Interest Rate Risk Assesment in Financial Markets. The Case of Turkey

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Abstract

An analysis of the risk associated with the interest rate is important because risk can serve as a measure of portfolio risk, financial risk, and decisional risk. There are several approaches to measuring the interest rate risk: Risk assessment can be based on the yield curve, on GARCH models, or on the Generalised Pareto distribution (GPD). Using data from the Istanbul Stock Exchange (ISE) Second Hand Bond Market, namely Government Bond interest rate closing quotations, for the time period 2001 through 2008, we used the GPD-based approach to obtain a value at risk at the 5

We found economic as well as statistical arguments for dividing the period under investigation into three sub-periods, period 1 reaching from January 2001 through September 2003 (characterised by high interest rates, decreasing rapidly after peak; large daily ?uctuations), period 2 from October 2003 through May 2006 (more moderate, and decreasing, interest rates; small daily

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?uctuations), and period 3 beginning in June 2006 and ending in August 2008 (moderate interest rates at a relatively stable level; moderate daily ?uctuations). Fitting GPDs to the data resulted in a good fit between the model and our data for all periods and maturities. Surprisingly, periods 1 and 3 turned out to be very similar with respect to the kurtosis of the distribution of interest rate changes as well as with respect to the tail properties, analyzed on the basis of the GPD. Our results can be used for a detailed assessment of the interest rate risk in Turkey.

Key words: Interest rate risk; Covered interest parity; Turkey; Generelased Pareto Distribution

1 Introduction

Interest is defined as the rent paid for the usage of capital that was requested in the form of borrowing. Conversely, it is the amount of compensation for the lender in return for sacrificing the money disposition as the creditor. This compensation value should provide an incentive equal to an amount that backs the creditor down from using the money. Ratio of this amount is the interest rate.

Risk on the other hand expresses the chance of occurance of an undesired event or events and non-accrual of an intended and/or planned expectation. In an economic sense risk is the probability of a monetary loss regarded with a transaction or loss resulting due to decreasing financial returns. Cyclical fluctuations and price changes can increase the risk of occurrance of the undesired situations.

Risk is divided into two as systemic and systematic risks. All securities in financial markets are subject to systematic risks, and systematic risks arise for example when fluctuations within political and economic conditions affect the behavior of assets in financial markets. As a result systematic risks are unavoidable in the sense that keeping them under control in a way is impossible. Systemic risks on the other hand are the risk related with controllable processes such as intra-firm investment risks or a risk that may be likely to occur due to a decision on a financial issue (Turanlı, Özden and Demirhan; 2002).

Interest rate risk should therefore be considered within the context of systematic risks. The fluctuations in interest rates could not totally be controlled but some measures may be taken or some tools would be developed against the interest rate risk.

Our first goal in this paper is to find a measure for interest rate risk. There are many reasons, economical as well as financial ones, why we should find a measure for interest rate risk. Measuring interest rate risk is important since it may be beneficial in taking measures before negative effects can take place in an economy (see Woodford, 1999). From the perspective of finance interest rate should be consid-

ered not only with economy but with many other factors as well. Ang and Bekaert (2001) mentioned risk hidden in the behavior of interest rates has direct effect on the functioning of markets. Duffie and Kan (1996) and Dai and Singleton (2000) had shown in their papers that interest rates not only affect the functioning of markets but also have the power to alter the structure of the markets.

There are many other perspectives as well. For example financial income perspective says that the income going to be generated in the future is effected by interest rates because today's value calculation is made by an assumed interest rate level. If there is an unexpected change in the interest rates there is a risk that the value of income would be lower than expected. From an institutional perspective, changes in interest rates affect a financial institution's market value (Carneiro and Sherris, 2008). Because the value of a financial institution's assets and liabilities on the one hand and off-balance-sheet contracts written on interest rates on the other are affected by a change in rates, the present value of future cash flows and in some cases even the cash flows themselves can change.

The focal point of the present paper is an investigation of the interest rate risk in the Turkish spot market for government bonds. We will first look at what has happened in the Turkish economy within the period under investigation (2001–2009). After this we will look at the statistical properties of changes in the daily series of interest rates.

