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TERM STRUCTURE OF INTEREST RATE AND MACROECONOMIC VARIABLES: THE TURKISH CASE

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Abstract

This study includes very initial analyses of ongoing research which investigate the relationship between term structure of interest rate and macro variables in Turkey. Initial .ndings indicate that corresponding relation has structural break around 2002 which coincides with new mon- etary policy namey in.ation targeting. In pre2002 period role of macro- economic variables in yield curve is limited however in post 2002 period macro variables play very crucial role in term structure of interest rate. We found that in.ation and exchange rate are two majar macro variables that determine the shape of yield curve.

Key Words: *term structure, interest rate, latent factor, yield curve*

JEL Classification: G1, E4, C5

1. INTRODUCTION

One of the most influential works that bring new breath to term structure modeling was proposed by Ang and Piazzesi (2003) (AP hereafter). AP proposed a term structure model with inflation and economic growth factors together with latent variables. In the model it is not allowed to bidirectional link i.e. there is no feedback for macro variables and contemporaneous correlation of macro and latent factors are zero. After constructing an affine term structure model with both observed and unobserved factors, AP estimate the model by using two-step consistent estimation procedure. In the first step the macro dynamics and coefficients of short rate are estimated by OLS. Holding estimated parameter fixed, in second step the rest of all parameters are estimated by numeric maximization. AP found that macro variables namely inflation and growth explain significant portion of (%85) movements in short and middle part of the yield curve but explain only about %40 percent of movements in long end of the yield. Comparing the latent factors from previous literature, significant part of the level and slope factor are attributed to macro factors especially to inflation. However AP's two stage estimation method relies on the assumption that short rate does not affect the macro variables.

Hördahl et al. (2006) redress shortcomings of bidirectional link between term structure of interest rate and macro economy and construct dynamic term structure model entirely based on three macroeconomic factors namely inflation, the output gap and short-term policy interest rate. The main assumption is that aggregate macroeconomic relationships can be described using a linear framework. Using German data and model is estimated by maximum likelihood estimation. They found that estimated macro variable parameters which are partly determined by the term structure are consistent with those estimated only macro variables. On the other hand model has significant explanatory power for the term structure. On the other hand it is found that yields don't seem to provide useful additional information in forecasting macro variables however model performs very well in forecasting yield curve.

Diebold et al (2006) examine the correlations between Nelson Siegel yield factors and macroeconomic variables. The basic model framework for yield curve is a latent factor model but in dynamics fashion. Diebold et al (2006) characterize the relationship among Level (L), Slope (S) and Curvature (C) factors and the macro economy. They found strong evidence of macroeconomic effects on future yield curve and somewhat weaker evidence that yield curve effects future macroeconomic variables. It is found that market yields contain important predictive information about federal funds rate.

In addition to these studies, Redebusch and Wu (2003), Ang et al. (2006) construct joint models and they both find that there is bidirectional link between yield curve and macroeconomic variables.

This study includes very initial analyses for the relationship between term structure of interest rate and macro variables in Turkey. Following parts are including factor analysis and regression analysis. Initial findings indicate that corresponding relation has structural break around 2002 which coincides with new monetary policy namely inflation targeting date. In pre2002 period role of macroeconomic variables in yield curve is limited however in post 2002 period macro variables play very crucial role in term structure of interest rate. We found that inflation and exchange rate are two major macro variables that determine the shape of yield curve.

2. FIRST LOOK AT THE DATA AND INITIAL ANALYSIS

This section provides an overview of data description, summary statistics and some simple analysis. We use monthly data covering the period 1993M1-2009M2 for 1, 2,3,4,6,9 and 12 months maturities interest rates; tr1, tr2, tr3, tr4, tr6, tr9, tr12. Interest rates data has been obtained by Riskturk Official bond market data has been collected from Istanbul Stock Exchange and spot yields are solved then by a simple interpolation scheme daily yield curve is constructed. We calculate monthly interest rates by taking monthly averages

We use numbers of macro data, including inflation, growth, capacity utilization, USD exchange rate growth, real effective exchange rate, interest rate of CBRT, change in Istanbul stock exchange rate, change in budget deficit, amount of domestic borrowing, capital account, current account balance. Macro variables are obtained from International Financial Statistics and Central Bank of Republic of Turkey.

