Has inflation targeting increased predictive power of term structure about future inflation: evidence from an emerging market ?

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Abstract

This paper contributes to the vast literature on the predictive power of term structure about future inflation, by focusing on an emerging market case. The following important result emerged in our paper: Monetary policy change is an important determinant of the relationship between term structure and inflation to the extent that even the existence of the relationship critically depends on the nature of monetary policy regime. In our case, the change in monetary policy is associated with the beginning of the implementation of an inflation targeting (IT) regime. While, before IT regime, the information in term structure does not provide any predictive power for future inflation, this phenomenon seems to be completely reversed after IT. Since the implementation of IT, term structure of interest rates has seemed to gain considerable forecasting power for future inflation.

Key Words: Term Structure of Interest Rate, Structural Break, Inflation, Monetary Policy, Inflation Targeting

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1. Introduction

The information content in term structure of interest rate about future inflation has been subject of considerable amount of research. The usefulness of this information in forecasting inflation has been extensively questioned in the related literature. This research has generated ambiguous results regarding the success of the term spread as a predictor of inflation. While some authors have asserted that the spread between long-term and short-term government bond rates appears frequently in the literature as a significant regressor in equations that predict inflation - particularly with long horizons - and that these predictive relationships appear to be robust over time and across different countries (e.g. Estrella, 2004, p.722); others noted that "With some notable exceptions, the papers in this literature generally find that there is little or no marginal information content of term spread for inflation at the short end of the yield curve, although Mishkin (1990b) found predictive content using spreads that involve long bond rates" (Stock and Watson, 2003, p. 795) [1].

In one of the most influential papers in the literature, Mishkin (1990a) found that, although term structure of short interest rates (six or less months) includes almost no information about future path of inflation, term structure of long maturities (9 and 12 month) have significant predictive power for inflation rate. Mishkin (1990b) further investigated the relationship with even longer maturities of one to five years and found that there is a great of information in the longer maturity term structure about the future inflation. Mishkin (1991) and Jorion and Mishkin (1991) applied same methodology to some OECD and European economies and they find familiar results.

Another area of research has focused on the question of to what extent this predictive power depends on monetary policy regimes. Mishkin (1990a) concludes that there is no evidence for changing in amount of information carried on term structure about future inflation as monetary regime changes. However, in his following paper, Mishkin (1990b) found that the coefficient relating term structure and inflations show significant changes associated with the change in the procedures for conducting monetary policy. Estrella and Mishkin (1997), also, examine the relationship between term structure of interest rate and inflation, monetary policy

[1] Gamber (1996), Gerlach, (1997), Ivanova et al. (2000), Nagayasu (2002), Estrella et al. (2003) and Trackz (2004) are all investigate the information content of term structure about future economic activity they all conclude that slope of yield curve is a good informative about the future inflation using spreads that involve long interest rates similarly to Mishkin (1990b).

and real economic activity in the USA and Europe. They conclude that term structure of interest rate has significant predictive power on both inflation and real activity and they also argue that the relationship between yield spread and future inflation might also differ with changes in monetary policy. Similarly, Gamber (1996), Estrella at al (2003), Telatar et al (2003), Bordo and Haubrich (2004), Tkacz (2004), Duffe (2006) all argue that the relationship between term structure of interest rate and inflation is not stable and affected by regime changes.

These issues are extensively examined, particularly for US, European countries, and other developed economies. However, this vast literature has remained scarce for emerging market cases. The whole literature on emerging market economy cases consists of a few papers to the best of our knowledge[2]. In the present paper we try to fill this gap by presenting a new research on Turkey. Turkey is one of emerging market economies that can constitute an important case study for this type of research since it has one of the biggest bond markets in the world among the developing countries[3].

The most important result emerging in our paper is the following: Monetary policy change is an important determinant of the relationship between term structure and inflation to the extent that even the existence of the relationship critically depends on the nature of monetary policy regime. In our case, the change in monetary policy is associated with the beginning of the implementation of an inflation targeting (IT) regime. Moreover, while, before IT regime, the information in term structure does not provide any predictive power for future inflation, this phenomenon seems to be completely reversed after IT. Since the implementation of IT, term structure of interest rates has seemed to gain considerable forecasting power for future inflation.

