The Expectation Hypothesis and expectations formation in Latin American rates markets

Abstract

This paper examines the Expectations Hypothesis of the Term Structure for Latin America, an important region within Emerging Markets local currency debt indices. We focus on longer maturities to account for the composition of the indices, the associated indexed investments, and the limited substitution effect between bonds of different tenors, which prevents us from extrapolating past results. Providing an alternative method to estimate expected yields, our results reject the Expectations Hypothesis for the last 12 years. Furthermore, we find that the term premium is the most important factor for its rejection. Our work also examines the dynamics of expectations formation in Latin American rates markets, finding evidence of some behavioral biases and rigidities in the expectations formation process that may contribute to the rejection of the Expectation Hypothesis.

1. Introduction

The study of interest rate expectations is one of the most important debates in the finance and macroeconomic literature. Most studies on interest rate expectations have used the Expectations Hypothesis of the Term Structure (EH) as a framework for analysis (Jongen and Verschoor, 2008). The EH states that the yield on a long bond is equal to the average expectation of the short-term yield over the life of the long bond, plus a (constant) term premium. The evidence presented tends to reject it (Froot, 1989; Roberds and Whitemann, 1999; Sarno, Thorton, and Valente, 2003; Jongen and Verschoor, 2008; Yi-Hsuan, Kuo, and Chiang, 2014; Schmeling, Schrimpf, and Steffensen, 2022). However, there are some exceptions, such as Roberds and Whitemann (1999) and Sarno, Thorton, and Valente (2003), who find that the validity of the EH depends on the maturities used, finding some maturities for which the EH is not rejected.

It is fair to say that previous studies that have tested the EH have focused on shorter maturities of the yield curve as more reliable information is available. Nevertheless, conclusions from studies for one maturity segment cannot be extrapolated to others because – and according to the segmented market or preferred habitat hypothesis (Van Horne, 1980; Modigliani and Sutch, 1966) - fixed income instruments with different maturities are not perfect substitutes due to institutional factors, regulations, or the relative dynamics of supply and demand. Furthermore, in the particular case of longer yields, Shiller (1979) notes that these are more volatile than implied in the standard representative-agent models[1]. This makes it difficult to extrapolate results from short yields studies.

One of the methods for testing the EH is based on the predictive ability of the implied forward premium on future changes in short-term yields, using expected future yields (Froot, 1989; Jongen, Verschoor, and Wolff, 2011). In this type of test, empirical research has used forecasts from surveys as expected future short yields (Froot, 1989; Jongen and Verschoor, 2008; Jongen et al., 2011). However, the use of forecasts is not free from caveats (Gemmi and Valchev, 2023; Eva and Winkler, 2023; Nordhaus, 1987). On the other hand, and for alternative tests of the EH, authors such as Yi-Hsuan et al. (2014) use data from the futures market to measure market expectations of future yields. These would be advantageous over forecasts as they better reflect investors' expectations (Yi-Hsuan et al., 2014). However, this requires a liquid futures market.

The main explanations for the failure of the EH are the presence of a time-varying term premium and the presence of expectation errors (Froot, 1989; Jardet, 2008; Yi-Hsuan et al., 2014). A time-varying term premium can be explained by changes in investors´ attitudes toward risk and liquidity conditions (Jongen et al., 2011)[2], while expectation errors can be attributed to both irrational expectations and statistical biases (Yi-Hsuan et al., 2014). Nevertheless, alternative explanations based on investors´ behavioral biases have also been proposed in the literature (Bulkley, Harris, and Nawosah, 2015). It is important to point out that all these studies differ in the methods, periods, and yields employed. The diversity of studies focused on the US or developed markets justifies the examination of the EH on a country or regional basis.

The first contribution of this paper is to examine the EH for longer yields in Latin America (Latam), a region that receives little attention in the literature, despite being the second most important region in any Emerging Markets (EM) local currency government debt index. Latam is also the region with the highest average foreign participation in its local currency curves (IMF, 2023a). Foreign participation in the local currency sovereign

[1] Heterogeneous agent models can also explain the higher volatility of longer rates (Xiong and Yan, 2010).
[2] Xiong and Yan (2010) argue that belief dispersion and relative wealth fluctuation among different types of investors also generate a time-varying risk premium, which helps to explain the rejection of the EH.

debt market in Latam tends to be biased towards medium- and long-term bonds[3] and this may be explained by the fact that a significant portion of non-resident investments in EM local currency government bonds is indexed (Arslanalp, Drakopoulos, Goel, and Koepke, 2020)[4]. EM local currency government bond indices are biased towards these tenors[5]. Local liability-driven investors (insurance companies and pension funds) also prefer long maturities.

The evidence also tends to reject the EH for Latam or EM (Caldeira and Smaniotto, 2019; Muzindutsi and Mposelwa, 2016; Galindo and Catalán, 2003; Konstantinou, 2006), albeit with some exceptions (Tabak, 2009; Elshareif, Yusop, and Tan, 2008). The number of years examined in these studies - between 8 and 18 - is significantly less than in the studies for developed markets. There is no common explanation for its failure in these studies. For example, Caldeira and Smaniotto (2019) argue that the EH could fail due to the high volatility of EM rates, while Galindo and Catalán (2003) propose the time-varying risk premium hypothesis, related to external shocks to the local currency. To our knowledge, no work has investigated the importance of the different components (term premium or expectation errors) in explaining the rejection of the EH.

Testing the EH in Latam using the predictive ability of the forward premium over changes in future short yields is limited by the lack of forecasts or a liquid derivatives market for longer yields. With this in mind, a second contribution of this paper is to propose an alternative method for estimating future yields. We use synthetic yields derived from the sum of market expectations for future US yields and the expected depreciation implied in currency forwards. This top-down approach draws on the extensive empirical work on the international and local factors affecting EM local currency yields (Peiris, 2010; Gadanecz, Miyajima, and Shu, 2014; Ebeke and Lu, 2014; among others). In these approaches, the current or expected level of US rates would be

[3] In Colombia, for example, non-residents hold about 27% of local currency government debt between February 2021 and April 2022. This percentage increases to 36% for maturities between 5 and 15 years and decreases to 10% for maturities between 0.5 and 2 years (Banco de la República, 2023).

[4] For Latin American sovereign bonds, this percentage varies from country to country. While in Colombia, non-resident investors hold more than 50% of their holdings in indexed investments, in countries such as Mexico, this percentage is around 30% (Arslanalp et al., 2020). This lower percentage in Mexico may be explained by the fact that the country has a larger and more liquid market.

[5] The JP Morgan GBI-EM Global Diversified Index is one of the main EM bond indices followed by investors (Arslanalp et al., 2020) As of November 2023, it has more than 70% of exposure in maturities higher than 3 years.

the most important international factor for the pricing of EM rates (Csonto and Ivaschenko, 2013; IMF, 2023b), especially in markets where non-residents are important players or in markets with a relevant share of indexed investments (Arslanalp et al., 2020; Converse et al., 2020).

On the other hand, the expected performance of the local currency is one of the most important factors for non-resident investors, as they generally do not hedge their investments in local bonds. Moreover, and from a fundamental perspective, currency fluctuations affect the country´s credit risk (Gadanecz et al., 2014). Hofmann, Shim, and Shin (2017) report that the credit risk premium of an EM local currency sovereign bond and portfolio flows are determined by currency movements against the USD (risk-taking channel of exchange rates). For domestic investors, considering the expectations of foreign investors is important as these players usually provide them with liquidity in the local market.