Figure 1 plots the lowest (1 month) and highest (12 months) maturities interest rates in the study and Figure 2 plots the 1 month interest rate and one month inflation rate (calculated from CPI). Short and long rates moves very closely and both level and variation of interest rates are gradually decreasing after 2002. Decreasing characteristic of the yields seem to be very related to the level of inflation in Turkey (Figure 2).

Figure 1 : Sort and Long Rate

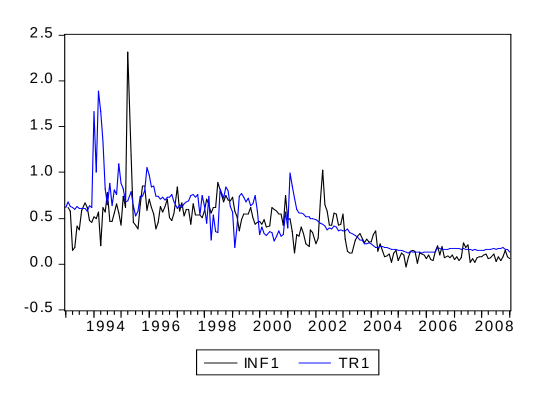

Figure 2 : Short rate and Inflation

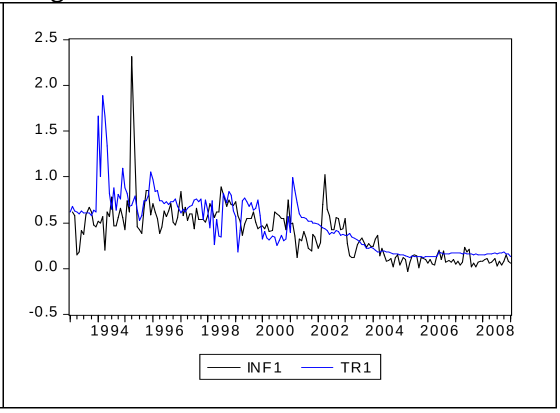

Figure 3: Term Spread

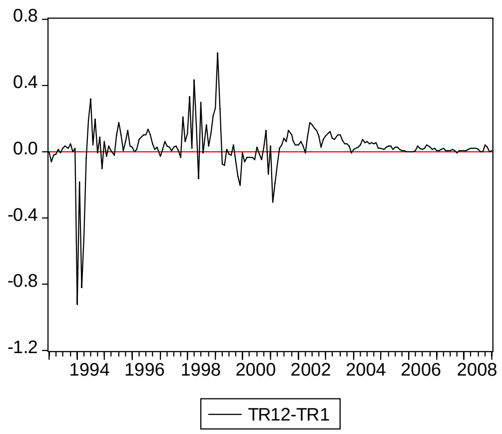

Figure 3 plots the spread between long and short rates namely twelve month and one month The yield curve usually upward sloping during the 1993-2009. In literature it is well documented that yield spreads are successfully predict the recession (Estrella and Mishkin, 1998, Inova et al. 2000, Chauvet and Potter, 2002). It is found that negatively sloped yield curve is always followed by a recession (Ang et al.2003). According to Durmus (2009), during 1993-2009 Turkey has experienced 3 recessions which are in 1994M4-1995M3, 1998M10-199911 and 2001M2-2002M2. On Figure 3 we can see that downward sloping yield curve coincides with these recession times.

