Term Structure and Macroeconomy: The Case of Serbia

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Abstract

The present paper uses an updated version of the Nelson-Siegel (1987) yield curve model to analyze the Serbian bond market. The estimation of the Serbian term structure is rather complex because the only bonds with maturities over one year are denominated in Euros rather than in dinars. In spite of this problem, the estimated yield curve is related to macroeconomic indicators in the standard fashion. Namely, the level and slope yield curve factors respectively reflect changes in inflation and industrial production. Some term structure factors Granger-cause inflation, depreciation and industrial production, and similarly, inflation Granger-causes some of the factors.

KEY WORDS: yield curve; Nelson-Siegel; impulse response; Serbia

JEL CLASSIFICATION: E43 - Determination of Interest Rates, Term Structure of Interest Rates; E44 - Financial Markets and the Macroeconomy

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1 Introduction

The Serbian bond market was created essentially from the scratch in the early 2000's. It consists of two major segments. The first is given by T-Bills and T-Bonds respectively issued by the National Bank of Serbia and the Serbian Ministry of Finance and the second originates in conversion of frozen foreign deposits from 1990's into bonds.[1] These bonds have become known as the Foreign Currency Savings Bonds (FCS-Bonds) and they are denominated in Euros rather then in dinars. The newly emerged bond market is a natural experiment in progress and has not yet been studied by researchers. We are able to fill this gap in the literature thanks to our access to the data on the Serbian bond prices.

Our objective in the present paper is to characterize the market for Serbian government bonds via estimation of the term structure (the yield curve). In general, an analysis of the yield curve is based on the simplest fixed-income instrument, a zero-coupon bond. The zero-coupon bond promises to pay a unit of currency on a given date in the future. The time between a current period and the pre-specified future date determines maturity of the bond. If kept till maturity, the bond earns a fictional, constant, annual interest rate, which is the bond's yield. Plotting yields of zero-coupon bonds, as a function of their respective maturities, results in the yield curve. A nice feature of the FCS-Bonds is that they are in fact zero-coupon bonds, which eliminates the need to calculate the fictional yield from data on coupon bonds, a necessary step in the yield curve estimation when one uses data from developed markets.

The first step in our quest to analyze the Serbian bond market is a choice of a term structure model. The existing types of modelling framework can be roughly divided into two groups, one theoretically motivated and the other empirically driven. The former group of models makes explicit assumptions about the development of state variables and uses either arbitrage or equilibrium arguments. The latter dynamic statistical models

[1]The other major players in addition to monetary and fiscal authorities are the Belgrade Stock Exchange, the Central Registry, and the National Savings Bank.

smooth data from asset prices without incorporating explicit factors presumed to drive the yield curve. Major examples of no-arbitrage models are those of Hull and White (1990) and Heath, Jarrow, and Morton (1992). Such models typically concentrate on fitting the term structure at each point in time by imposing no-arbitrage conditions. While they might be very useful in pricing derivatives, they do not reveal much in terms of dynamics or forecasting of interest rates. The fundamental contributions in the equilibrium tradition include Vasicek (1977), Cox, Ingersoll, and Ross (1985), Duffie and Kan (1996), and more recently, de Jong (2000) and Dai and Singleton (2000). Since the equilibrium models focus on the process driving the instaneous rate, they can potentially be used for forecasting. However, Duffee (2002) demonstrates that they forecast rather poorly and are inconsistent with many stylized facts.

Current dynamic statistical modelling originates in methodology introduced in McCulloch (1971), McCulloch (1975) and further advanced in Langetieg and Smoot (1981) who all use polynomial splines to approximate a discount function. A failure of these models to generate a variety of shapes for the yield curve and to produce stable forward rates led to improvement suggested in Vasicek and Fong (1982). They transform the argument of the discount function rather than the function itself, which enables them to apply standard OLS estimation of the discount factor coefficients and to avoid tedious non-linear estimation. Application of this methodology on the US T-Bills results in stable forward rates, which are continuous function of time. Moreover, the implied term structure can assume a variety of shapes often observed in reality.

Nelson and Siegel (N-S, 1987) further advance results of Vasicek and Fong (1982). They propose a simple exponential model, which is sufficiently flexible to generate a variety of yield-curve shapes. Its improved version is described in Svensson (1994) and further discussed in Diebold and Li (2003). Variations of this model are often used by central banks to form inflationary expectations - e.g. the Bank of England (see Deacon and Derry 1994). The N-S model is a three-factor model where the factors are actually

time varying parameters and can be interpreted as level, slope, and curvature of the yield curve.[2] Diebold, Rudebush, and Auroba (DRA, 2003) relate the three factors to macroeconomic variables such as capacity utilization, the federal funds rate, and inflation using the US data. Since the N-S model is relatively easy to estimate, has intuitive interpretation, conforms to stylized facts, relates to macroeconomic variables, and can be used for forecasting, we use it to analyze the term structure of the Serbian bond market.

We estimate the factors/parameters in the N-S model of the yield curve bi-weekly using the data for Serbian T-Bills and FCSB's. The covered period is from November 20 in 2001 to February 3 in 2005. Specifics of the Serbian bond market posses two challenges. The first is infrequent auctioning of the T-Bills issued by the National bank of Serbia (NBS-Bills) and by the Republic of Serbia (RS-Bills) with maturities respectively 7-60 and 91-182 days. To be able to estimate the whole yield curve, we combine bi-weekly data on NBS-B's and RS-B's with daily data on FCSB's in two-week periods in such a way that there is at least one auction during each period.

The second challenge reflects the segmentation of the Serbian bond market into dinar-denominated T-Bills and Euro denominated FCS-Bonds. If we use nominal interest rates, we ignore different level of riskiness of the FCS-Bonds due to exchange rate fluctuation. Typically, investment in foreign currency financial assets is perceived as riskier. This effect is somewhat mitigated by distrust of the Serbian public of the dinar due to experienced hyperinflation but is difficult to quantify in our data. Another possibility is estimation of the yield curve parameters using real yields. The disadvantage of this approach is necessity on taking a stand on expectations for exchange rates and inflation from 2005 on since FCS-Bonds' expiration dates are up to 2017. In both approaches, it is impossible to distinguish between effects of depreciation and domestic inflation on the yields. We address the problem by adjustment the Euro denominated bonds by the ex-post annual depreciation since the National Bank of Serbia has been able to adopt a managed floating

[2]Knez, Litterman, and Sheinkman (1994) is an example of another type of a multi-factor model.

system with predictable depreciation but has been less successful in controlling inflation.

We first estimate the N-S three factor model using all yields for the whole sample period. We follow the three factors over time and find that both their volatility and confidence intervals are reduced in September 2002. This date coincides with introduction of continuous trading and additional series of FCS-Bonds at BSE. We view this date as a structural break and decide to drop observations form before out of our sample. We further note that observed (and hence estimated) yields on FCS-Bonds are unrealistically high during time close to their expiration period, which is May. The decrease of bond prices is accompanied by a decrease in transactions. We interpret this irregularity as a market friction and do not use yields on the FCS-Bonds two months prior to their expiration date.