Our third contribution is the analysis of behavioral biases in expectations formation that could lead to systematic expectation errors and thus contribute to the failure of the EH. In the literature, expectation errors are mainly associated with changes in macro variables or investors´ sentiment (Yi-Hsuan et al., 2014). However, expectations formation may be systematically biased due to behavioral biases. Research on this area is limited and focuses on the US. For example, Bulkley et al. (2015), analyzing the expectation errors of yields´ forecasts, find that two behavioral biases influence the formation of expectations, thus contributing to the failure of EH: the Law of Small Numbers (LSN) and the conservatism bias. The LSN[6] implies a positive serial correlation of forecast errors at shorter lags ("gambler´s fallacy") and a negative one at longer lags ("hot hand fallacy") (Bulkley et al., 2015, Jin and Peng, 2024). The serial correlation of expectation errors should be zero according to rational expectations.

The gambler´s fallacy implies mean-reverting behavior in expectations formation (Jin and Peng, 2024). In this context, the extrapolative expectations model could be an alternative method to test it. If mean-reverting behavior exists, the recent trend is extrapolated negatively into the future (Cavaglia, Verschoor, and Wolff, 1993; Jin and

[6] The LSN implies that agents assume that the characteristics of the sample reflect the characteristics of the population more closely than sampling theory would predict (Bulkey et al., 2015). In the behavioral finance literature, this may be an example of beliefs bias. Agents tend to update their beliefs in violation of Bayes´ rule (Briére, Calami, Di Giansante, Huynh, and Novelli, 2023). LSN beliefs would also lead to excess volatility (Jin and Peng, 2024).

Peng, 2024). On the other hand, the conservatism bias – investors updating their beliefs too slowly compared to the Bayesian framework - implies that expectation revisions are small at short lags and have predictive power for future revisions (Bulkey et al., 2015).

In addition, Bordalo, Gennaioli, Ma, and Shleifer (2018), and Eva and Winkler (2023), based on the Coibion and Gorodnichencko´s (GC) coefficient (Coibion and Gorodnichencko, 2015), point to the existence of under/overreaction in the formation of expectations. This could be due to the fact that investors tend to underreact to news for short-term rates forecasts, while for longer-term forecasts, they tend to overreact, driven by a bounded-rationality framework based on "autocorrelation averaging" (Wang, 2021). Due to limited attention, investors do not have the cognitive capacity to process many time series in real-time. On the other hand, Coibion and Gorodnichencho (2015) point out the existence of information rigidities. If investors can process all available information (i.e., rational expectations), changes in expectations should have no predictive power for future expectation errors (Coibion and Gorodnichencko, 2015; Schmeling et al., 2022). These tests are part of the rationality (orthogonality) test of expectations (errors) (Froot, 1989; Yi-Hsuan et al., 2014), which is frequently a complement to the EH test.

Consistent with the general findings, we reject the EH for longer maturities in Latam. We find that the term-premium component is the main cause for its rejection, in contrast to previous US results where expectation errors play the main role (Froot, 1989; Yi-Hsuan et al., 2014). Our results also hold to different trends in US rates. When analyzing expectations formation, we find that the LSN predictions only hold for Mexico and we document the presence of mean-reverting behavior in expectations formation in Colombia and partly in Mexico. In contrast, we cannot find the presence of the conservatism bias in our interest rates forecasts. Finally, the analysis also reveals that expectations formation exhibits overreaction, which is consistent with the "autocorrelation averaging" hypothesis (Wang, 2021). Alternatively, this may also indicate information rigidities in the rates markets (Coibion and Gorodnichencko, 2015). The general conclusions also apply when using different pairs of tenors.

The remainder of this paper proceeds as follows. Section 2 discusses the data and methodology. Section 3 presents and discusses our main results, including a descriptive analysis of the expectation errors. Finally, Section 4 summarizes.

2. Data and methodology

2.1. Data

Data for sovereign yields in Latam countries is neither homogenous nor complete, both on financial platforms and local sources. Nevertheless, we have more consistency in the data for interest rates swaps (IRS). BIS data shows that the turnover of IRS in local currencies in Latam increased significantly between 2010 and 2022 (BIS, 2022)[7]. According to Kreicher, McCauley, and Wooldridge (2017), swap markets have been replacing government yields as fixed income benchmarks, particularly at the long end of the yield curve. Swap and sovereign yields are highly correlated and tend to follow similar trends, as both react to changes in local and international conditions. Investors participate in both markets using hedging and arbitrage strategies (Banco de la República, 2023).

To test the EH, we consider the 5yr IRS as the short-term rate and the 10yr IRS as the long-term rate. This is our base case scenario. These are the benchmark tenors for the medium and long term, respectively. We use data on IRS yields for Chile, Colombia, and Mexico from January 2013 to May 2024. The floating leg is the local currency short-term rate. The choice of sample length and country is motivated by data availability. In addition, we can proxy expected international factors with the expected US yields based on the US IRS (5yr5yr IRS)[8]. Finally, data on expected depreciation (i.e., local factors) may be derived from currency forwards. The source is Bloomberg and we use weekly data in all cases.

One of the advantages of our sample is that there is no structural change in monetary policy or local inflation dynamics in the region. Furthermore, and following many authors such as Jardet (2008), we take two different sub-periods within the full sample that are associated with different US rates trends. The first sub-period is from July 2013 to July 2016, a period in which US rates followed a declining trend. The second sub-period is from August 2016 to the end of 2018, when they followed the opposite trend. Our sample also includes some important developments in Latam´s market. Chile, for example, increased its share of the JP Morgan GBI-EM Global Diversified Index from a negligible level at the end of 2016 to 3.2% at the end of 2018 (Chilean Ministry of

[7] This trend is also reported in data from CME Group: https://www.cmegroup.com/trading/otc/latin-american-swap-clearing.html.

[8] Bloomberg ticker: S0042FS 5Y5Y BLC Curncy.

Finance, 2019). In the case of Colombia, its weight increased from 3.9% to 8.0% between March and September 2014 (Romero, Vargas, Cardozo, and Murcia, 2021).

2.2. Unbiasedness test

The predictive ability (unbiasedness) of the forward premium over the subsequent change in the short rate is one of the standard tests of the EH (Froot, 1989). Defining $fp_t^{(10,5)} = f_t^{(10,5)} - r_t^5$ as the forward premium, $f_t^{(10,5)}$ as the forward rate, which is the 5yr yield in 5 years implied in the current yield curve, and r_t^5 as the 5yr yield (short-rate), we obtain:

$$r_{t+5}^5 - r_t^5 = \alpha_1 + \beta_1\left(fp_t^{(10,5)}\right) + \vartheta_{1,t+5} \ldots (1)$$

We test Equation (1) for each country using OLS with Newey-West standard errors to adjust for the overlapping data problem that can lead to serial correlation in the errors. r_{t+5}^5 is the 5yr yield (short rate) in 5 years and ϑ_{t+5} is a random noise. The null hypothesis under the EH is that $\beta_1 = 1$. Testing $\alpha_1 = 0$ is only valid under the pure expectations hypothesis, but other versions allow $\alpha_1 \neq 0$, which may reflect a compensation for liquidity (Jongen et al., 2011).