As an initial analysis, we try to investigate whether the yield curve predict recession in Turkey by using a simple probit model. The model is following;

$$y_t = \beta' s_{t-k} + \varepsilon_t$$

$$R_t \begin{cases} 1, \; if \; y_t < 0 \\ 0, \; if \; y_t > 0 \end{cases}$$

Estimated equation is

$$P(R_t = 1) = F(\beta' s_{t-k})$$

where y_t represents the occurrence of recession at time t and s is the vector including constant and spread as independent variables. We use monthly GDP[1] growth (logGDP-logGDP$_{-12}$), and capacity utilization as dependent variable. When the monthly growth is negative then in estimated equation R_t takes values 1 and 0 otherwise. When we use constructed GDP growth as dependent variable, we cannot find any evidence that spread predict recession.

However use of capacity utilization change to determine recession time (it indicates similar recession times with Durmus (2009) shows that negatively sloped yield curve has some prediction power on recession. We find that coefficient of spread for k=3, is -1.26 and significant at 10 percent level. For any other lag structure coefficients are insignificant. These findings indicate that when spread between long and short yield turns in negative, it can be read as a signal for coming recession.

In the literature it is documented the instability of yield curve and unstable relationship between macroeconomic variables and yield curve (Stock and Watson, 2003). The main source of instability is regarded as monetary policy. In Turkey there is monetary policy shift in 2002 in which inflation targeting is started. A detail look at the interest rates and macroeconomic variables, indicates a structural change of series around 2002. This is mainly because of different type of economic and political conditions including monetary regimes[2]. In order to clarify this argument we employ structural break test on interest rates and macroeconomic variables. By employing Quandt-Andrews endogenous structural break test on the regression y=c+ε where every series are regressed on only constant, we found level structural break around 2002 for all variables[3].

In the light of these findings, we divide sample period as 1993:01- 2001:12 (pre 2002) and 2002:01-2009:01 (post 2002) to get more accurate results and see the effects of monetary policy regimes.

[1] Monthly GDP is calculated from quarterly GDP by using qubic spline method

[2] During 1993-2002 period Turkey experienced three financial crises and a great earthquake. During 1989-1993 CBRT mostly did not sterilize the capital inflow however in 1995-1999 period CBRT choose to sterilized inventory policy. On the other hand, over the 200-2001 period fixed exchange rate regime is used. Also in this period goverment was changed nine times .

[3] We also apply another endogenous structural break test developed by Bai and Perron (1998,2003) and find very similar break dates.

Table 1: Break Test

Variable	Endogenous break date	Variable	Endogenous break date
tr1	2002M4	tr12	1999M12
tr2	2002M3	inf	2003M2
tr3	2002M3	growth	2003M6
tr4	2002M11	usdgr	2002M4
tr6	2002M11	cugr	2003M1
tr9	1999M12		

3. FACTOR ANALYSIS

One common way of analyzing yield curve is factor model approach which enables to express a large set of variables as a function of small set of unobserved factor. Dai and Singletoon (2000) show that yield curve can be very well expressed by three factors.

Among practioner Nelson and Siegel (1997) representation of yield curve is very popular. Nelson and Siegel representation is:

$$y(\tau) = \beta_{1t} + \beta_{2t}\left(\frac{1-e^{-\lambda_t \tau}}{\lambda_t \tau}\right) + \beta_{3t}\left(\frac{1-e^{-\lambda_t \tau}}{\lambda_t \tau} - e^{-\lambda_t \tau}\right)$$

where β_{1t}, β_{2t}, β_{3t} and λ are parameters, $y(\tau)$ is yield with maturity τ .Nelson-Siegel yield curve is derived from a constant plus Laugerre function, which is a popular mathematical approximating function, type forward rate curve.

Diebold and Li (2006) describe that this model is a dynamic latent three-factor model in which β_1, β_2 , and β_3 time varying level, slope and curvature.