In the previous two studies of Turkish economy, Sahinbeyoglu and Yalcin (2000) and Telatar at. al. (2003) both tried to extract information about inflation by using term structure of

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[2] Except the two studies on Turkey are mentioned below, to the best of our knowledge, the following two papers on Mexico constitute the only examples of this line of research on emerging market economies. In one of those studies Gonzales et al. (2000) investigate the predictive power of term structure of interest rate for different macroeconomic variables including inflation. In the other study, Ogaki and Santealla (2000) analyze the effects of term structure of interest rate on exchange rate not on inflation. Although it is a small European economy, we can also include Greece in our short list by quoting Drakos (2001) who investigates the impact of monetary policy on term structure of interest.

[3] More information on the size and importance of Turkish fixed income market can be found at http://www.ise.org.

interest rate. Sahinbeyoglu and Yalcin (2000) applied the Mishkin's (1990a,b) model to Turkish economy and found that term structure of nominal interest rates has a significant but, contrary to previous studies and theoretical expectations, negative effects on future inflation path. They argued that the result may due to the high volatile and no-deep financial market. In addition to this, volatility in real interest rate, imbalances in macroeconomic variables, persistent high inflation, and structure of public sector borrowing created uncertainty and pressure on financial markets that prevent to extract healthy information. Telatar at al (2003) visited the relationship between yield curve and inflation in Turkey and find that fixed coefficient regression model is rejected by data. By taking into account the political instability[4], high and volatile inflation during corresponding period (1990-2000), they argued that the usage of a time-varying-parameter model is more appropriate. They found that, contrary to Sahinbeyoglu and Yalcin (2000), there is a positive relationship between the slope of yield curve and inflation. However, information content of the yield curve about future inflation found as very low.

In this paper we extent the period of the analysis until the beginning of 2009. By incorporating the data after the implementation of IT (January 2002), we are able to analyze the effect of a monetary policy regime change on the relationship between term structure of interest rate and inflation. As indicated above, we found that monetary policy has a decisive effect on the relationship. As presented below, our work reveals that the beginning of the IT registers a structural break both in inflation and in the relation between the yield curve and inflation. This structural break plays a key role in the nature of the relationship in the sense that, after the break the relationship becomes significant[5] and yield curve has achieved considerable power for forecasting inflation.

The rest of the paper is organized as follows. The second section analyzes the time series properties of the data. The results of this section indicate the possibility of a unit root in inflation series which leads us to take into the account the consequences of having a mixture of variables in our estimations. In the third section we use Bai and Perron (1998, 2003) procedure to determine the possible break date in the mean inflation. In the fourth section we

[4] Turkey had 11 different governments during 1990-2000.

[5] In an interesting study Gonzales et al. (2000) also analyze the predictive content of term structure for different macroeconomic variables, including inflation, using two different periods of Mexican Economy which they call economic turmoil and stability. Term structure is found to have predictive power in both periods for inflation as for the pooled regression which combines both periods. However, like in Sahinbeyoglu and Yalcin (2000), the coefficients are not correctly signed.

apply the same procedure once more to determine the possible break date in the relationship between yield curve and inflation. Section five tests the forecasting power of yield curve for future inflation before and after the structural break. Section six concludes.

2. Time series properties of the data

The data are monthly and range from January 1995 to January 2009. We denote annualized inflation from t to $t+h$ expressed at a monthly frequency as $\pi_t^h = \frac{12}{h}\left(\log CPI_{t+h} - \log CPI_t\right)$. CPI series, published by Turkish Institute of Statistics on monthly basis, are seasonally adjusted[6]. To construct interest rate spreads we use Treasury bond rates with maturities 1, 3, 6 and 12 months[7]. These data are obtained from Istanbul Stock Exchange database on a daily basis[8] and monthly averages are used in the estimation. Spreads are calculated as the differences between short (1 month) and "medium" and "long" rates (3, 6, 12 months). Unfortunately, it is not possible to find interest rates in longer maturities for Turkish economy, especially in the early periods of our data mainly because of the lack of deep financial market and high uncertainty. This is also true even after 2001 although a significant drop in the inflation rate occurred associated with the implementation of IT regime at that date[9]. We denote term spread between m and n months maturity as $\xi^{m,n}$ in our following empirical exercise. For example term spread of difference between 12 and 1 months interest rate is denoted by $\xi^{12,1}$.