2.2.1. Deviation from the unbiasedness hypothesis

Allowing a non-zero term premium implies that not all investors are risk-neutral and indifferent when it comes to replacing long-term bonds with successive bonds with short-maturities (Yi-Hsuan et al., 2014). For this reason, a non-zero term premium can be defined as the difference between the forward premium and the change in the expected future rate. We can express this in Equation (2):

$$TP_t^{(10,5)} = fp_t^{(10,5)} - E_t \Delta r_{t+5}^5 \ldots (2)$$

Where $E_t \Delta r_{t+5}^5$ is the difference between the expected future 5yr yield and the current short-term rate. In addition, we assume that our estimated future short-term yield is not necessarily the true market expectation at time t+5, and it is subject to errors (Froot, 1989; Jongen and Verschoor, 2008).

$$r_{t+5}^5 = E_t r_{t+5}^5 + \varepsilon_{t+5} \ldots (3)$$

Having defined both the term premium and the ex-post expectation errors in Equations (2) and (3), we can decompose the rejection of the EH into a time varying term premium and an expectation errors component. The traditional OLS decomposition of β_1 from Equation (1) implies that:

$$\beta_1 = \frac{Cov\left[r_{t+5}^5 - r_t^5; fp_t^{(10,5)}\right]}{Var\left[fp_t^{(10,5)}\right]} \ldots (4)$$

After some algebra (Froot, 1989; Yi-Hsuan et al., 2014), we can arrive at:

$$\beta_1 = 1 + \frac{Cov\left[-TP_t^{(10,5)}; fp_t^{(10,5)}\right]}{Var\left[fp_t^{(10,5)}\right]} + \frac{Cov\left[\varepsilon_{t+5}; fp_t^{(10,5)}\right]}{Var\left[fp_t^{(10,5)}\right]}$$

$$\beta_1 = 1 + \beta_{tp} + \beta_{ee} \ldots (5)$$

Deviation of β_1 from 1 (EH applies) can be explained by a time-varying term-premium (β_{tp}) and to expectation errors (β_{ee}). With the help of the estimated yield ($E_t r_{t+5}^5$), it is possible to estimate both β_{tp} and β_{ee}.

2.3. Construction of expected yields: the top-down approach

To arrive at Equation (5), we need $E_t r_{t+5}^5$. We take market expectations of future US yields levels from the 5yr US IRS in 5yr, which is considered the base yield. To control for country-specific factors, Ebeke and Lu (2014) use – among others - the 2yr expected depreciation included in the current currency forward, while Gadanecz et al. (2014) use the 1yr expected depreciation in the currency (forecasts). Weekly data for 1yr expected depreciation (forecasts) are not available for our sample, but we can obtain data for the expected depreciation on 1yr and 2yr forwards. Most of the negotiation in the FX forwards markets in Latam are for short maturities[9]. One of the advantages of our approach is that it only considers available market data.

Based on this framework, we can proxy the expected local currency 5yr yield in 5yr (defined as $E_t r_{t+5}^5$) by:

$$E_t r_{t+5}^5 = US5yr5yr_t + s_t^e \ldots (6)$$

[9] According to BIS data for April 2022 (BIS 2022), an average of 91% of the total amount of outright forwards with a maturity of 6 months or less are negotiated in Chile, Colombia, and Mexico.

Where $US5yr5yr_t$ is the 5yr5yr USD IRS (proxy for international factors) and s_t^e is the expected forward depreciation (proxy for local factors). We will discuss later on the choice of the relevant tenor for the expected forward depreciation.

2.4. Behavioral biases

2.4.1. The Law of Small Numbers and conservatism bias

The availability of expected yields allows us to test how investors form their expectations. Bulkey et al. (2015) propose two equations for testing two behavioral biases that could explain the failure of EH. In the first case, the LSN would imply that the n-step ahead expectation errors for the short yield would be positively correlated at shorter lags, which may suggest mean-reversion behavior (gambler´s fallacy), and negatively correlated at longer lags (hot hand fallacy). To simplify the notation, we redefine the ex-post expectation errors ε_{t+5} from Equation (3) as δ_t. The LSN can be tested as follows:

$$\delta_{t+m} = \alpha_2 + \beta_2(\delta_t) + \vartheta_{2,t} \ldots (7)$$

If the LSN applies, β_2 should be positive for small values of m (1,2,3,4, and 5 months) and negative for longer values. On the other hand, we can use the extrapolative expectations model to test mean reversion in expectations formation, which is the first implication of the LSN. In this case, the change in the expected short-term rate, right-hand side of Equation (1), can be estimated by:

$$E_t r_{t+5}^5 - r_t^5 = \alpha_3 + \beta_3(r_t^5 - r_{t-m}^5) + \vartheta_{3,t} \ldots (8)$$

Where m takes small values as before. If β_3 is greater than zero, expectations would exhibit bandwagon effects. If it is negative, they would exhibit mean reversion (Cavaglia et al., 1993). In the case of the conservatism bias, which implies that expectation revisions are positively correlated at short lags (Bulkey et al., 2015), the equation for testing it is:

$$E_{t+m} r_{t+5}^5 - E_{t+m-1} r_{t+5}^5 = \alpha_4 + \beta_4\left(E_t r_{t+5}^5 - E_{t-1} r_{t+5}^5\right) + \vartheta_{4,t} \ldots (9)$$

For m = 1, 2, 3, 4, and 5 months, β_4 is expected to be positive.

2.4.2. Over/under reaction on expectations formation

Coibion and Gorodnichencko (2015) propose the following equation to test whether ex-post forecast errors can be predicted by forecast revisions.

$$r_{t+5}^{5} - E_t r_{t+5}^{5} = \alpha_5 + \beta_5\left(E_t r_{t+5}^{5} - E_{t-1} r_{t+5}^{5}\right) + \vartheta_{5,t} \ldots (10)$$

Where $\left(E_t r_{t+5}^{5} - E_{t-1} r_{t+5}^{5}\right)$ is the change in expectations between t-1 and t. From a behavioral standpoint, authors such as Bordalo et al. (2018) and Eva and Winkler (2023) state that a negative value of β_5 suggests overreaction in expectations formation. Coibion and Gorodnichencko (2015) and Schemeling et al. (2022) suggest information rigidities in expectations formation for a statistically significant β_5. In all equations, we employ OLS with Newey-West adjusted standard errors. Obtaining statistically significant β_2, β_3, β_4, and β_5 suggest that our yields´ estimations are systematically biased, which is at odds with rational expectations.

3. Results and discussion

We use the annualized implied 2yr forward depreciation because it yields a (slightly) lower RMSE for our entire sample, compared to the 1yr forward. In addition to the formal tests described in the previous section, we also analyze the descriptive statistics of the expectation errors. All our variables were tested for stationarity (Appendix 1) and in the cases where we obtain a non-stationary series, we take their first difference in the respective regression.

In addition, and to test Equations (7) to (10), we add two dummy variables. For the three countries, we add a dummy variable related to the period of falling US rates (July 2013 to July 2016). Then, and only for Chile and Colombia, we add another dummy variable for each country that refers to the respective period in which these countries significantly increased their share in the JP Morgan GBI-EM Global Diversified Index. To save space, we do not report these coefficients.

3.1. Unbiasedness tests

Table 1 contains the results of the unbiasedness test of Equation (1). Panel A refers to the entire sample spanning from January 2013 to May 2019, the last month for which we have ex-post expectation errors (data until May 2024). The EH appears to be rejected for all countries. The Wald test leads us to reject the null hypothesis of $\beta_1 = 1$. In the case of Colombia and Mexico, β_1 is statistically equal to zero. For Chile, we have a significant value for β_1 of less than one but greater than zero, similar to the results for the US in Froot (1989) and Yi-Hsuan et al. (2014). In the Chilean case, market participants predicted the correct direction of yield movements, but not enough to meet the EH.