Finally, we will derive a measure of interest rate risk based on the Generalised Pareto Distribution. This approach is similar to Neftçi and Bali (2001), who argue that the return distributions cannot be assumed to be normally distributed, and extreme value theory should be used as a model for the tails of the distributions instead, an idea which leads to the Generalised Pareto Distribution. Extreme Value Theorem is comprehensively treated by Embrechts and Chavez-Demoulin (2004), and Gilli and Kellezi (2003). Meyfredi (2005) has used the estimation of risk measures associated with fat tails for stock market returns in several countries.

Gencay, Selçuk and Ulugülyağcı (2002) applied this to ISE and derived a prac-

tically useful VaR measure in order to be considered as an alert system for the market. Gencay and Selçuk (2001) had already applied a similar methodology for overnight interest rates of Turkish money markets in order to derive a measure querying whether the ex-ante interest overnight levels are indicators of the 2001 crisis or not.

Similar to Gencay and Selçuk (2001), Neftçi and Bali (2001) are using an extreme value approach involving the Generalised Pareto Distribution to compute a VaR for interest rates for the American market.

In this study we are trying to estimate with which probability the interest rates from Istanbul Stock Exchange Secondary Bond Markets go to some value tomorrow, our goal being to define an interest rate risk and to derive a measure for spot market rates concerning 91, 182, 273, 365 and 456 day-to-maturity of bonds. Our approach is similar to Neftçi and Bali (2001).

Section 2 of the study talks about the recent history of Turkish economy, Section 3 defines the data and statistical properties; Section 4 looks at the time series properties of interest rates, and Section 5 reports results concerning GPD-based interest rate risk measurement. Section 6 concludes the paper.

2 Recent History of Interest Rates in Turkey

We have analysed the period between 2001-2009 for interest rates of Istanbul Stock Exchange Second Hand Bond Market. For the purpose of our analysis, we shall devide this period into three sub-periods as follows:

- period 1, from January 2001 to September 2003
- period 2, from October 2003 to May 2006
- period 3, from June 2006 to August 2008
- period 4, from September 2008 to March 2009

We believe that this division is justified by economic and political events affecting Turkey. Furthermore, we shall see in Section 4 below that a statistical breakpoint analysis leads to a division into the first three periods. (For a somewhat finer formulation of breakpoints, see Table 3.)

The Period of 2001 and 2008 in General

First of all, it is possible to seperate this whole period into only two periods: the period until 2002; and the period from 2003 through 2008. Starting from the beginning of 2001 and ending with the end of 2002 there were three events that mainly shaped this period:

- the economic crises experienced on 28 February 2001
- September 11 2001
- Turkish General Elections in November 2002

The period was comprised of many instabilities in terms of both economy and politics throughout the period (Insel, 2003).

Between 2003 and 2008, 7% growth was seen in the economy on average. Per capita GDP had increased by 30%, domestic currency has revalued 30% as well. On the other hand a 100% set back was seen on Trade and Balance of Payments Deficit.

Inflation dropped to 12% from 40% and the interest rate level dropped to a figure of 21% from 76% of end of 2001 figure.[1]

The Period Between January 2001 and September 2003

As mentioned above the period was shaped with economic and political instablities. The resolution that authorises the Turkish National Assembly for sending troops to Iraq was approved with 50% majority on 2003-10-06. According to the news expressed the day after this was perceived as a "political integrity" by the markets.[2]

It is beneficial also to mention that the inflation was explained to be the 30 years lowest before two days of voting.[3] Then, four days later the Treasury explained a debt structuring in the sense of swapping the short term government bonds with longer maturities. Interest rates had dropped 200 basis points and Turkish Government is now able to borrow for longer term.[4]

The Period between October 2003 and May 2006

There were four main events shaping this period:

- WTO abolished trade barriers

[1]All the figures here are taken from Banking Ragulation and Supervision Ageny (BDDK) Financial Markets Report, March-June 2006, Number 1-2. Available online at http://www.bddk.org.tr/english/Reports/Financial_Markets_Report/1971fprMart Haziran2006ingilizce.pdf - Accessed October 2008

[2]Hurriyet Online "Tezkere Geçti Asker Iraka Gidiyor, Kabul 358 Red 183", date: 2003-10-07. Available online at http://webarsiv.hurriyet.com.tr/2003/10/07/hurriyetim.asp, Accessed October 2008

[3]Hurriyet Online Enflasyona Eylül elmesi date: 2003-10-04 Available online at http://webarsiv.hurriyet.com.tr/2003/10/03/hurriyetim.asp, Accessed, October 2008

[4]Hurriyet Online "Para Kurulu Toplandı", date: 2003-10-15 Available online at http://webarsiv.hurriyet.com.tr/2003/10/15/hurriyetim.asp, Accessed October 2008

- Capital flows rendered more liberalised
- Growth of developed economies had increased
- This growth brought inflation in developed countries.