We re-estimate the term structure using the shorter and cleaned dataset. The three yield curve factors are more stable over time with narrower confidence intervals. The term structure is concave during the estimated period, which is consistent with a subsequent positive growth of real GDP. The level factor is increasing and so is inflation. The curvature is decreasing as well, probably due to decreasing foreign exchange premium since the exchange rate is less volatile. We further examine the relationship among the term structure factors and macroeoconomic indicators, namely inflation, depreciation, and industrial production. They are highly correlated and shocks in inflation and industrial production are reflected in the time series behavior of the level and slope factors, respectively. This approximately confirms findings of DRA for the Serbian data. Moreover, inflation Granger-causes the slope and curvature factors, and the slope Granger-causes inflation, and the curvature depreciation and industrial prodiction, confirming the predictive power of the term structure with respect to the business cycle.

The rest of the paper is organized as follows. Section 2 discusses historical origins of the Serbian bond market and a debt repayment program. Section 3 provides detailed information regarding the types of bonds available in Serbia and describes the macroeco-

nomic variables. Section 4 describes the N-S model and reports its estimation results. Section 5 addresses the relationship between term structure and macroeconomy in Serbia. Section 6 concludes.

2 Origins of the Bond Market in Serbia

History

Bond market in Serbia originates in its pre-transition past. This is because throughout the 1970s and 1980s one of the major resources of foreign capital for the Socialist Federal Republic of Yugoslavia (SFRY) were the bank savings of its residents, but even more of its citizens working abroad. However, under the former socialist regime, all banks were under government supervision and therefore major investment decisions could not be reached without political consent. Therefore, profit was not the leading criteria behind the most of investment decisions. Since the banks were unable to generate enough profit to repay deposits with generous interests, by 1990 it was too late for most depositors to claim their savings. By that time, due to the shortage of any hard currency, banks first severely limited withdrawal amounts and later curtailed withdrawals altogether. In 1991, unable to resolve this situation in any other way, Federal Republic of Yugoslavia (FRY) proclaimed a moratorium on government debt towards all private depositors, referred to as "old foreign currency savings". At the time of the moratorium, the total outstanding balance was close to 6 billion DEM.

The build-up of political tensions that led to the collapse of SFRY left Serbia and Montenegro united in an effort to continue the legacy of the previous country. However, with civil war on its borders, FRY was not setting economic development as its top priority. By 1992 FRY was politically and economically isolated. A high level of inflation was followed by rapid depreciation of the local currency, the dinar. It should be noted that consumers in FRY have probably experienced the highest hyperinflation of all time

and converting the dinar into hard currency was the only means of protection from high inflation.

The first attempt to resolve the government debt based on "old foreign currency savings" was made with the adoption of the law on regulating the public debt of the Federal Republic of Yugoslavia arising from citizens' foreign exchange savings. As part of a new financial infrastructure in Serbia, three key institutions were established: the National Savings Bank, the Belgrade Stock Exchange, and the Central Registry. Each of these institutions fits a complex mosaic and plays a role in the financial environment. The government also recognized most of its financial liabilities towards private depositors and committed itself legally to paying all the frozen deposits by 2011. Nevertheless, this new law was from the very beginning full of technical and practical difficulties. It assumed a debt conversion into bonds on a voluntary basis. The bonds were issued in paper format and thus were liable to forgery and theft. The non-electronic format of bonds proved to be complicated for trading and clearing procedures as well. Finally, the law was tied to the GDP growth levels which were unattainable at that time. This ambitious but unrealistic attempt turned out to be a great burden for the state budget and was economically unsustainable. With no major results, this attempt proved a politically motivated solution which lowered already severely damaged public confidence.

Debt Repayment Program

In 2002, a new law was adopted, which presented a modified and more realistic solution to the "old savings" problem. It kept the spirit of the previous law by avoiding the withdrawal of old bonds, but the new solution was to convert the government debt to private depositors into bonds of the Republic of Serbia and Republic of Montenegro. The payment schedule was also changed and included bond maturity between 2002 and 2016. All bonds issued by the previous law could be converted on a 'one to one' basis into new 'series A' bonds of the Republic of Serbia. Bonds were issued in electronic format in order

to avoid all major difficulties experienced under the previous law. All data regarding the bond holders, maturities and payment schedules were stored in the Central Registry, an institution set up for such a purpose.[3] This solution required that all bond holders have a specialized trading account in a bank of their choice. The procedure assumed that all trading went through the Central Registry and that money was transferred into bank accounts. This improved and simplified the securities trading and reduced the possibility of mistake or fraud.

On August 19, 2002, the Republic of Serbia issued bonds of series A in accordance with the new legal framework in the total amount of 4.2 billion EUR. This represented the total debt of Republic of Serbia towards old foreign currency savings depositors. The amount of the last four bond series accounted for 37.2% of the total debt, which means that the government was relying on acquiring bonds before they reach maturity through the process of privatization or by allowing the possibility of purchasing government property with 'frozen savings' bonds. One of the objectives of the new law was to coordinate the bond maturity structure with budget income. According to the payoff model, an estimated GDP growth of 3% to 5% was needed in order to avoid economic slowdowns. This was a realistic projection and proved to be a sustainable burden for the budget in the first two years of bond payments. The trading volume in the first six months was around EUR 100 million. During that period the annual yields varied from 13% to 14% for short-term bonds, from 8% to 15% with longer term to maturity.

The debt repayment program was accompanied by restructuring of the banking system. As a result of introduction of stricter solvency indicators, a total of twelve state-owned banks lost their business licenses and were subsequently closed. Payments to depositors from all these banks were transferred to the newly formed National Savings Bank [4] and

[3]It was founded by a separation from the National Bank and by connection with the shareholders' database from the temporary depository of the Privatization Agency. It plays a crucial role in over-the-counter market bond trading by keeping a unified record on owners of all issued securities on the territory of Serbia.

[4]The National Savings Bank was formed with the primary purpose of providing a service in bond distribution and payment program. Most bond holders preferred to sell their bonds before maturity

two other banks (Jubanka a.d. and Kosovska banka a.d.), which outlived the changes of banking regulations and also participated in bond distribution. It was up to these banks to provide a financial, but also educational, service to all debt holders. Soon, a great number of broker firms started offering their services which also contributed to emergence of the Serbian bond market.

Bonds and the Exchange Rate System

The NBS has the exchange rate policy of the managed float. Officially, the dinar is determined by levels of supply and demand on the money market and the level of exchange rate is formed on a daily basis. However, like most central banks, the NBS is interested in keeping the exchange rate stable, thus avoiding the potential imbalances in the real sector that could follow. Within the association of banks, the positions of banks towards the supply or demand for the dinar are established based on their needs for currencies during each day. If these positions were to show a greater imbalance between supply and demand for currencies that would have a significant impact on the level of the exchange rate, the NBS would intervene in order to reduce the gap, thus stabilizing the market.

