPENDIX A: DATA SOURCE

This table shows the selected interest rates to compute the parametric model of Nelson & Siegel (1987). For maturities <= 1 year we consider three maturities 3m, 6m and 12m. For maturities < 1year, we consider maturities for 2y, 5y and 10 years.

TABLE A1

DATA SOURCES FOR INTEREST RATES

	Interest rates 1y	Interest rates 1y
Brazil	Interest rates swaps	Government bonds
Canada	Government treasury-bills	Government bonds
Chile	Interest rates swaps	Government bonds
Euro Zone	Generic Euro government bills and bonds	Government bonds
Japan	Government treasury-bills	Government bonds
Mexico	Government treasury-bills	Government bonds
New Zealand	Government treasury-bills	Government bonds
Poland	Interbank rates	Government bonds
Thailand	Thai bond dealing centre; interpolation of selected bond near to maturity	Government bonds
Turkey	Bank association of Turkey TRLibor rates	Government bonds
UK	London Interbank offered rate (LIBOR in US dollar)	Government bonds
US	London Interbank offered rate (LIBOR in pounds)	Government bonds

APPENDIX B:
ECONOMIC GROWTH ROLLING ESTIMATION

This table reports the modified Diebold-Mariano test and *p*-values. Under the null, both models have the same predictive power, while under the alternative is different. When the Diebold-Mariano statistic is negative and statistically significant, this represents evidence in favor of the predictive power of model based bond interest rates. Full sample corresponds to December 2007 to December 2013, Subsample A corresponds to December 2007 to July 2009 and Subsample B corresponds to August 2009 to December 2013.

TABLE B1

ECONOMIC GROWTH FORECAST EVALUATION

	Full sample			Subsample A			Subsample B		
	h=3	h=6	h=12	h=3	h=6	h=12	h=3	h=6	h=12
Brazil	–0.75	–0.99	–0.59	–1.17	–0.97	–0.57	–0.20	–0.48	–0.14
	0.46	0.33	0.56	0.25	0.34	0.58	0.84	0.64	0.89
Canada	0.32	0.18	0.21	0.21	0.17	0.10	0.30	0.00	0.11
	0.75	0.86	0.83	0.84	0.87	0.92	0.76	1.00	0.92
Chile	–0.74	–0.66	–0.84	–0.45	–0.38	–0.22	–0.49	–0.41	–0.62
	0.46	0.51	0.40	0.66	0.71	0.83	0.63	0.68	0.54
Euro Zone	–2.42	–1.69	–0.46	–2.17	–1.80	–1.05	–2.31	–1.50	–0.27
	0.02	0.09	0.65	0.04	0.09	0.30	0.03	0.14	0.79
Japan	–0.10	–0.26	0.08	–2.08	–1.72	–1.01	0.45	0.28	0.63
	0.92	0.79	0.94	0.05	0.10	0.33	0.65	0.78	0.53
Mexico	–1.70	–1.61	–2.13	–1.68	–1.39	–0.81	–0.88	–0.86	–1.45
	0.09	0.11	0.04	0.11	0.18	0.43	0.38	0.40	0.15
New Zealand	–1.66	–1.43	–1.16	–1.65	–1.37	–0.80	–0.61	–0.44	–0.17
	0.10	0.16	0.25	0.12	0.19	0.43	0.54	0.66	0.86
Poland	–2.48	–2.67	–1.85	–1.75	–1.45	–0.85	–1.55	–1.76	–0.84
	0.02	0.01	0.07	0.10	0.16	0.41	0.13	0.08	0.40
Thailand	–1.26	–0.23	–0.16	–1.27	–1.05	–0.62	–0.87	0.36	0.45
	0.21	0.82	0.87	0.22	0.31	0.55	0.39	0.72	0.65
Turkey	–1.80	–2.19	–1.18	–1.89	–1.57	–0.92	–1.11	–1.48	–0.62
	0.08	0.03	0.24	0.07	0.13	0.37	0.27	0.15	0.54
UK	–1.48	–1.85	–1.29	–1.31	–1.08	–0.63	–0.80	–1.19	–0.62
	0.14	0.07	0.20	0.21	0.29	0.53	0.43	0.24	0.54
US	–0.61	–1.06	–0.86	–0.66	–0.54	–0.32	–0.32	–0.77	–0.58
	0.54	0.29	0.39	0.52	0.59	0.75	0.75	0.44	0.56