It is possible to say that this period was the period of capital flows between diverse markets. Total volume of capital circulation throughout the world had reached approximately to $15 trillion according to IMF Economic Outlook.[5]

Developing countries in this sense were also the beneficiaries. $2 trillion out of this $15 trillion had flown to them and Turkey was benefited from this with $90 bn foreign investment according to Turkish Central Bank Inflation Report.[6]

+EMBI Turkey Risk Index published by JP Morgan was explained on this date. This index as is believed gives the risk appetit of investors regarding the specific market. And according to this Index Report only the Turkeys Index figure was going compared with other developing countries.[7] Benchmark Bond interest rate at Istanbul Stock Exchange Secondary Bond Markets was increased to 19% on this day and Central Bank followed suit by increasing gradually the overnight borrowing interest rate by 7% throughout month of June.

The Period between 2006-06-02 and 2008-08-29

There were four main events that shaped the period:[8]

- inflation fear of developed countries
- increase in interest rates

[5]International Monetary Fund (IMF) World Economic Outlook October 2006, pp 1-6 Available online at http://www.imf.org/external/pubind.htm , Accessed, October 2008

[6]Turkish Central Bank, Inflation Report 2006-IV pp. 41-46, Available online at http://www.tcmb.gov.tr/ , Accessed, October 2008

[7]Ibid. See graph on page 8.

[8]International Monetary Fund (IMF) World Economic Outlook, October 2008, Financial Stress, Downturns and Recoveries pp 1-46 Available online at http://www.imf.org/external/pubs/ft/weo/2008/02/pdf/text.pdf , Accessed, October 2008

- sub-prime crises through the end of the year 2007
- Banking Crises throughout the world.

3 Data and Their Statistical Properties

3.1 The Data and Their Origin

We use daily closing quotations of interest rates of at ISE Bounded Bond Purchasing Market 90, 182, 273, 365 and 456 days to maturity government bonds. This data is available upon request from ISE. A plot of the series is shown in Figure 1 for the three periods under investigation. There are no corporate bonds in this market. The Turkish Bond Market is dominated by Treasury Bonds. As mentioned in the beginning, we are looking for a measure which is capable of showing the risk in this market.

The rates comprise the period between 2001 and 2008 and can be treated as time series. This type of data is critised as they are being lagged values and required to be collected retrospectively and they need to be processed before their message about the economy as a whole can be distilled. However as this data comprised of past values we believe it will reflect the effect of lagging situation in the analysis to be done below.

3.2 Statistical Properties of Daily Interest Rate Changes

Let (i_t) designate any of the five interest rate series (t indicates the day). In this section, we are interested in the behaviour of the changes in this series, that is, in the series

$$r_t = \frac{i_t - i_{t-1}}{i_{t-1}} \cdot 100\%. \tag{1}$$

Tables 1 and 2 give an analysis of the distributional properties of the percent point changes in the five series for the four periods in terms of mean, variance and standard