Nevertheless, supply/demand ratio levels continue to be the fundamental factor of the dinar exchange rate formation, and the central bank acts mostly as a buffer against severe fluctuations which could damage the stability of the economy. The dinar exchange rate has been relatively stable in the past few years in the sense of predictable depreciation (about 11% annually) against all major world currencies. This predictability paired with the memory of hyperinflation of dinar in the nineties had made the investment in the FCS-Bonds very attractive.

which left the National Savings Bank with a large supply. This situation put it in a position to affect the secondary, mainly over-the-counter, market for bonds and the bank is hence often viewed as a monopoly.

3 Data

Bonds Traded in Serbia

There are currently two types of government bonds with maturity less then one year in Serbia. These are the bills issued by the National Bank of Serbia (NBS-Bills) and the Republic of Serbia Treasury Bills (RS-Bills) issued by the Serbian Ministry of Finance. The first auctions of NBS-Bills occurred in April 2000, while RS-bills were first issued three years later. Initially, NBS-Bills were traded on the stock exchange. Online trading was introduced in October 2003, with lower transaction costs and higher trading volumes. While interest rates were not significantly affected, the number of market participants decreased. Auctions for NBS-Bills take place approximately once every two weeks. RS-Bills are auctioned irregularly, approximately in one to two month periods. Although they were presented as the additional instrument for the development of the financial market, RS-Bills never reached the stock exchange. Instead, they have only been traded on the online auctions through the system of the Ministry of Finance. The typical maturities of NBS-Bills are 7, 14-15, 30, and 60 days while those of RS-Bills are longer, e.g. 91,154, and 182 days. There is no secondary market for either type of bill and they are denominated in dinars. The first NBS-Bills matured in January 8, 2001. Data on the short term bonds were kindly provided by the National Bank of Serbia.

The only available bonds with maturities over one year are FCS-Bonds. FCS-Bonds are traded on the Belgrade Stock of Exchange (BSE)[5] and over-the-counter (OTC). On the BSE a transaction is concluded at the moment the total quantity requested is met or when a pre-specified share of quantity of a trading order placed on the BSE is executed. When the transaction is executed, the confirmation has to be converted to electronic format and then submitted in the same format to the Central Registry and to the member who concluded the transaction. All transactions are settled through a Beoclearing, which is a

[5]The BSE was reactivated during socialist reforms in 1989 and it has been functioning without interruption ever since. The institutional framework and activities of the stock exchange are stipulated by the Law on Securities and Other Financial Instruments' Market.

delivery-versus-payment system. The settlement period for bonds is T+3. Following the execution of the transaction, brokers and custodian banks inform their clients about the concluded settlement. According to the rules of trading of the BSE, authorized traders on the OTC are obliged to submit information about completed trades by electronic mail. Furthermore, all prices concluded on the trading session should be published on the BSE web page. This rule is not obeyed in practice.

While we do not have records on prices in OTC transactions, the Central Registry provided us with partial information on the OTC trading, which included number of bonds traded over-the-counter in 2004. We merge this information with the data from the BSE and report the results in Table 1. The OTC trades are mostly close to 80% of the overall trading volume. The potential reason for the large portion of FCS-Bons being traded OTC is that banks (mainly the National Savings Bank) are in a position to form larger portfolios (for amounts over 1 million Euros). While this is not unusual (a similar number would be 100% in the Czech Republic or Hungary), the fact that prices for this segment of the bond market are not publicly available is a sign of potential problems such as insider trading, lack of liquidity, arbitrage, etc. Consequently, our results need to be viewed with some caution. Inclusion of this data (existing but not released by the Central Registry) would make our analysis more complete and could potentially alter some of our findings. The data could also shed some light on inefficiencies and arbitrage opportunities, which are likely to be present in a non-transparent market.

FCS-Bonds are traded actively on a secondary market and we possess the daily data series, which were purchased from the Belgrade Stock Exchange. The data on FCS-Bonds' issues has been available since November 2001 for single price auctions which were replaced by continuous trading in March 2003. The following series were issued: A2002, A2003, A2004, B. We took the B series out of our dataset since it was clearly an outlier with unrealistically high yields. Additional bond series were introduced in August 2002 and their trading on the BSE started on September 9, 2002.

Calculation of Yields

Some aspects of the Serbian data are less suitable for the term structure estimation. One issue is that maturing FCS-Bonds have extremely high yields (about 60%) inside of sixty days to their expiration date. May is the month of maturity for bonds expiring on a given year and we noticed that the number of traded securities of bonds close to maturity decreased in the last two months before the expiration date. It seems that this is due to a lower demand for bonds, which may be caused by an existing market friction. Since the trading volume decreases on the OTC market as well, it is not likely that low bond prices at BSE are the results of bonds flowing out of the stock of exchange. To avoid the apparent bias, we decided to exclude yields of FCS-Bonds during a two-months period before their expiration date.

The yield curve is typically extracted from the prices of discount bonds, which are not observed since bonds with long-term maturities are coupon bonds. Our analysis is in this aspect simplified since all the FCS-Bonds are discount bonds. On the other hand, these bonds are denominated in euros. Typically, foreign currency deposits are riskier than domestic ones and domestic investors require a a positive premium to purchase them. In the case of Serbia however, FCS-Bonds are perceived as *safer*. Distrust of the dinar due to its loss of value in the nineties hovers over the landscape of expectations still. Therefore, the foreign exchange risk premium might be viewed as rather small and close to zero. Hence we neglect it in our estimation but later touch upon the issue in a follow up discussion. We simply adjust the yields on the FCS-Bonds by depreciation of the dinar. Specifically, let us define the annual nominal yield as i_t, the adjusted yield as y_t, and the YUD/Euro Exchange rate as S_t. The adjustment is then calculated as

$$y_t\% = i_t\% + \frac{S_t}{S_{t-one\ year}} * 100\%.$$

The exchange rate float only starts in January 2001, so for this year we use annualized depreciation with respect to January 2001. Finally, we merge annualized yields on bonds with those on bills. We comment on the historical yields later on, when comparing them

to our estimates.

Macroeconomic series

We choose three series to characterize macroeconomic conditions: inflation, depreciation and industrial production. The initial data period is September 2002, to be consistent with our analysis of yields. We use monthly series for CPI and an industrial production from the web site of the Serbian Statistical Office and the exchange rate YUD/EURO from the NBS. The summary statistics are in Table 2. Both inflation and depreciation are less than 1% monthly. Industrial production grows on average 2.5% with respect to the average of the previous year.

4 Yield Curve Estimation

Methodology

In principle, a suitable term structure model should be able to reproduce stylized facts documented in the literature and also be sufficiently flexible to accommodate idiosyncrasies of a given bond market. Following Diebold and Li (2003), the stylized facts could be summarized as follows: (i) The mean yield curve is increasing and concave; (ii) The shape of the yield curve can change over time. Potential shapes include upward sloping, downward sloping, humped, and inverted humped; (iii) Dynamic properties of yields are more persistent than those of yield spreads; (iv) The long end of the yield curve is less volatile than the short end; and finally (v) Short rates are less persistent than long rates.