<< INSERT TABLE 1 ABOUT HERE>>

We obtain similar results in the first sub-period, between July 2013 and July 2016, a period with falling US rates. In Panel B of Table 1, the EH is again rejected for all countries. Mexico is the only country for which β_1 is statistically equal to zero. Colombia and Chile report higher values of β_1 (compared to the whole sample) but they are not statistically equal to one. This suggests that the forward premium better predicts expected changes in future rates when US rates fall. In the second sub-period, the EH is again rejected for all countries (Panel C), as all the coefficients are not statistically significant[10]. Interestingly, Chile is the only country where β_1 is closer to 1 in both Panel A and Panel B. However, in the second sub-period (Panel C), that coefficient drops and becomes statistically insignificant, like the other two countries. From the end of 2016 to the end of 2018, Chile increased its weight in the EM local-currency indices[11], which may distort the relationship reported in the previous panels of Table 1. Romero et al. (2021) and Ebeke and Lu (2014) report that higher non-resident investors participation may increase yields´ volatility.

Testing the EH in specific periods is relatively common in the literature. Schmeling et al. (2022) report that the EH cannot be rejected when market participants expect (US) rate hikes, but when they expect rates cuts, the EH fails. Jardet (2008) finds that the EH is also rejected in some periods of "economic stability", and Yi-Hsuan et al. (2014) report that the EH is particularly rejected in times of crisis. In our case, and for

[10] For Chile and Colombia, we are also not able to reject the null hypothesis of the Wald test (β_1=1), but this can be explained by the dispersion (standard deviation) of the estimates.
[11] The weight increase in Chile was spread over almost 3 years, while in Colombia, it was concentrated in 6 months in 2014 (Romero, et al., 2021).

Chile in particular, it is over the period when US rates are falling when β_1 is closer to one, in contrast to the findings of Schmeling et al. (2022).

It is also interesting to note that the standard deviation of our β_1 estimates are similar for the full sample and the first sub-period. Nevertheless, they increase in the second sub-period, with Chile being the country with the highest increase compared to the full sample and the first sub-period. When US rates increase, the precision of the estimates decreases. This higher dispersion does not seem to be related to the volatility of US rates, as the MOVE index[12] is similar on average in the two sub-periods, but it could be related to the deterioration in global liquidity conditions. The average level of the TED spread[13] has increased in the second sub-period and it is related to worsening liquidity conditions. Country-specific factors may also explain this higher dispersion.

Overall, our results suggest that for Latin America the EH does not hold for the period 2013 to 2024, which is broadly consistent with previous international results. As a general explanation, the higher volatility of EM long yields (Shiller, 1979; Caldeira and Smaniotto, 2019) may explain our results. In addition, Mexico and Chile experienced (external) shocks over our period, which may help to explain the EH rejection (Galindo and Catalán, 2003). In the case of Mexico, the country experienced a significant increase in the volatility of its financial assets at the end of 2016, explained by the potential implications of US elections. On the other hand, Chile experienced an increase in its weight in EM local currency indices between 2016 and 2018. These distortions can affect both the term premium and the expectation errors component in both countries. However, as mentioned above, these results should be treated with caution as the yields, methodologies, and periods of the previous studies are different.

3.2. Deviation from the Unbiasedness Hypothesis

In this section, we analyze the components of the EH failure. Panel A in Table 2 shows the results for the entire sample. In all cases, the term premium component seems to be more relevant for the rejection of the EH than the expectation errors. The

12 The MOVE index measures the US bond market volatility by tracking a basket of OTC options on US IRS.

13 The TED spread is the difference between the three-month US Treasury bill and the three-month LIBOR based on US dollars. It is a market measure of liquidity conditions.

contribution of the expectation errors component is relevant for Chile and Colombia, but almost negligible for Mexico. These results differ to some extent from the US results of Froot (1989) and Yi-Hsuan et al. (2014). In the latter two studies, the authors report negative estimates for both the term premia and the expectation errors component, with the latter being most important in explaining the deviation of β_1 from one, especially at longer horizons. However, these results are consistent with those of Jardet (2008), who finds that the distortions to the unbiasedness hypothesis arising from a time-varying term premium are quantitatively more important for the US than those arising from the expectation errors component. Naudon and Yan (2016) find significant spillover effects of US term premia on the term premia of local currency yields in Latam.

<< INSERT TABLE 2 ABOUT HERE>>

In Panel B of Table 2, we obtain similar results. The term premium component is more relevant in explaining the deviation of β_1 from one but the value of the expectation errors component increases for the three countries, compared to the full sample. The value of the term premium decreases for Chile and Colombia compared to Panel A (Table 2) but increases for Mexico. Finally, in Panel C (Table 2), we report the results for the second subperiod. In Chile and Colombia, the component attributable to the term premium increases compared to the full sample and the first sub-period. It decreases for Mexico. In contrast, the value attributable to expectation errors decreases for Chile compared to the full sample and the first sub-period and increases for Colombia and Mexico.

The results from Tables 1 and 2 (Panel A in both cases) show that the deviation of β_1 from one in Equation (1) is mainly explained by the term premium component. Schmeling et al. (2022) point out that in Equation (1), a β_1 greater than one may indicate an underestimation of future yield changes. Following this reasoning, it would be valid to argue that in our case the term premium component leads to an overestimation of future short-term yields, since β_1 is not even close to one in any case. Jongen et al. (2011) find that changes in risk and liquidity conditions may explain changes in the term premium. The credit ratings of the three countries were downgraded over our sample, worsening the risk perception about them. On the other hand, liquidity conditions (TED spread) also exhibited higher volatility in the second sub-period. These fundamental factors, among others, may cause market participants to overestimate future yields

As stated previously, and compared to the full sample, the expectation errors component shows higher changes in the second sub-period (Table 2, Panel C). Chile and Mexico show the highest changes. Yi-Hsuan et al. (2014) point out that the expectation errors component can be due to irrational expectations (i.e., sentiment) and statistical biases that may originate from expected regime changes that do not materialize (i.e., peso problem). The Mexican case may better reflect both explanations in the second sub-period. At the end of 2016, all Mexican assets experienced significant volatility due to the impact of political developments in the US. In contrast, the expectation errors component in Chile abruptly decreased to become almost negligible, although this may be distorted by its increase in indices´ weight. The expected currency forward depreciation also reflects these changes for both countries (Appendix 2).

3.3. Expectation errors

Table 3 presents the summary statistics for the expectation errors. In Panel A, we show the results for the entire sample. Chile and, to a lesser extent Colombia, show negative ex-post expectation errors, indicating an overestimation of future yields, while Mexico shows the opposite results (positive expectation errors). The overestimation of Chilean and Colombian rates could also include a liquidity premium that is not present in the more liquid Mexican market, albeit the magnitudes are not consistent with the relative liquidity between the two countries. The Mexican expectation errors are the only ones that appear to be stationary (Appendix 1). We reject the normality assumption in all cases.

<< INSERT TABLE 3 ABOUT HERE>>

On the other hand, the standard deviation of expectation errors in Mexico is significantly lower over the entire period. Miah, Ali, and Hammoudeh (2016) point out that countries with higher inflation also have higher expectation errors and that their yields are more predictable (lower standard error). This is partly consistent with our results. In our entire sample, Chile and Colombia had the highest inflation volatility and also reported the highest standard error of their respective expectation errors.