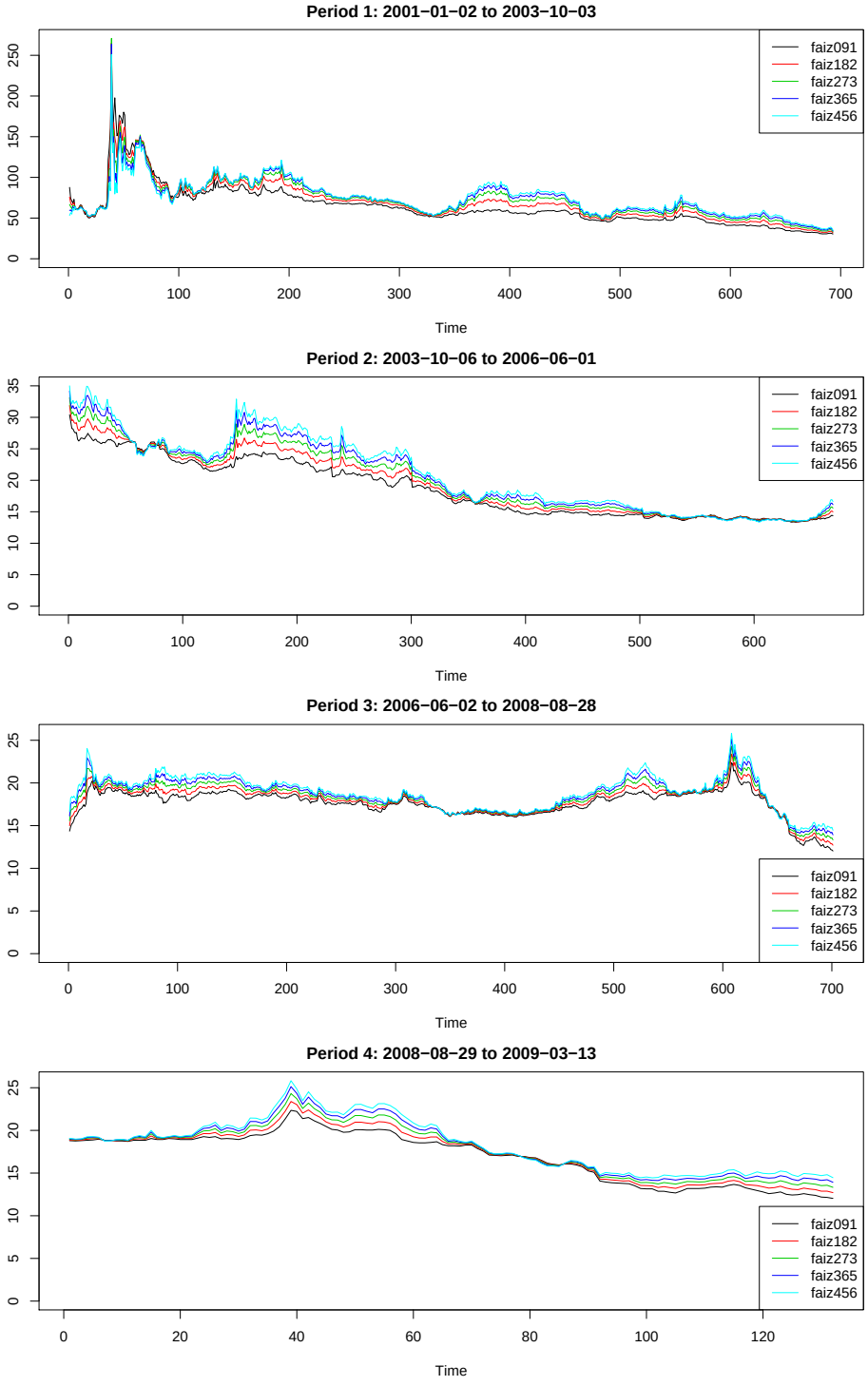

Figure 1: The faiz series, three periods

	faiz091	faiz182	faiz273	faiz365	faiz456
period 1: 2001-01-02 – 2003-10-06 (692 observations)					
mean	−0.06	0.01	0.08	0.15	0.21
var	21.07	30.39	47.59	66.10	83.44
std deviation	4.59	5.51	6.90	8.13	9.13
skewness	5.92	9.46	13.14	14.68	15.22
std error	3.40	5.36	6.40	7.63	7.46
kurtosis	102.24	184.92	283.46	323.01	334.77
std error	37.06	65.58	112.60	139.78	134.40
period 2: 2003-10-07 – 2006-06-01 (666 observations)					
mean	−0.11	−0.11	−0.11	−0.10	−0.10
var	0.74	0.94	1.33	1.81	2.31
std deviation	0.86	0.97	1.15	1.35	1.52
skewness	−1.65	−0.62	0.02	0.29	0.38
std error	0.68	0.65	0.67	0.65	0.65
kurtosis	13.37	11.31	10.83	10.52	9.91
std error	4.29	2.24	1.81	1.99	2.09
period 3: 2006-06-02 – 2008-08-29 (569 observations)					
mean	0.05	0.04	0.04	0.03	0.03
var	0.71	0.80	1.04	1.36	1.71
std deviation	0.84	0.90	1.02	1.16	1.31
skewness	1.10	2.40	2.99	2.99	2.80
std error	0.86	1.36	1.46	1.37	1.32
kurtosis	11.02	24.74	30.01	29.07	26.19
std error	5.60	11.19	12.93	11.80	9.97
period 4: 2008-09-01 – 2009-03-13 (131 observations)					
mean	−0.33	−0.29	−0.25	−0.22	−0.19
var	1.83	2.20	2.78	3.48	4.25
std deviation	1.35	1.48	1.67	1.87	2.06
skewness	−0.31	−0.10	0.03	0.12	0.16
std error	0.82	0.58	0.37	0.31	0.25
kurtosis	5.07	3.28	1.96	1.12	0.69
std error	1.68	1.08	0.82	0.61	0.46