Diebold and Li (2003) argue that a version of the Nelson and Siegel (1987) yield curve with somewhat altered factorization meets the above criteria. The model is give as follows:

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

where $y_t(\tau)$ is the nominal interest rate, τ is the maturity of a given bill and t is the current date. This factorization differs somewhat from Nelson and Siegel (1987) and allows for an intuitive interpretation of the three latent dynamic factors β_{1t}, β_{2t} and β_{3t}. It also avoids

estimation difficulties due to multicolinearity. Since the loading on the first factor is a constant, it can be interpreted as a long-term factor, which does not converge to zero with increasing maturity. The loading on the second factor begins at 1 but quickly decreases to zero and can thus be viewed as a short-term factor. Finally, the loading on β_{3t} starts at 0, increases, and then slowly declines; hence it can be viewed as a medium-term factor.

From a different perspective, the three factors can be interpreted as level, slope, and curvature of the yield curve, respectively. To see that β_{1t} determines the level of the term structure, it is enough to realize that its size affects yields of all maturities equally and that $y_t(\infty) = \beta_{1t}$. If we define the yield curve slope as $y_t(\infty) - y_t(0)$, it exactly equals β_{2t}. Moreover, β_{2t} changes the slope of the yield curve since its loading is greater for shorter yields than for longer yields. The medium term factor has the greatest loading on yields with medium maturities and therefore increases the yield curve curvature, typically defined as $2y_t(24) - [y_t(3) + y_t(120)] = .00053\beta_{2t} + .37\beta_{3t}$, with maturity given in months.

The Nelson-Siegel yield curve formula is parsimonious yet flexible and surely capable of replicating the stylized facts regarding yield curves. In particular, the average term structure is calculated using factor averages and can be in general increasing and concave. It can also reproduce a variety of shapes on a given date, which can change depending on variability of the factors. Strong persistence in the level factor translates into persistent yield dynamics and weak persistence in the slope factor into weak persistence of the spreads. The variance of short yields depends on the variance in the first two factors and the long yield variance only on the level. Therefore, short-term yields are more volatile. The same reasoning implies that longer rates are more persistent than shorter ones.

To characterize the yield curve, we need to estimate the parameters $\theta = (\beta_{1t}, \beta_{2t}, \beta_{3t}, \lambda_t)'$. Parameter λ_t is typically not estimated but set to the value maximizing the loading factor next to the β_{2t} (medium-term part) at 30 months i.e., setting $\lambda = 0.0609$. Diebold and Li (2003) estimate the factors using ordinary least squares at each date. Due to the lack of bonds of different maturities on any given date, we cannot use this strategy and fit

the yield curve daily. Instead, we assume that the coefficients are stable in a short time period (two weeks) and use a cross-section of data of selected daily observations on bond interest rates. Using ordinary least squares (OLS), we then estimate β_{1t}, β_{2t}, and β_{3t} on a bi-weekly basis.

Estimation Results

We first conduct our estimation using the data series starting in December 2001. To characterize the evolution of cross-sectional beta estimates $\hat{\beta}_t = (\beta_{1t}, \beta_{2t}, \beta_{3t})'$ over time we report their time series in the left panel of Figure 1. One can clearly see the development of the bond market in Serbia. Before September 2002, only a few series of the FCSB bonds were traded. The estimates settle down somewhat after the introduction of additional bond series. A similar pattern can be identified using confidence intervals from cross-sectional regressions. To view the Serbian market from yet another perspective, we plot the number of observations for yields over time as well, which also marks September 2002 as a break-point - see Figure 2.[6] We present the newly estimated β's in the right panel of Figure 1. The three plots indicate that all $\hat{\beta}$'s are more stable with narrower confidence intervals.[7]

We follow the estimated term structure over time and show its snapshots in September 2002, 2003, and 2004, and in February 2005 - see Figures 3 to 6, respectively. The yield curve is concave in all the cases, indicating a growing economy. This prediction is roughly confirmed, when one notices real GDP growth rates in the years 2002-2005 (source: the Economist Intelligence Unit, Country Data): 4.3%, 2.4%, 8.8%, and 5.5%, respectively.

[6]The number of observations drops regularly around the end of each year, marking the beginning of the Serbian Christmas season. Serbia celebrates Christmas according to the Eastern Orthodox Church, which uses the Julian calendar, making January 6 the Christmas Eve.

[7]Please note a different scale on the y-axis in the left and right panels of Figure 1.

5 Macroeconomy and the Yield Curve

As argued in Diebold, Rudebush, and Auroba (2003), the N-S model is widely used by central banks all over the world to study the interaction of yields and macroeconomic variables. DRA study this type of relationship formally. They estimate the N-S model using the Kalman filter approach and combine the model with macroeconomic variables. The macro variables they use consist of what is considered to be the minimum set of fundamentals needed to characterize the dynamics of the macroeconomy. The measures of the economy are manufacturing capacity utilization, the federal funds rate, and annual price inflation. These are chosen to capture the level of real economic activity relative to potential, the instrument of monetary policy, and the inflation rate, respectively.

DRA use the N-S model alone as well as in combination with macro variables. A by-product of their study is the fact that both of these models explain the term structure dynamics rather well. This is reassuring from the perspective of our study, in which we use a yields-only type of the N-S model. Further analysis by DRA shows that macro variables can be related to the three factors of the N-S model: level, slope, and curvature. The first observation made by DRA using US data is that the level factor is correlated with actual inflation, which suggests a relationship between the level of the yield curve and inflationary expectations, consistent with the Fisher equation. The second interesting observation is that the slope of the yield curve may be connected to the business cycle because the second factor of the N-S model is correlated with capacity utilization.

DRA further investigate interactions between the economy and the yield curve using impulse response functions and variance decomposition. While the macro variables react very little in response to changes in slope or curvature, they respond strongly to the level factor. An increase in level causes increases in capacity utilization, the funds rate, and inflation. In other words, an increase in future perceived inflation implies a lower real interest rate giving a boost to real economic activity followed by a reaction of the Federal Reserve. Of interest are also responses of the yield curve factors to changes in macro

variables. For example, an increase in the funds rate is followed by an increase in slope, and then a decline, perhaps due to monetary policy raising the short end of the yield curve. Also, the level factor responds positively to inflation surprises.

The present paper examines the relationship among the yield curve factors and macroeconomic variables for the case of Serbia. Based on data availability, we will focus on interaction among the N-S factors and inflation, industrial production, and exchange rate. All the considered time series have been tested for unit roots using the Augmented Dickey Fuller test with lag selection based on the Schwartz information criteria and the Phillips Perron test with the Barlett kernel estimation and the Newey-West data dependent bandwidth. The null hypothesis of the unit root has been rejected in all cases at 10% level of significance.