A visual inspection of the expectation errors (Appendix 2) may complement the analysis. For Mexico, the ADF test suggests that they are stationary. For Colombia and Chile, however, there is a trend change around the middle of 2016. The implied 2yr forward depreciation is the only country-specific factor in our expected yields, and it shows a decreasing trend for Chile and Colombia, consistent with the increase in their ex-post expectation errors. In Chile, the forward depreciation was even negligible at the end of 2019. This could be due to the recovery of oil and copper prices in 2016, the main exports for Colombia and Chile, respectively, whose performance is strongly correlated with these currencies. In Chile, the higher indices´ weight could contribute to the forward performance, as rebalancing effects push up demand for the currency. In Mexico, the forward depreciation began rising at around the same time, which could be attributed to political developments in the US.

Panel B in Table 3 contains the summary statistics of the expectation errors for our first sub-period. In this subperiod, the overestimation is higher for Chile and Colombia, but for Mexico, it is similar to the whole sample. This suggests that market participants in Chile and Colombia tend to overestimate future yields even more in periods of falling US rates, perhaps because they expect future adjustments (i.e., regime change). The standard deviation of both expectation errors is significantly lower than in Panel A. Finally, Panel C in Table 3 shows the summary statistics for the second sub-period (rising US yields). In all cases, we have an underestimation of future yields, but it is small for Mexico. It is interesting to note that only for Chile and Colombia, the ex-post expectation errors change from overestimation to underestimation. This could be related to the decreasing expected depreciation implied in the forwards for these currencies.

3.4. Behavioral biases

Table 4 shows the results of the short- and long-term predictions of the Law of Small Numbers. The LSN predicts that the n-step ahead expectation errors are positively correlated at shorter lags (mean-reverting behavior), but negatively correlated at longer lags. In this exercise, due to the limited data length, we only consider the entire sample and a maximum of 44 months for longer lags. The results are inconclusive. However, the relatively short sample prevents us from generalizing our results. For Chile and Colombia, we obtain statistically insignificant coefficients in almost all cases, which prevents us from drawing any supportive conclusion for the validity of the LSN.

In Mexico, the only country where expectation errors seem to be stationary, the results seem to be closer to expectations. We obtain significant and positive values for β_5

for short lags, and negative values for longer lags (Table 4). In this sense, we only obtain results for Mexico that confirm both predictions of the LSN and are consistent with the results of Bulkey et al. (2015), who analyze the US market for the period 1952-2012. Mexican rates have the highest correlation with US rates, explained not only due to geographical proximity but also economic dependence. It is interesting to note the presence of this behavioral bias in one of the most developed markets in Latam.

<< INSERT TABLE 4 ABOUT HERE>>

The results of the extrapolative expectations test (Equation (8)) are presented in Table 5. We consider the same short lags as in Equation (7) to make our results comparable. In the Colombian case, the evidence suggests the presence of mean-reverting behavior in expectations formation. We obtain statistically significant negative values for β_3 for all lags considered. This can be explained by the relatively lower development of the Colombian market. For Chile and Mexico, we report positive and negative coefficients, respectively, but they are weak. Overall, the evidence suggests that the extrapolation bias is present to varying degrees in the Latam rates market, even when yields are estimated using market data, although this bias usually comes from surveys (Briére et al., 2023). In any case, these results are not entirely consistent with the results of the baseline test of the first implication of the LSN (Equation (7)).

<< INSERT TABLE 5 ABOUT HERE>>

On the other hand, Table 6 contains the results of the test for the conservatism bias. In all cases, we find a fairly weak serial correlation between revisions of expectations, obtaining a statistically insignificant coefficient of β_5. Bulkey et al. (2015) also report small coefficients, but in their case, most are positive and statistically significant. The conservatism bias could be due to agents updating their beliefs too slowly, explained by institutional constraints leading to forecasts´ stickiness (Nordhaus, 1987). However, our estimations are based on market data and are not subject to any consistency or smoothing requirement, which could explain the weakness of our results.

<< INSERT TABLE 6 ABOUT HERE>>

Our results also show overreaction in expectations formation (Table 7). The negative and significant values for β_5 reported in all cases are consistent with the overreaction hypothesis. A negative forecast error occurs when expectations are strongly revised upwards. Bordalo et al. (2018) report similar results in their work for medium to long-term rates in the US. They also report a positive relationship between the persistence of the series and the CG coefficient, on which the overreaction test is based (Equation (10). The higher volatility (lower persistence) of long-term rates (Shiller, 1979) or the higher volatility of EM assets may cause investors to overreact. Autocorrelation averaging could also explain longer yields overreaction (Wang, 2021). Finally, overreaction may also be related to loss aversion. The more frequently investors revisit their expectations, the more prone they are to expectation errors (Briére et al., 2023).

<< INSERT TABLE 7 ABOUT HERE>>

Finally, the results in Table 7 also suggest the presence of information rigidities in the three countries, as expectation errors can be predicted with actual data. Overreaction and information rigidities are not necessarily exclusive explanations. The analysis of expectation errors is usually a complement to the EH test. According to the rational expectation hypothesis, investors efficiently use all available information when forecasting future variables, so that any ex-post estimation error should be orthogonal to all current or past information (Jongen and Verschoor, 2008; Yi-Hsuan et al., 2014). Jongen and Verschoor (2008) and Miah et al. (2016) report that investors do not use all available information in their yield forecasts and find that forecasts´ errors can be predicted with current variables, suggesting inefficiencies in expectations formation. Our results are also consistent with this hypothesis.

3.5. Robustness tests

We replicate all the previous exercises for different pairs of tenors across the respective swap curves. We will only discuss and report the results for the 4yr-2yr pair, as this is the only bucket for which it was possible to obtain data for all countries. When using the 8y-4yr and 6yr-3yr tenors, not available for all countries, the results do not change qualitatively. We then only refer to the entire period.

The results shown in Table 8 also reject the EH. The coefficient for the (change in the) forward premium is even smaller for Chile and Colombia than in Table 1, Panel A. However, these coefficients are not significant. In the case of Mexico, we obtain a significant but negative coefficient, rejecting the theoretical value of 1. When we look at the components that explain the deviation from the unbiasedness hypothesis (Table 9), we find that the component associated with the term premium is higher than in our baseline results for Chile and Mexico and still dominates in Chile and Colombia. In contrast to Panel A in Table 2, but in line with the work of Froot (1989) and Yi-Hsuan et al. (2014), we also obtain a negative value for the component associated with expectation errors in Chile and Mexico. In the specific case of Mexico, the values of both components are quite similar.

<< INSERT TABLE 8-9 ABOUT HERE>>

The main characteristics of the expectation errors (Table 10) show similar directional patterns compared to the base case (Panel A in Table 3). The mean of expectation errors for the 2yr yield in Chile and Colombia is higher (in absolute values) than in the case of the 5yr yield, but with a significantly lower standard deviation. Shorter rates are more predictable. The opposite is true for Mexico, with lower expectation errors for the 2yr case, but a significantly higher dispersion that is the highest among all the countries analyzed.