[Table 1 is here]

To determine the time series properties of the data, we first perform unit root tests. Table 1 shows the results of three ADF-type tests that have the null hypothesis of non-stationary. Among three ADF tests, the ADF-WS (Park and Fuller, 1995) and the ADF-GLS test (Elliott,

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[6] Hence, π_t denotes the monthly inflation rate.

[7] In fact, we first perform the following transformation to our data: $R = \ln(1+i)$, where i is the interest rate.

[8] The interest rate data has been obtained by Riskturk (www.riskturk.com). In constructing the yield curve official bond market data has been collected from Istanbul Stock Exchange. Since the Turkish Fixed Income Bill and Bonds are traded in an official exchange (more information can be found at http://www.ise.org) a reliable official data exists and the market is rather liquid for an emerging market. Once the official data is obtained from the ISE, the spot yields are solved. Then a simple interpolation scheme is used to construct the yield curve. We believe a more advanced yield curve construction technique such as Nelson and Siegel (1987) (see Diebold and Li (2006)) do not make a big difference since the correlation between these two techniques was very high. More details can be found in http://www.riskturk.com.

[9] Longer rates with maturities higher than one year has recently started to be observed in Turkish economy. We interpret this fact as evidence on that the market has just begun to develop confidence on the implemented policy.

1996) are designed to have higher power than the standard ADF. They perform also particularly well in small samples, and there has been evidence for having better power than the standard ADF test (see, for example, Pesaran, 2007). Two versions (an intercept only and an intercept plus trend)[10] of these tests are applied for different orders of augmentations. The lag order of ADF tests are either determined by Akaike Information Criteria (AIC) by setting the maximum lag to 12[11]. All tests with a trend term are unambiguously indicate all series are I(0). For the intercept only case, all tests also confirm the stationarity of all spreads with a single exception (ADF_GLS for $S^{3,1}$). Therefore we have sufficient evidence to assume that all spreads are I(0) as it should be expected from a theoretical point of view as well. However, while all tests without trend reject the unit root in inflation, tests with trend point out nonstationarity.

Hence we have mixed evidence on the time series properties of inflation[12] depending on whether the DGP of inflation contains a trend or not. A closer look at the data (see Figure 1 below) gives a clear impression on the presence of a break in inflation. Therefore to obtain more evidence on time series properties of inflation we also consider two unit root tests which take into account the structural breaks in the data. As is well known Perron (1989) asserts that a stationary series can be spuriously seen nonstationary in the presence of breaks. Hence, in our case, inflation may spuriously be detected as nontstationary, in tests with trend, because of breaks[13]. In Perron (1989) test, which is a test with exogenous breaks, structural break date is assumed to be known and taken to be as the beginning of the IT period 2002:01 for the inflation. This choice is justified on the ground that the statistical evidence, presented in the following section, clearly indicated the presence of breaks at that date. On the other hand in Perron (1997) structural break date is assumed to be endogenous and is estimated during estimation process of unit root regressions. The results of these tests are illustrated on Table 2 and null hypothesis of unit root rejected by all test statistics except one. This leads us to conclude, with some minor reserves, that inflation is stationarity process with a possible break in the data. However, in the following sections we also take the possibility of a unit root in the inflation into consideration.

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[10] The inclusion of the linear trend term, by making an analogy to PPP case, can be justified by Harrod-Samuelson-Balassa effects or measurement error in prices, particularly in the treatment of quality (e.g., see Pesaran et al., 2009).