We first conduct the Granger causality tests (see Granger 1969). The concept of Granger causality does not refer to common understanding of the word; rather, it reflects mutual predictability of given variables. It attempts to quantify usefulness of variable (say, y) in prediction of another another variable (x). y is said to Granger-cause x if x and its past values improve prediction of y when used in addition to past y's. The following bivariate regressions are estimated:

$$\begin{array}{rcl} y_t & = & \alpha_0 + \alpha_1 y_{t-1} + \ldots + \alpha_l y_{t-l} + \beta_1 x_{t-1} + \ldots + \beta_l x_{t-l} + \epsilon_t, \\ x_t & = & \alpha_0 + \alpha_1 x_{t-1} + \ldots + \alpha_l x_{t-l} + \beta_1 y_{t-1} + \ldots + \beta_l y_{t-l} + u_t \end{array}, \tag{2}$$

for all 30 pairs of the term structure factors and macroeconomic variables. The null hypothesis is

$$H_0 : \beta_1 = \beta_2 = \ldots = \beta_l = 0 \tag{3}$$

and if it is rejected, then x Granger causes y in the first regression and viceversa in the second regression.

Table 3 reports F-statistics, which are the Wald statistics for the joint hypothesis (3). The level factor β_1 and inflation are intimately related via Granger causality, confirming the relationship found in DRA. The curvature factor provides extra information in

explanation of time series behavior of the slope factor $beta_2$, inflation, depreciation and industrial production. This is perhaps not so surprising since the curvature parameter contains not only information about the yields but also about the past depreciation of the dinar, which can have additional predictive content. Finally, inflation also improves the prediction of the curvature factor as well.

Following DRA and complementing Granger causality tests, impulse responses to exogenous shocks are calculated as well. Contrary to the notion of Granger causality, the impulse responses do address the question of causality in the standard sense. A VAR process for the six series is estimated with two only lags for endogenous variables due to a small number of observations. Impulse response functions are shown in Figure 7 and include 95% confidence intervals. We can see (almost) significant responses of the level factor to inflation and of the slope factor to industrial production, similarly to DRA (who use capacity utilization instead of industrial production). In other words, the macro economic situation determines the shape of the yield curve. According DRA, the opposite is not true - in our case however, depreciation does respond to changes in the slope factor. There are two potential explanations for this phenomenon - it may be artificially caused by the fact that our yield data do include ex-post depreciation or it may be caused by the smaller size of the Serbian economy as compared with the United States, in which case some of the interest changes may be exogenous.

6 Summary

There are several potential pitfalls in attempting to fit a yield curve for the Serbian bond market: primary vs. secondary market, dinar denominated vs. euro denominated bonds, bi-weekly (or irregular) auctions vs. daily trading, bonds maturing in May, etc. Yet in spite of these problems, the altered N-S model seems to do rather well in the environment of a developing market. It does not only fit the yields on the daily traded FCS-Bonds but

also the short term Treasury yields. This (relative) empirical success is possible in spite of the fact that we are missing a big segment of the market given by OTC transactions.

We further investigate the relationship between the state of the Serbian economy and the term structure. As is the case in developed markets, a concave yield curve is associated with a greater growth of the economy. A subsequent analysis confirms this first impression since the slope factor reacts to changes in industrial production. Moreover, the level factor reacts to changes in inflation. The slope factor also contains relevant information for prediction of inflation and the curvature factor for that of depreciation and industrial production. On the other hand, inflation adds additional information in an analysis of the slope and curvature factors.

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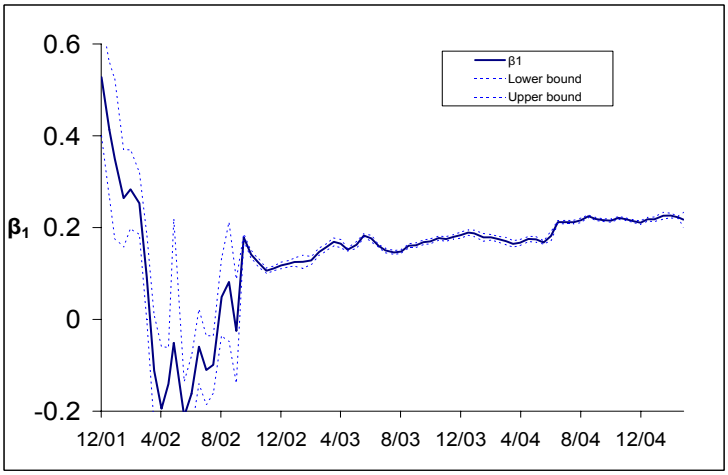
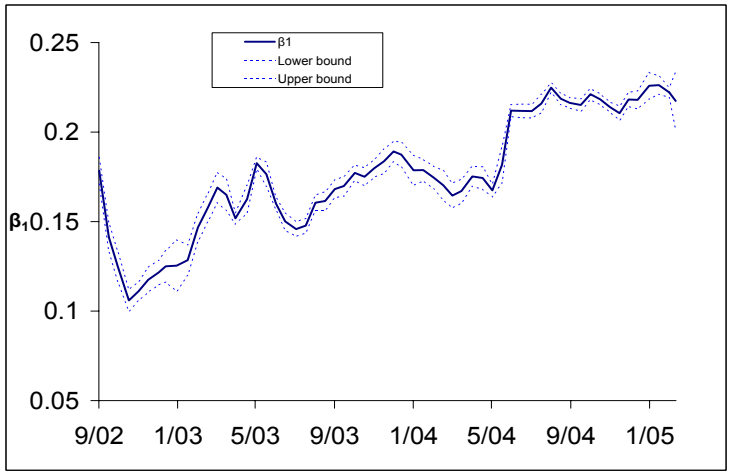
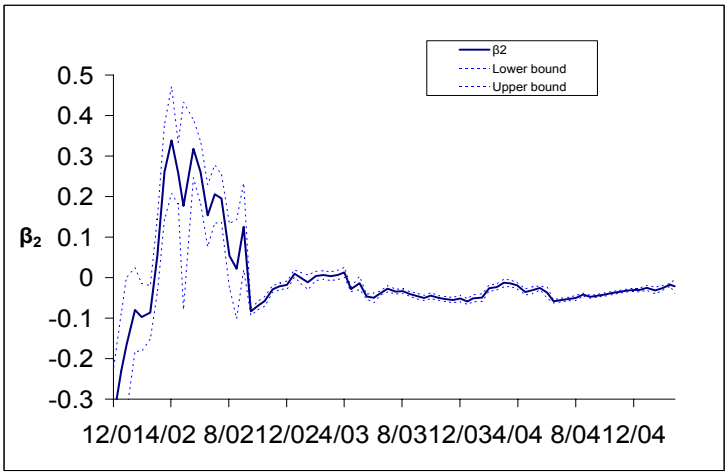
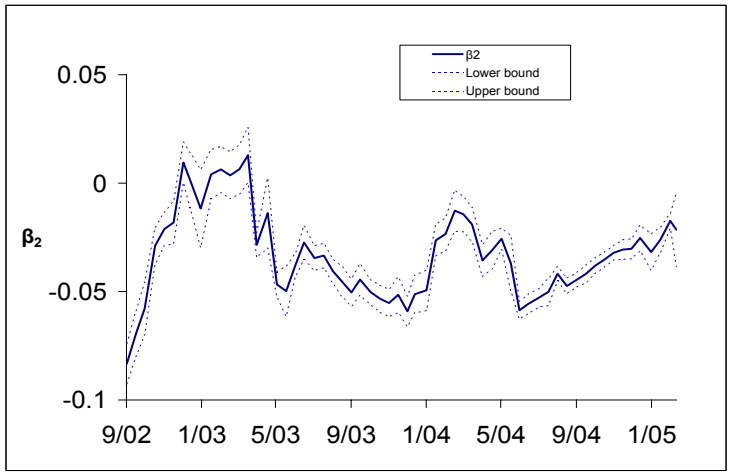
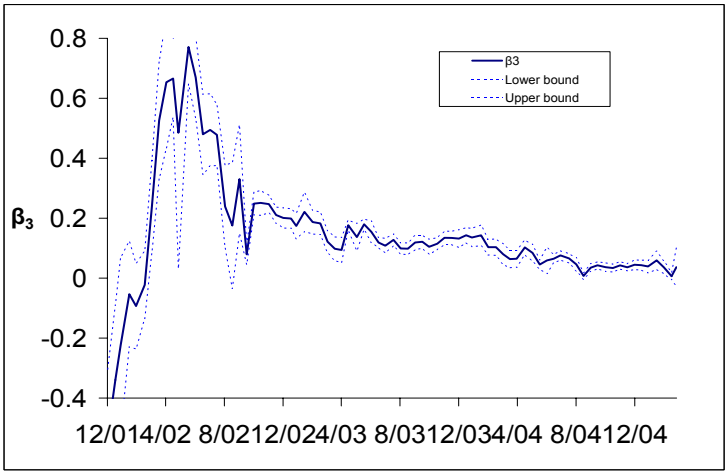
Figure 1: Time series of $\hat{\beta}$'s (with 95% confidence intervals) - all data and data since September 2002