<< INSERT TABLE 10 ABOUT HERE>>

The predictions of the LSN also show no relevant trend, obtaining non-significant coefficients in almost all cases, even for Mexico (Table 11). The mean-reversion behavior test (Table 12) shows some results that deviate from the base case (Table 5). For both Chile and Mexico, we report positive significant coefficients for β_3. This would suggest bandwagon effects in expectations formation (Cavaglia et al., 1993). On the contrary, the Colombian case shows similar results to the baseline test (Table 5). In the case of the conservatism bias (Table 13), our results also show no trend. Finally, Table 14 shows similar results to Table 7, β_5 is statistically different from zero and negative, supporting the hypothesis of overreaction in expectations formation at shorter yields.

<< INSERT TABLE 11-14 ABOUT HERE>>

4. **Conclusions**

In this paper, we extend the analysis of the EH and expectations formation for rates markets in Latin America, a region that has received little attention in the literature despite its importance in Emerging Market local currency sovereign debt indices. Our period covers recent years not covered by previous studies for Latam/EM, allowing us to examine the dynamics of expectations in a context where local dynamics have been relatively stable but the index weight has increased for part of our sample, and where there have been divergent trends in US yields. In contrast to most of the literature, we focus on the intermediate and longer maturities of the yield curve, reflecting the composition of the indices and the bias of the main players in these markets: institutional and non-resident investors, the latter mainly adopting an indexing approach. Furthermore, the imperfect substitution effect between different maturities of the yield curve or different periods and methods prevents us from extrapolating past results.

In the forward premium test of the EH, we reconsider the traditional approach that relies on forecasts or estimates from derivative markets, given the lack of reliable data. Our approach uses a top-down perspective where our expected yields are constructed from the market´s expected US yields and the expected depreciation implied in the FX forwards. Our method finds its empirical basis in the extensive research on the determinants of local EM yields. Furthermore, we extend the previous EM literature on the EH and analyze not only the role of the term premium component but also the role of expectation errors as a cause of the EH failure. We then analyze the expectation errors derived from our estimated yields and for the first time in the EM literature, introduce possible behavioral explanations that could explain the EH rejection in Latam.

Data consistency and availability define our sample. We use local currency interest rates swap yields for Chile, Colombia, and Mexico. These markets have grown in recent years and show a high correlation with local currency government yields. Our results confirm the rejection of the EH found in previous research. When we divide our sample into different periods, corresponding to different trends in US yields, the conclusions are generally the same. The higher volatility of longer rates or EM assets could explain our results. Next, we find that the term premium is the main component explaining the EH failure. We also find that the component associated with expectation errors is positive on average, which contrasts with previous US results. We intend to provide some explanations, but this is clearly an area for future research.

The main novelty of this work, the analysis of behavioral biases in expectations formation, shows mixed results in the Latam case. The LSN predictions appear to hold only for Mexican rates, which is consistent with previous findings from the US. Mexican and US yields tend to be highly correlated. Our results also suggest the existence of mean-reverting behavior in expectations formation for Colombia and to a lesser extent in Mexico. On the other hand, the conservatism bias does not seem to be present in our sample. Furthermore, our results suggest overreaction in the expectations formation process. The overreaction could be due not only to the volatility of long-term rates that adds to the traditionally higher volatility of EM assets but also to autocorrelation averaging in expectations formation. These results also suggest the presence of information rigidities in Latam.

In any case, these results suggest that expectations formation in the Latam rates markets is not fully consistent with the rational expectations hypothesis, thus contributing to the rejection of the EH. The literature addressing these specific behavioral biases is sparse and focuses on the US for a sample that is much longer than ours. Therefore, our results should be taken cautiously while opening a window for further research.

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Table 1: unbiasedness tests

Panel A: full sample January 2013 to May 2019

	α_1	β_1	Wald test p-value $\beta_1 = 1$	Conclusion
Chile	0.01	0.56***	0.01	EH rejected.
Std error	*0.01*	*0.17*		
Colombia	0.01	0.17	0.00	EH rejected.
Std error	*0.02*	*0.15*		
Mexico	0.00	0.02	0.00	EH rejected.
Std error	*0.01*	*0.20*		

* Significant at 90%, ** significant at 95%, *** significant at 99%.

Panel B: July 2013 to July 2016

	α_1	β_1	Wald test p-value $\beta_1 = 1$	Conclusion
Chile	0.00	0.63***	0.03	EH rejected.
Std error	*0.01*	*0.17*		
Colombia	-0.01	0.27**	0.00	EH rejected.
Std error	*0.02*	*0.13*		
Mexico	-0.01	0.20	0.00	EH rejected.
Std error	*0.02*	*0.14*		

* Significant at 90%, ** significant at 95%, *** significant at 99%.

Panel C: August 2016 to December 2018

	α_1	β_1	Wald test p-value $\beta_1 = 1$	Conclusion
Chile	0.01	0.29	0.19	EH rejected.
Std error	*0.02*	*0.54*		
Colombia	0.03	0.49	0.23	EH rejected.
Std error	*0.03*	*0.42*		
Mexico	-0.01	0.22	0.01	EH rejected.
Std error	*0.03*	*0.28*		

* Significant at 90%, ** significant at 95%, *** significant at 99%.

Notes: The parameter estimates are for Equation (1) of the main text. The standard errors of the coefficients are given in italics. For the Wald test, a p-value less than 0.05 indicates the rejection of the null hypothesis.

Table 2: components of the failure of the EH

Panel A: full sample

	Term premium	Expectation errors
Chile	-0.87	0.44
Colombia	-0.99	0.17
Mexico	-0.97	-0.02

Panel B: July 2013 to July 2016

	Term premium	Expectation errors
Chile	-0.91	0.54
Colombia	-1.07	0.34
Mexico	-0.88	0.08

Panel C: August 2016 to December 2018

	Term premium	Expectation errors
Chile	-0.68	-0.03
Colombia	-0.88	0.37
Mexico	-1.10	0.32

Notes: This table shows the betas of the term premium and expectation errors, which are computed from Equation (5).

Table 3: summary statistics of expectations errors

Panel A: full sample

	RMSE	Mean	Std deviation	Skewness	Kurtosis	JB stat
Chile	3.22	-0.93	3.09	0.25	-1.67	42.35***
Colombia	2.96	-0.16	2.96	0.45	-1.18	30.61***
Mexico	1.05	0.71	0.77	-0.64	-0.66	28.86***

Panel B: July 2013 to July 2016

	RMSE	Mean	Std deviation	Skewness	Kurtosis	JB test
Chile	3.66	-3.55	0.89	1.15	1.28	46.19***
Colombia	2.76	-2.56	1.03	-0.19	-0.32	1.68
Mexico	1.10	0.72	0.83	-0.73	-0.72	17.49***

Panel C: August 2016 to December 2018

	RMSE	Mean	Std deviation	Skewness	Kurtosis	JB test
Chile	2.63	2.42	1.03	-0.37	0.20	3.04
Colombia	3.41	2.59	2.24	-0.72	-0.51	12.03***
Mexico	0.90	0.56	0.71	-0.29	-1.01	7.11***

Notes: This table provides summary statistics for the expectation errors provided by Equation (3). The sample period is January 2013 through May 2019. For the Jarque-Bera test, the null hypothesis is that the time series is normally distributed. *, **, and *** means rejection of normality at 10, 5, and 1 percent significance level, respectively.