[11] Schwarz Bayesian Criteria yield qualitatively same results.

[12] This result is broadly consistent with the existing literature in which the ambiguity about the stationarity or nonstationarity of inflation does not seem to be removed yet.

[13] Since all tests indicate stationarity of spreads, and since it is a reasonable result from theortical grounds, it is not necessary to perform these tests for spreads.

[Table 2 is here]

3. Structural break tests for inflation

In this section we test one of the hypotheses that we consider in this study: A structural break corresponding to the beginning of the implementation of IT, which, we think, is easier to verify than a structural break occurring in the relation between inflation and term structure of interest rate. As mentioned above, an apparent break in the inflation series clearly shows itself in the data as is shown in Figure 1.

[Figure 1 is here]

To test the presence of a break in inflation series we employ Bai and Perron (1998, 2003) procedure which involves running regressions and testing for breaks simultaneously. We first test the presence of breaks in the mean inflation by running a regression including only a constant in the inflation equation[14]. We consider single break in the data and allow a trimming value being equal to 0.15 All $supF_T(1)$ tests, U Dmax and W Dmax test statistics are significant at 5 percent level indicating the rejection of the null hypotheses of no break against the alternative of a single break. The estimated break date is the first month of 2002, which exactly coincides with the start of IT. The break date has a 95 percent confidence interval of 2001:12-2002:08. The estimated means are significant, and after 2002 mean of monthly inflation significantly decreases from 0.53 to 0.12.

[Table 3 is here]

4. Structural break tests for the relation between inflation and term structure of interest rate

Given the above statistical evidence on the presence of a break in the inflation, in this section we consider one of the other hypotheses of this paper which states the possibility of a structural change in the relationship between term structure of interest rate and inflation. We employ Bai and Perron (2003) procedure for the following regression.

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[14] We allow serial correlation in errors of the regression.

$$\pi_t = \alpha + \beta \xi_t^{m,n} + \varepsilon_t \tag{1}$$

Where π is one month inflation and ε is the usual disturbance term. We analyze the presence of breaks in this relationship when $\xi^{m,n} = \xi^{12,1}, \xi^{6,1}, \xi^{3,1}$ by considering a single break[15].

[Table 4 is here]

All sup$F_T(1)$ tests point out the rejection of the null of no break in favor of a single one[16] in the relation between inflation and spreads. The estimated break date, as before, is 2002:01 for all the spreads, which is the beginning of the implementation of IT. To solidify the existence of break in relation (1), we also employ Andrews-Quandt and Andrews-Ploberger structural break tests for an unknown single break (see Andrews and Ploberger, 1994 and Hansen, 1997) and find 2002:01 as the break date as well[17]. Therefore we conclude that there are notable empirical evidences to conclude that corresponding relationship has a break at 2002:1.

5. Estimating the relation between inflation and term structure of interest rate

In this section, following Stock and Watson (2003) we estimate the regression in (2) to analyze the predictive content of spreads for π_t^h, i.e. inflation over the coming h months. Given the above evidence on structural break occurring at 2002:01 in the relation between inflation rate and term structure of interest rate we run forecasting regressions both before and after the break date separately.

$$\pi_t^h = \beta_0 + \sum_{i=0}^{p} \beta_{1,i} \xi_{t-i}^{m,n} + \sum_{i=0}^{q} \beta_{2,i} \pi_{t-i} + v_t \tag{2}$$

We consider forecast horizons, h, up to 12 months. For each h the lag length (p, q) of the forecasting regression is selected by searching across $5^2 = 25$ alternative models spanned by $p = q = 0,1,\ldots,4$. These models are estimated by OLS and lag orders p and q are selected by

[15] Bai and Perron's procedure also delivers us the parameter estimates in the corresponding "regimes" indicated by the estimated break dates. We do not report these parameter estimates here as they do not deliver us statistically significant results. They are available upon request.
[16] Since U Dmax and W Dmax test statistics are identical to sup$F_T(1)$ we do not report these statistics.
[17] These results are available upon request.

using AIC. As the data are overlapping the error term v_t is serially correlated so the test of predictive content is computed by using heteroscedasticity and autocorrelation consistent (HAC) standard errors.