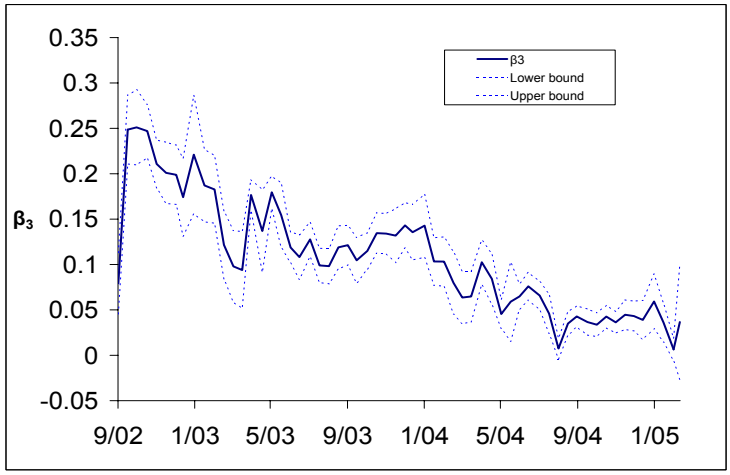


Figure 2: Number of observations over time

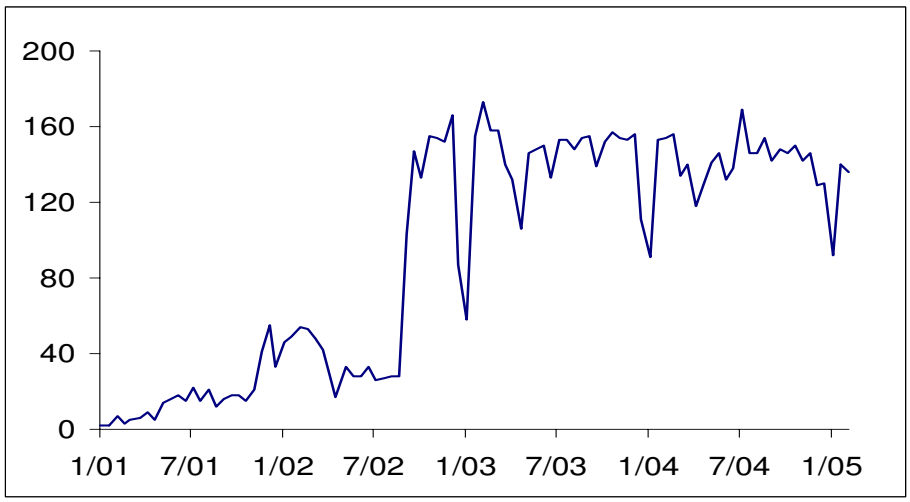


Figure 3: Observed versus estimated yields, September 2002

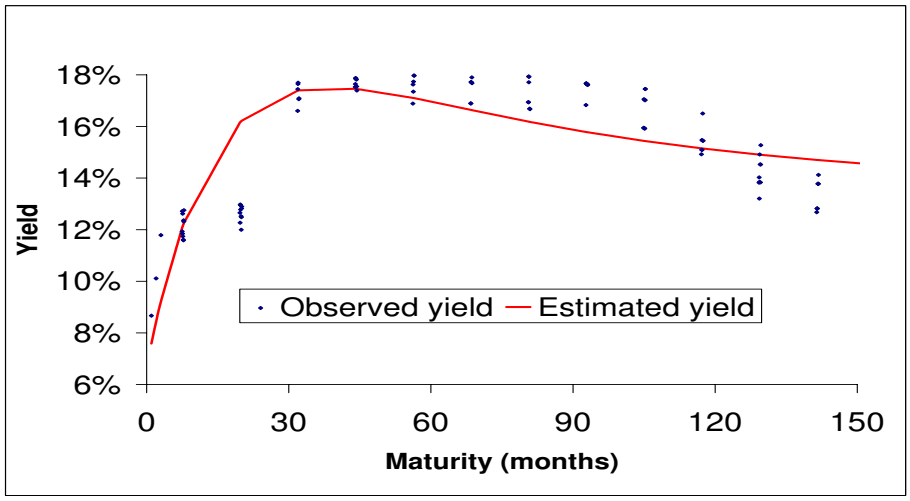


Figure 4: Observed versus estimated yields, September 2003

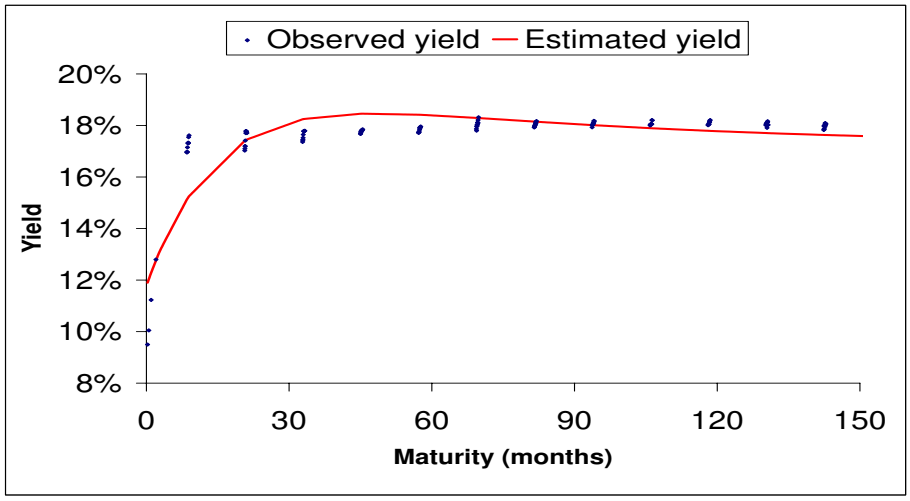