Table 4: short and long-term predictions of the LSN

	Chile		Colombia		Mexico	
	$\boldsymbol{\beta_2}$	**R2**	$\boldsymbol{\beta_2}$	**R2**	$\boldsymbol{\beta_2}$	**R2**
1-month	0.05	0.02	0.03	0.00	0.76***	0.60
Std error	*0.06*		*0.09*		*0.06*	
2-months	-0.05	0.02	0.06	0.00	0.52***	0.30
Std error	*0.07*		*0.05*		*0.10*	
3-months	-0.03	0.03	-0.01	0.00	0.28**	0.12
Std error	*0.08*		*0.05*		*0.13*	
4-months	-0.05	0.02	0.01	0.01	0.14	0.05
Std error	*0.06*		*0.05*		*0.13*	
5-months	0.04	0.01	-0.01	0.00	0.10	0.02
Std error	*0.05*		*0.06*		*0.13*	
24-months	-0.10	0.02	-0.05	0.00	-0.22**	0.06
Std error	*0.07*		*0.07*		*0.11*	
30-months	-0.12**	0.02	-0.11	0.01	-0.19*	0.05
Std error	*0.06*		*0.07*		*0.11*	
36-months	-0.03	0.01	0.02	0.01	0.03	0.02
Std error	*0.13*		*0.07*		*0.10*	
40-months	-0.01	0.00	0.02	0.01	0.04	0.00
Std error	*0.09*		*0.09*		*0.11*	
44-months	-0.04	0.00	0.04	0.00	0.10	0.02
Std error	*0.08*		*0.11*		*0.11*	

* Significant at 90%, ** significant at 95%, *** significant at 99%.

Notes: The parameter estimates are for Equation (7) of the main text. The sample period is January 2013 through May 2019. The standard errors of the coefficients are given in italics. Given that we are using weekly data, we assume that a month has 4 weeks.

Table 5: mean-reversion behavior

	Chile		Colombia		Mexico	
	β_3	R2	β_3	R2	β_3	R2
1-month	0.05	0.01	-0.31***	0.04	-0.01	0.01
Std error	*0.06*		*0.11*		*0.04*	
2-months	0.09	0.01	-0.40***	0.06	-0.03	0.01
Std error	*0.06*		*0.12*		*0.04*	
3-months	0.07	0.01	-0.30***	0.04	0.02	0.01
Std error	*0.07*		*0.08*		*0.04*	
4-months	0.04	0.01	-0.39**	0.06	-0.03	0.01
Std error	*0.06*		*0.17*		*0.04*	
5-months	0.05	0.01	-0.32***	0.04	-0.03	0.01
Std error	*0.06*		*0.10*		*0.04*	

* Significant at 90%, ** significant at 95%, *** significant at 99%.

Notes: The parameter estimates are for Equation (8). The right-hand side of the equation to the change in the short-rate in the last *m*-months. Given that we are using weekly data, we assume that a month has 4 weeks.

Table 6: predictions of the conservatism bias

	Chile		Colombia		Mexico	
	β_4	R2	β_4	R2	β_4	R2
1-month	-0.11	0.04	-0.12	0.03	0.02	0.03
Std error	*0.08*		*0.12*		*0.07*	
2-months	-0.11	0.03	-0.11	0.03	0.07	0.03
Std error	*0.09*		*0.08*		*0.09*	
3-months	-0.04	0.01	-0.08	0.04	-0.19**	0.04
Std error	*0.09*		*0.09*		*0.08*	
4-months	0.03	0.00	-0.01	0.06	-0.08	0.01
Std error	*0.08*		*0.07*		*0.07*	
5-months	0.05	0.00	0.03	0.07	-0.03	0.00
Std error	*0.08*		*0.07*		*0.07*	

* Significant at 90%, ** significant at 95%, *** significant at 99%.

Notes: The parameter estimates are for Equation (9) of the main text. The sample period is January 2013 through May 2019. The standard errors of the coefficients are given in italics. Given that we are using weekly data, we assume that a month has 4 weeks.

Table 7: over/under reaction hypothesis

	$\boldsymbol{\beta_5}$	**R2**
Chile	-0.23***	0.09
Std error	*0.03*	
Colombia	-0.31***	0.12
Std error	*0.05*	
Mexico	-0.37**	0.05
Std error	*0.18*	

Notes: The parameter estimates are for Equation (10). The change in expectations refers to the right-hand side of Equation (10), the GC coefficient. The standard errors of the coefficients are given in italics. R2 is the measure of fit.

Table 8: unbiasedness tests

Full sample using 4yr and 2yr yields

	$\boldsymbol{\alpha_1}$	$\boldsymbol{\beta_1}$	**Wald test p-value** $\boldsymbol{\beta_1 = 1}$	**Conclusion**
Chile	0.00	0.11	0.00	EH rejected.
Std error	*0.01*	*0.12*		
Colombia	-0.01	0.024	0.00	EH rejected.
Std error	*0.01*	*0.10*		
Mexico	-0.01	-0.28**	0.00	EH rejected.
Std error	*0.01*	*0.11*		

* Significant at 90%, ** significant at 95%, *** significant at 99%.

Notes: see Table 1 for details.

Table 9: components of the failure of the EH

Full sample using 4yr and 2yr yields

	Term premium	Expectation errors
Chile	-0.60	-0.29
Colombia	-1.07	0.10
Mexico	-0.63	-0.65

Notes: see Table 2 for details.

Table 10: summary statistics of expectations errors

Full sample using 2yr yields

	RMSE	Mean	Std deviation	Skewness	Kurtosis	JB stat
Chile	1.59	-1.45	0.67	0.42	-0.59	14.34***
Colombia	1.57	-0.93	1.26	0.12	-1.20	20.80***
Mexico	2.34	0.23	2.33	-0.35	-0.81	15.99***

Notes: see Table 3 for details.

Table 11: short and long-term predictions of the LSN

Full sample using 2yr yields

	Chile		**Colombia**		**Mexico**	
	$\boldsymbol{\beta_4}$	**R2**	$\boldsymbol{\beta_4}$	**R2**	$\boldsymbol{\beta_4}$	**R2**
1-month	0.06	0.02	0.20*	0.04	0.00	0.03
Std error	*0.06*		*0.11*		*0.04*	
2-months	0.02	0.01	0.08	0.01	0.13*	0.04
Std error	*0.07*		*0.07*		*0.07*	
3-months	-0.01	0.01	0.06*	0.00	0.00	0.01
Std error	*0.06*		*0.04*		*0.06*	
4-months	-0.07	0.01	-0.01	0.00	-0.01	0.01
Std error	*0.05*		*0.04*		*0.05*	
5-months	0.06	0.00	-0.01	0.00	0.06	0.01
Std error	*0.04*		*0.05*		*0.05*	
24-months	0.01	0.02	0.06	0.01	-0.08	0.01
Std error	*0.05*		*0.04*		*0.07*	
30-months	0.05	0.02	-0.08	0.01	0.03	0.02
Std error	*0.06*		*0.05*		*0.05*	
36-months	0.13*	0.06	0.04	0.01	0.05	0.00
Std error	*0.06*		*0.08*		*0.08*	
40-months	-0.11**	0.04	0.09	0.01	-0.05	0.00
Std error	*0.05*		*0.07*		*0.07*	
44-months	0.07	0.06	0.02	0.00	-0.11	0.01
Std error	*0.07*		*0.07*		*0.09*	

* Significant at 90%, ** significant at 95%, *** significant at 99%.

Notes: see Table 4 for details.