Diebold and Li (2006) shows that Nelson-Siegel yield curve representation is a dynamic latent three-factor model in which β_{1t}, β_{2t} and β_{3t} time varying level, slope and curvature factors. Parameter λ governs the exponential decay rate. Small values of λ produces slow decay and large values of λ produces fast decay and small and large value better fits the curve at the short and at the long respectively. Additionally λ determine at where β_{3t} reaches its maximum. Loadings on β_{1t} is 1 which means that it does not decay to zero in the limit and hence can be regarded as long term factor. The loadings on β_{2t} starts at 1 but quickly and monotonically decay to zero so it can be interpreted as short term factor. On the other hand loadings on β_{3t} starts at zero, increases and then decays to zero: Thus it can be viewed as medium term factor. Following literature, these factors also may be interpreted in terms of level, slope and curvature factors respectively (Diebold and Li, 2006).

Figure 4: Factor Loadings

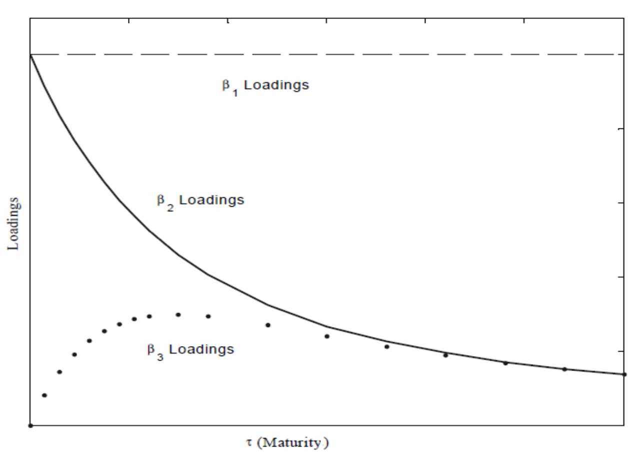

Figure 4 plots the factor loadings. We can easily show that an increase in β_{1t} increases entire yield curve equally hence change the level of yield curve. β_{2t} closely related to yield curve slope which is defined as long minus short rate (usually ten years minus three months yield). It is defined the yield curve slope as y(∞)-y(0) which exactly equal to - β_{2t}. Short rates loads on β_{2t} is much more, an increase in β_{2t} increases short yield more than long yields. Lastly β_{3t} is closely related to curvature because an increase in β_{3t} increases medium term very much but short and long yield very small (Diebold and Lee,2006).

One way of estimating parameters of θ={ β_{1t}, β_{2t}, β_{3t}, λ_t } is use of nonlinear least squares for each month. Employing nonlinear least square produces numbers of challenging numerical optimizations and ready to stuck in local maximums. Instead of doing this, we can estimate parameter by ordinary least square if we can fix the λ. How can one find a fixed value for λ? We can find an appropriate value for λ, if we consider that λ determines the maturity at which curvature factor namely β_{3t} reach its maximum. In the literature two or three years are commonly used in that regard. However in our study longest maturity is 12 months. By taking the maturity scale into consideration three or four month can be properly used, and we use the average of these and picked the 3.5 months. We found that value that maximizes the loadings on β_{3t} at maturity 3.5 (i.e. τ=3.5) months is 0.4483. Using τ=3.5 and λ=0.4483 we estimate β_{1t}, β_{2t} and β_{3t} by employing least squares.

In literature, level, slope and curvature factors have empirical counterparts. As level factor is the most persistent one, long rate is regarded as empirical level factor, in our study it is y(12). Empirical slope factor was defined above, in here it corresponds to y(1)-y(12). Empirical curvature factor is usually defined as 2y(24)-y(120)-y(3). However in this study highest maturity is 12 and by taking scale into consideration, we define empirical curvature factor as [y(3)+y(4)]-y(12)-y(3).

In pre 2002 period, correlation between β_{1t} , β_{2t} , β_{3t} ,and their empirical counterparts are 0.82, 0.96 and 0.99. In post 2002 period correlations are 0.99, 0.99 and 0.97 respectively. In both period, estimated factors and their empirical counterparts are highly correlated, and correlation is increasing in post 2002 period..Figure plots the factors and empirical counterparts during whole period.