Figure 5: Observed versus estimated yields, September 2004

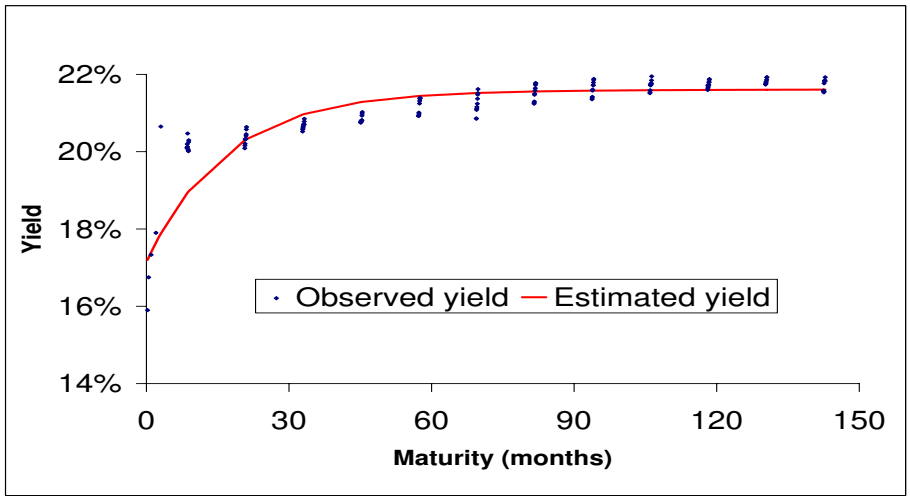


Figure 6: Observed versus estimated yields, February 2005

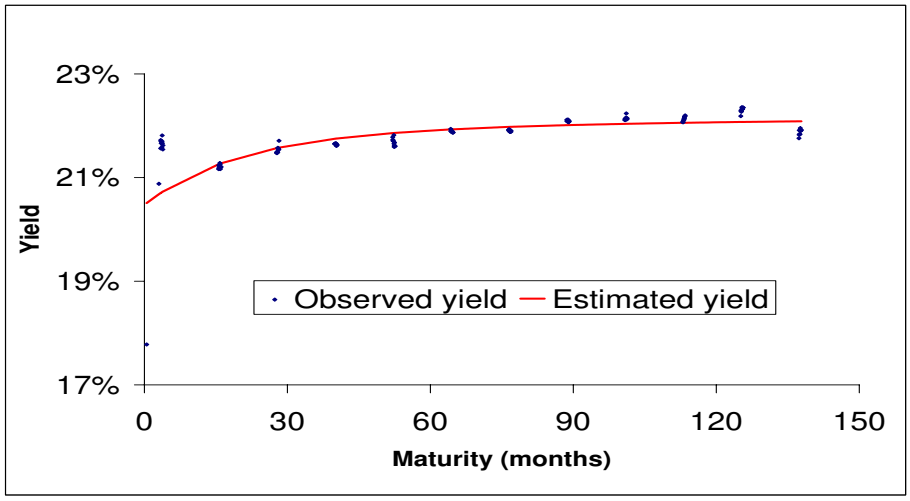


Figure 7: Response to Cholesky One S.D. Innovations ± 2 S.E.

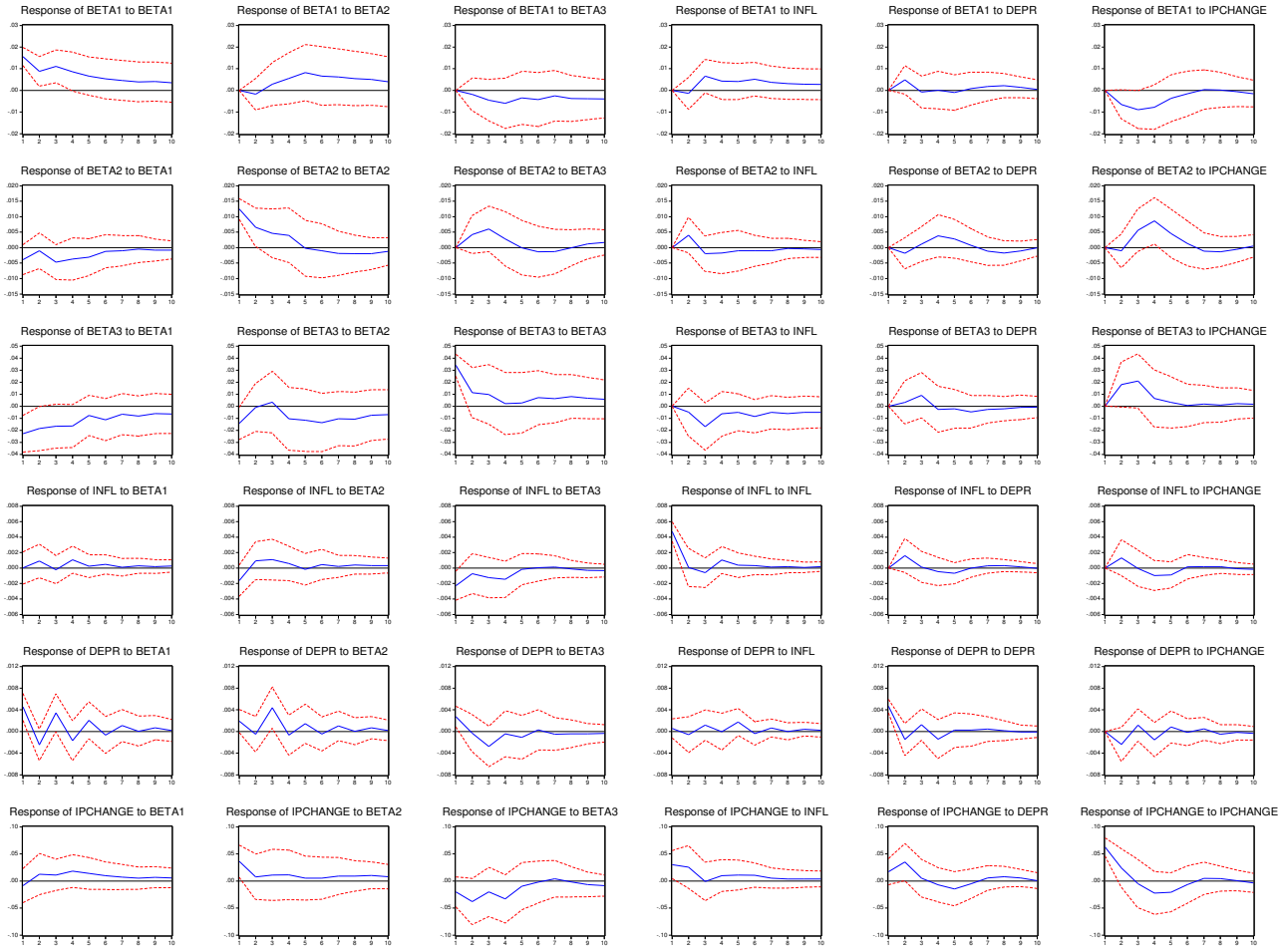


Table 1: OTC trading as a percentage of total trading (i.e. OTC+BSE)