Table 12: mean-reversion behavior

Full sample using 2yr yields

	Chile		Colombia		Mexico	
	$\boldsymbol{\beta_3}$	**R2**	$\boldsymbol{\beta_3}$	**R2**	$\boldsymbol{\beta_3}$	**R2**
1-month	0.17**	0.03	-0.28**	0.03	0.14***	0.07
Std error	*0.07*		*0.12*		*0.04*	
2-months	0.17***	0.04	-0.30***	0.03	0.13***	0.05
Std error	*0.06*		*0.09*		*0.04*	
3-months	0.07	0.01	-0.27***	0.03	0.11***	0.05
Std error	*0.07*		*0.08*		*0.03*	
4-months	0.09	0.02	-0.31**	0.03	0.12***	0.06
Std error	*0.07*		*0.14*		*0.04*	
5-months	0.09	0.01	-0.25**	0.02	0.13***	0.06
Std error	*0.07*		*0.11*		*0.04*	

* Significant at 90%, ** significant at 95%, *** significant at 99%.

Notes: see Table 5 for details.

Table 13: predictions of the conservatism bias

Full sample using 2yr yields

	Chile		Colombia		Mexico	
	$\boldsymbol{\beta_4}$	**R2**	$\boldsymbol{\beta_4}$	**R2**	$\boldsymbol{\beta_4}$	**R2**
1-month	-0.25***	0.08	-0.17	0.06	-0.05	0.02
Std error	*0.07*		*0.11*		*0.08*	
2-months	-0.15*	0.03	-0.09	0.03	0.06	0.02
Std error	*0.09*		*0.09*		*0.08*	
3-months	-0.02	0.01	-0.06	0.03	-0.14*	0.02
Std error	*0.07*		*0.09*		*0.07*	
4-months	0.02	0.00	-0.03	0.05	-0.13*	0.02
Std error	*0.08*		*0.08*		*0.07*	
5-months	-0.09	0.01	0.02	0.05	0.01	0.00
Std error	*0.06*		*0.06*		*0.06*	

* Significant at 90%, ** significant at 95%, *** significant at 99%.

Notes: see Table 6 for details.

Table 14: over/under reaction hypothesis

Full sample using 2yr yields

	β_5	R2
Chile	-0.24***	0.15
Std error	*0.02*	
Colombia	-0.29***	0.15
Std error	*0.05*	
Mexico	-0.24***	0.17
Std error	*0.04*	

Notes: see Table 7 for details.

Appendix 1: stationarity tests (2013 - 2019)

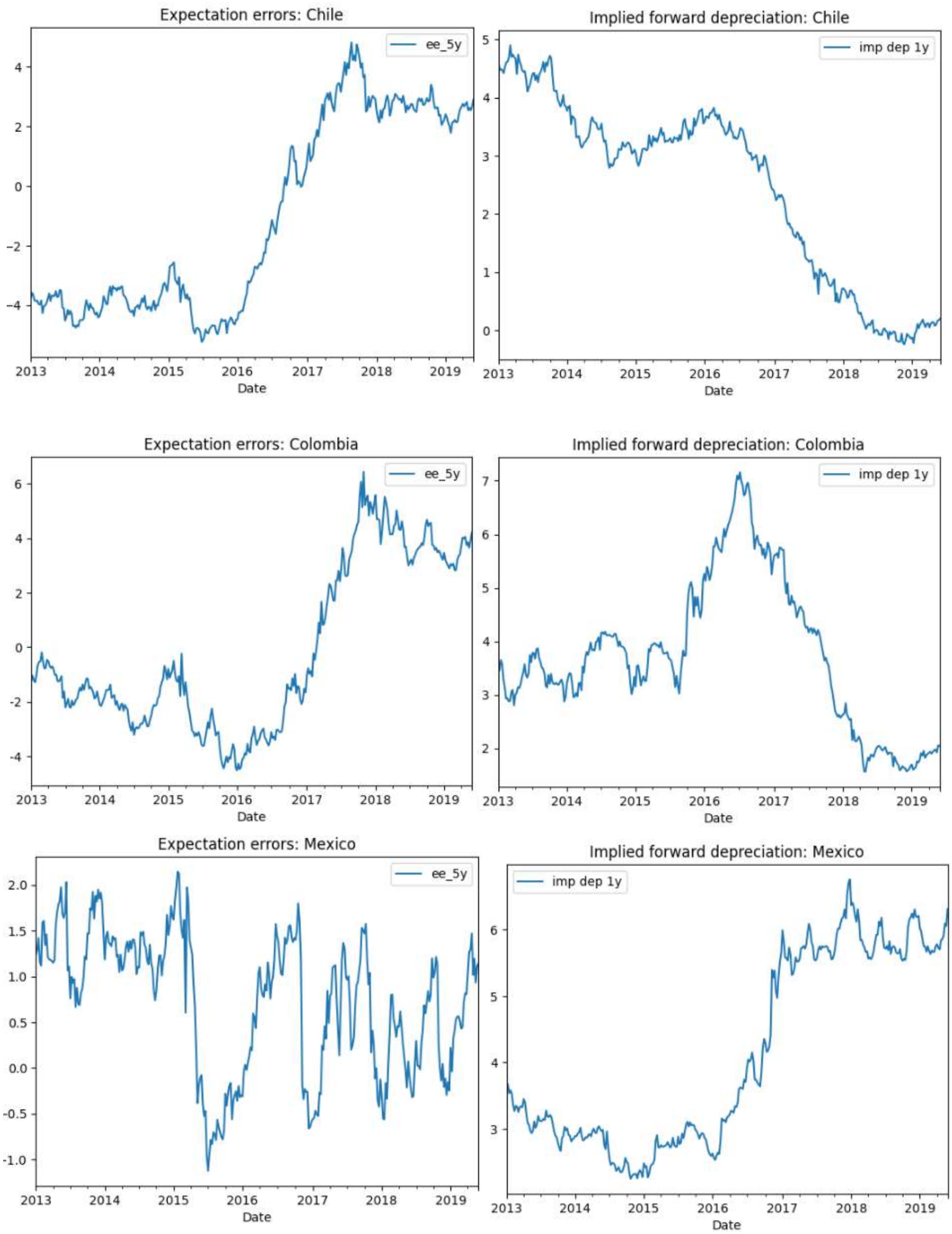
ADF t-stat

	Chile	Colombia	Mexico
5y			
Forward premium	-2.82*	-2.64*	-0.89
Estimated short rate	-0.68	-1.08	-1.43
Expected change in short rate	-0.91	-0.69	-2.18
Term premium (Equation (4))	-1.11	-1.91	-1.39
Expectation errors	-0.51	-0.84	-3.70***
2y			
Forward premium	-2.51	-1.68	-0.39
Estimated short rate	-0.16	-1.65	-0.81
Expected change in short rate	-2.36	-1.21	-0.58
Term premium (Equation (4))	-0.68	-1.76	-0.70
Expectation errors	-1.94	1.59	-0.52

* Significant at 90%, ** significant at 95%, *** significant at 99%.

For the ADF test, the null hypothesis is that the times series is non-stationary. *, **, and *** mean rejection of non-stationarity at 10,5, and 1 percent significance level, respectively.

Appendix 2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Date
Implied forward depreciation: Chile
imp dep 1y
Date
Expectation errors: Colombia
ee_5y
Date
Implied forward depreciation: Colombia
imp dep 1y
Date
Expectation errors: Mexico
ee_5y
Date
Implied forward depreciation: Mexico
imp dep 1y
Date