Table 2: Descriptive Statistics and Unit Root Test

	Pre 2002				Post 2002		
	Mean	Std.Dev	ADF		Mean	Std.Dev	ADF
β_{1t}	0.65	0.24	-3.68*		0.26	0.14	-1.93
β_{2t}	-0.02	0.25	-4.02*		-0.06	0.06	-3.98*
β_{3t}	0.23	0.65	-8.36*		-0.002	0.06	-6.17*

* indicates significant at 0.05 level

4. ROLE OF MACROECONOMIC VARIABLES

What about role of macroeconomic variables in this picture? By now we can analyze the relation between macro variables and estimated latent factors to get clues about the role of macroeconomic variables in yield curve dynamics. Table 2 documented the descriptive statatistics and Augmented Dickey Fuller unit root test results for factors. Only for β_{1t} in post 2002 period null of unit root cannot be rejected.

Table 3: Correlations (Pre 2002)

	β_{1t}	β_{2t}	β_{3t}
β_{1t}	1	-0.19	-0.56
β_{2t}	-0.19	1	-0.05
β_{3t}	-0.56	-0.05	1
Growth	0.29	-0.11	0.01
Inflation	0.35	-0.29	0.00
USD Growth	0.40	-0.01	-0.05

In pre 2002 period, β_{1t} has the highest correlation with β_{3t} . From Fisher equation one can expect a link between the level of the yield curve and inflation expectations hence 0.35 correlation between β_{1t} and inflation is consistent with this. Including Diebold et.al. (2006), Hordahl et al (2006), and Rudebusch and Wu (2003), in macro finance literature this relation is common theme. However correlation between usd dollar growth and level of yield curve is a bit higher than correlation of inflation. Previous studies show that exchange rate has important role in risk premium, price level and monetary policy (Diboğlu and Kibritçioğlu, 2004) in Turkey. This link is not documented before in corresponding literature and indicates that exchange rate should not be rule out in yield curve studies in an emerging market like Turkey.

As we documented before -β_{2t} is highly correlated with slope of yield curve y(12)-y(1). In literature it is well documented that slope of yield curve is a good predictor of future economic growth. Correlation between β_{2t} and growth shows that there is no expected link. but correlation with inflation is about 0.30. Including Mishkin (1990), Estrella and Mishkin (1998), Estrella (2004) among others showed that slope of yield curve predicts future inflation. So correlation between slope factor and inflation is consistent with these studies.

Table 4: Correlations(Post 2002)

	β_{1t}	β_{2t}	β_{3t}
β_{1t}	1	-0.87	0.26
β_{2t}	-0.87	1	-0.25
β_{3t}	0.26	-0.25	1
Growth	-0.75	0.66	-0.44
Inflation	0.92	-0.80	0.33
USD Growth	0.52	-0.35	0.24

The same correlation table for post 2002 period draws a different picture. Fist of all, the correlation between level and slope factor is very high which indicate that both of them effected by common factor/factors. Correlation of inflation with level factor is 0.90 and slope factor is -0.80. . On the other hand growth has high correlation with both level and slope factor. Also USD growth's correlation is not low with these factors. From this picture we can say that both level and slope factor mainly driven by inflation and growth. While in pre2002 period, curvature factor is not correlated any macro variables, in post 2002 period correlation with macro variables is considerable high. This findings indicates that in post 2002 period yield curve is mainly driven by the macro variables.

5. CONCLUSION

This study includes very initial analyses for the relationship between term structure of interest rate and macro variables in Turkey. Initial findings indicate that corresponding relation has structural break around 2002 which coincides with new monetary policy namely inflation targeting date. In pre2002 period role of macroeconomic variables in yield curve is limited however in post 2002 period macro variables play very crucial role in term structure of interest rate. We found that inflation and exchange rate are two major macro variables that determine the shape of yield curve.

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