	A2004	A2005	A2006	A2007	A2008	A2009	A2010	A2011	A2012	A2013	A2014	A2015	A2016
Jan 2004	84.1	76.7	69.5	64.0	62.0	76.6	73.1	76.1	79.8	82.2	81.7	60.7	72.5
Feb 2004	82.3	42.1	52.3	51.3	51.0	55.4	62.8	56.6	63.8	61.2	66.1	80.3	69.4
Mar 2004	73.8	65.4	85.6	87.2	89.2	88.9	85.5	74.5	76.3	68.0	74.9	76.1	74.5
Apr 2004	72.9	76.2	82.8	86.0	87.8	85.6	83.8	73.1	74.4	78.0	74.4	84.4	76.9
May 2004	85.4	85.4	71.7	83.6	63.2	57.5	54.9	78.6	77.9	79.5	81.8	69.7	54.8
Jun 2004	100.0	81.4	67.8	69.9	79.1	78.0	71.5	73.9	59.6	61.4	61.0	46.7	62.3
Jul 2004		87.7	85.2	87.4	85.6	82.2	78.3	82.4	83.9	82.1	75.9	64.6	72.3
Aug 2004		83.3	81.4	84.0	83.4	88.8	87.6	84.1	84.7	81.0	74.2	79.1	40.2
Sep 2004		89.6	81.7	73.8	75.5	62.9	63.5	62.4	72.3	83.4	67.3	87.6	75.9
Oct 2004		76.6	78.9	72.5	74.1	46.3	64.9	82.8	76.2	75.6	79.8	77.1	74.0
Nov 2004		73.2	68.9	83.6	87.2	79.5	79.1	84.1	82.2	77.8	80.7	80.7	75.5
Dec 2004		87.6	89.1	85.3	79.3	73.8	66.8	88.1	90.1	85.0	82.9	90.2	71.8
Overall	78.7	79.0	77.7	80.4	80.4	78.2	75.7	79.2	80.1	78.4	76.7	79.2	70.3

Table 2: Data Summary Statistics (2002:9-2004:12)

Notes:
BETA1-BETA3 are the time series of the OLS estimates of the yield curve parameters, INFL is the inflation rate, DEPR is depreciation of YUD w.r.t. EURO, and IPCHANGE is the change of the industrial production index w.r.t. to the average of the previous year

	BETA1	BETA2	BETA3	INFL	DEPR	IPCHANGE
Mean	0.173953	-0.035785	0.114561	0.008588	0.009217	0.025281
Median	0.174935	-0.037940	0.109105	0.008693	0.010746	0.023228
Maximum	0.224820	0.009548	0.251120	0.017648	0.026304	0.196389
Minimum	0.111090	-0.083307	0.007457	-0.002215	-0.021914	-0.200893
Std. Dev.	0.031922	0.021585	0.063804	0.005307	0.009098	0.096418
Skewness	-0.127018	0.403542	0.348453	-0.118387	-1.413060	-0.212121
Kurtosis	2.278573	3.089526	2.259809	2.161788	6.331436	2.574158
Jarque-Bera	0.682489	0.769300	1.205820	0.885105	22.26633	0.421543
Probability	0.710885	0.680689	0.547217	0.642395	0.000015	0.809959

Correlations

	BETA1	BETA2	BETA3	INFL	DEPR	IPCHANGE
BETA1	1.000000	-0.420173	-0.838065	0.243140	0.397155	0.380047
BETA2	-0.420173	1.000000	0.208431	-0.391655	0.030684	-0.228823
BETA3	-0.838065	0.208431	1.000000	-0.208541	-0.206369	-0.362428
INFL	0.243140	-0.391655	-0.208541	1.000000	-0.089200	0.543635
DEPR	0.397155	0.030684	-0.206369	-0.089200	1.000000	0.114171
IPCHANGE	0.380047	-0.228823	-0.362428	0.543635	0.114171	1.000000

Table 3: Pairwise Granger Causality Tests (2002:09 2006:01, 2 Lags)

Null Hypothesis:	Obs	F-Statistic	Probability
BETA2 does not Granger Cause BETA1	30	5.87	0.01
BETA1 does not Granger Cause BETA2		0.49	0.62
BETA3 does not Granger Cause BETA1	30	1.54	0.23
BETA1 does not Granger Cause BETA3		0.53	0.59
INFL does not Granger Cause BETA1	30	4.45	0.02
BETA1 does not Granger Cause INFL		3.03	0.07
DEPR does not Granger Cause BETA1	30	1.82	0.18
BETA1 does not Granger Cause DEPR		1.39	0.27
IPCHANGE does not Granger Cause BETA1	28	0.07	0.94
BETA1 does not Granger Cause IPCHANGE		1.91	0.17
BETA3 does not Granger Cause BETA2	30	2.96	0.07
BETA2 does not Granger Cause BETA3		1.36	0.27
INFL does not Granger Cause BETA2	30	2.08	0.15
BETA2 does not Granger Cause INFL		0.82	0.45
DEPR does not Granger Cause BETA2	30	0.33	0.72
BETA2 does not Granger Cause DEPR		0.43	0.66
IPCHANGE does not Granger Cause BETA2	28	1.52	0.24
BETA2 does not Granger Cause IPCHANGE		1.25	0.31
INFL does not Granger Cause BETA3	30	3.08	0.06
BETA3 does not Granger Cause INFL		2.24	0.13
DEPR does not Granger Cause BETA3	30	1.72	0.20
BETA3 does not Granger Cause DEPR		3.35	0.05
IPCHANGE does not Granger Cause BETA3	28	0.47	0.63
BETA3 does not Granger Cause IPCHANGE		2.59	0.10
DEPR does not Granger Cause INFL	40	1.01	0.38
INFL does not Granger Cause DEPR		1.30	0.28
IPCHANGE does not Granger Cause INFL	28	1.11	0.35
INFL does not Granger Cause IPCHANGE		0.73	0.49
IPCHANGE does not Granger Cause DEPR	28	0.37	0.69
DEPR does not Granger Cause IPCHANGE		0.95	0.40