The hypothesis that spread has no predictive content for future inflation correspond to the hypothesis that $\beta_{1,i} = 0$ for all *i*s in the model. We test this hypothesis by using heteroscedasticity and autocorrelation robust F-statistics. Panel a of Table 5 reports the results of these tests for the period the break (1995:1-2001:12). The tests, with a few exceptions, indicate that term spreads do not have predictive power for future inflation.

[Table 5 is here]

However, when we investigate the period of 2002:1-2009:1, as the results in panel b of Table 5 there is ample evidence on that the term spreads have predictive power on future inflation. In particular, relatively shorter two spreads (6 and 3 month's spreads), have predictive power for all forecast horizons, *h*, while the longest spread has this predictive power only for short forecast horizons. Therefore, in Turkish case, the information content of term spread for inflation seems to be concentrated at the short end of the yield curve rather than the "long" end. Overall, in the IT period, interest rate spreads can be used as useful predictors of inflation.

6. Conclusion

In this paper we analyzed the predictive power of the term structure about future inflation for Turkey, which constitutes an important emerging market case study for this type of research with its reasonably sizeable bond market. The empirical evidence presented in this paper indicated that the monetary policy change happened in 2002 played an important role in the nature of the relationship between term structure and inflation. All structural break tests clearly indicated a break, associated with the beginning of IT, in the relation between term structure and inflation. Moreover, even though, before IT, it is only possible to find very week evidence on the predictive content of term structure on future inflation, term structure gains a considerable predictive power after IT. Hence the evidence suggests that, in the IT regime, the information content in term structure of interest rate has become useful for predicting future inflation. Based on this result, it is possible to argue that market players' expectations embedded in the term structure of interest rates has started to turn out to be right in the IT regime. Hence, IT regime may have provided suitable environment in which forecasting inflation is easier.

As mentioned above, in Turkish case, the information content of term spread for inflation seems to be concentrated at the short end of the yield curve rather than the “long” end[18]. This fact may be explained on the following grounds. It is known that short maturity papers still have a considerable weight among the total number of papers traded in Turkish market[19] even though there has been a significant drop in the inflation since the implementation of the IT. Although this phenomenon has recently begun to change and longer maturities have emerged in the market, for almost all period under consideration in this study the share of long term papers in the market remained low relative to short term papers. Therefore the information about the future inflation embedded in the term structure is concentrated more in short horizon and this particularity of Turkish market has rendered the short horizon yield curve more predictable about future inflation.

[18] This result is in contrasts with the results of Mishkin (1990b) and others, where the information content is rather concentrated on the long end of the yield. However, as mentioned before, it is not appropriate to compare the “long” maturity in Turkish case with the long maturity of the studies on developed countries, which is usually around 1-5 years.

[19] See http://www.ise.org.

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TABLES

Table 1: Unit Root Tests

	ADF		ADF-GLS		ADF-WS	
	Intercept	Trend and Intercept	Intercept	Trend and Intercept	Intercept	Trend and Intercept
π_t	-1.70	-6.45**	-0.29	-6.48**	-1.38	-6.66**
$\xi^{12,1}$	-3.47**	-3.68**	-2.36**	-3.60**	-3.62**	-4.01**
$\xi^{6,1}$	-2.78**	-3.47**	-1.70*	-3.45**	-2.92**	-3.77**
$\xi^{3,1}$	-3.20**	-3.87**	-1.08	-3.11**	-3.18**	-4.17**

- **, *: Indicates that the null of unit root is rejected at 5 and 10 % significance levels.

Table 2: Perron Unit Root Tests with Breaks for π_t

Test	Exogenous Break	Endogenous Time Break		
Model	Test statistics	Model	Break Date	Test statistics
Model (A)	-7.383**	IO1	2003:03	-5.21**
Model (B)	-7.97**	IO2	2001:12	-5.99**
Model (C)	-7.35**	AO	2005:08	-4.54

-The exogenous break date is 2002:01
- Model A, B, C are defined by Perron (1989, p.1394).
- IO1: Innovational outlier with a change in the intercept. IO2 : Innovational outlier with a change in the intercept and in the slope. AO : Additive outlier with a change in the slope only but both segments of the trend function are joined at the time break. Critical values tabulated were by Perron (1997;362-3624).
- **, *: Indicates that the null of unit root is rejected at 5 and 10 % significance levels.
- The optimal lag length for the Perron regressions are determined by adding lags until the Ljung-Box test rejects residual correlation at %5 level.

Table 3: Break Tests

$supF_T(1)$	U Dmax	W Dmax
124**	124**	124**
α_1 0.53, (22,8**)	α_2 0.12 (3.79**)	$\hat{T}$ 2002:1 (2001:10-2003:02)

- $supF_T(k)$ tests the null hypothesis of zero break against k breaks, U Dmax and W Dmax test the null hypotheses of zero break against 1 breaks. See Bai and Perron (1998, 2003) for the details of tests.
- **, *: Indicates that the null of unit root is rejected at 5 and 10 % significance levels.
- $\hat{T}$ indicates the estimated break date.
-α_1 and α_2 refer to the constant terms in two different regimes associated with the estimated break date. In parenthesis are t statistics for constants and %95 confidence intervals for $\hat{T}$

Table 4: Break Tests

	$supF_T(1)$	Break Date
$\xi^{12,1}$	123.33**	2002:01
$\xi^{6,1}$	149.06**	2002:01
$\xi^{3,1}$	97.53**	2002:01

- $supF_T(1)$ tests the null hypothesis of zero break against 1 breaks. See Bai and Perron (1998, 2003) for the details of tests.
- **, *: Indicates that the null of unit root is rejected at 5 and 10 % significance levels.

Table 5: Forecasting Power of Term Spread

(a) Before 2002

	$\xi^{12,1}$		$\xi^{6,1}$		$\xi^{3,1}$	
h	Selected Model (p,q)	F statistics	Selected Model (p,q)	F statistics	Selected Model (p,q)	F statistics
1	(2,1)	5.38**	(1,1)	2.84*	(1,1)	0.98
2	(1,4)	2.20*	(1,1)	0.63	(1,1)	0.39
3	(1,4)	1.21	(1,2)	0.44	(1,2)	0.35
4	(1,4)	1.35	(1,1)	0.30	(1,1)	0.08
5	(1,4)	1.38	(1,1)	0.29	(1,1)	0.10
6	(1,4)	1.47	(1,1)	0.25	(1,1)	0.19
8	(1,4)	1.75	(1,1)	0.22	(1,1)	0.24
10	(1,4)	1.98*	(1,4)	0.63	(1,1)	0.13
12	(1,4)	1.77	(1,1)	0.36	(1,1)	0.10

(b) After 2002

	$\xi^{12,1}$		$\xi^{6,1}$		$\xi^{3,1}$	
h	Selected Model (p,q)	F statistics	Selected Model (p,q)	F statistics	Selected Model (p,q)	F statistics
1	(2,1)	4.89**	(2,1)	5.13**	(2,1)	5.14**
2	(1,1)	6.29**	(1,1)	6.74**	(1,1)	3.13**
3	(1,4)	2.29**	(1,4)	2.80**	(4,1)	5.47**
4	(1,4)	1.10	(4,1)	4.13**	(4,1)	4.57*
5	(4,1)	1.21	(4,1)	4.65**	(4,1)	4.36*
6	(4,1)	1.15	(4,1)	4.55**	(4,1)	4.15*
8	(1,4)	1.54	(4,1)	4.64**	(4,1)	3.22**
10	(4,1)	1.39	(4,1)	3.94**	(4,1)	2.72*
12	(4,1)	1.60	(4,1)	4.31**	(4,1)	3.03**

- **, *: Indicates that the null of no predictive power is rejected at 5 and 10 % significance levels.

FIGURES

Figure 1: Monthly inflation rate of Turkey