Table 1: Statistical properties of interest rate changes, four periods

	faiz091	faiz182	faiz273	faiz365	faiz456
period 1: 2001-01-02 – 2003-10-06 (692 observations)					
min	−38.20	−45.74	−48.25	−48.66	−48.13
median	−0.10	−0.13	−0.16	−0.14	−0.13
max	70.25	102.17	144.86	176.72	200.37
day of min	2001-02-26	2001-02-26	2001-02-26	2001-02-26	2001-02-26
day of max	2001-02-20	2001-02-23	2001-02-23	2001-02-23	2001-02-23
period 2: 2003-10-07 – 2006-06-01 (666 observations)					
min	−7.09	−6.73	−7.05	−8.59	−9.70
median	0.00	−0.02	−0.07	−0.07	−0.13
max	4.58	6.20	7.34	8.56	9.81
day of min	2004-09-08	2004-12-20	2004-05-12	2004-05-12	2004-05-12
day of max	2004-05-10	2004-05-10	2004-05-10	2004-09-20	2004-09-20
period 3: 2006-06-02 – 2008-08-29 (569 observations)					
min	−3.80	−4.55	−5.17	−5.84	−6.32
median	0.00	0.00	0.00	0.00	−0.05
max	7.24	9.48	11.16	12.49	13.55
day of min	2006-07-04	2006-07-04	2006-07-04	2006-07-04	2006-07-04
day of max	2006-06-26	2006-06-26	2006-06-26	2006-06-26	2006-06-26
period 4: 2008-09-01 – 2009-03-13 (131 observations)					
min	−6.76	−6.54	−6.46	−6.27	−6.15
median	−0.23	−0.22	−0.26	−0.30	−0.33
max	4.73	5.17	5.51	5.77	5.95
day of min	2009-01-16	2009-01-16	2009-01-16	2009-01-16	2009-01-16
day of max	2008-10-27	2008-10-27	2008-10-27	2008-10-27	2008-10-27

Table 2: Quantiles of interest rate changes, four periods

deviation, skewness, kurtosis, minimum, median, and maximum.

There are obvious differences between the periods: The range of daily changes is widest for period 1; the variance and the kurtosis are largest for period 1. The behaviour of the five series within the periods gives insight into the characteristics of the different maturities, but also reveals further differences between the periods. In particular, some of the characteristics resulting from Tables 1 and 2 are:

- The arithmetic mean of the daily changes in the faiz series increases from faiz091 through faiz456 in period 1, but not in the other three periods. An explanation may be that period 1 was regarded as risky by many investors in the sense that the Turkish financial market's risk premium is still high. As a consequence, investors demanded high long-maturity interest rates as a compensation for risks in future periods.

- The variance increases from faiz091 through faiz456 throughout all periods, in other words: The interest rate risk increases with maturity.

- The tail behaviour of the distributions, as expressed in the kurtosis, is more complex. The kurtosis becomes larger as maturity increases only in period 1. This points again to an elevated risk for higher maturities in period 1. The results of Tables 1 and 2 point to a high risk in period 1, lower (and similar) risks in periods 2 and 3, and further reduced risk in period 4. The kurtosis generally points to heavy tails in all periods across all series, with a few exceptions. For example, it seems noteworthy that faiz456 has no significantly positive kurtosis anymore in period 4. The more complex kurtosis structure justifies using the GPD as a means to study the tail behaviour of the interest rate change distributions.

- The ratio between minimum and maximum percentage point change is increasing with maturity during periods 1, 2, 3, but not during period 4. This is also clearly visible in the boxplots in Figure 2.

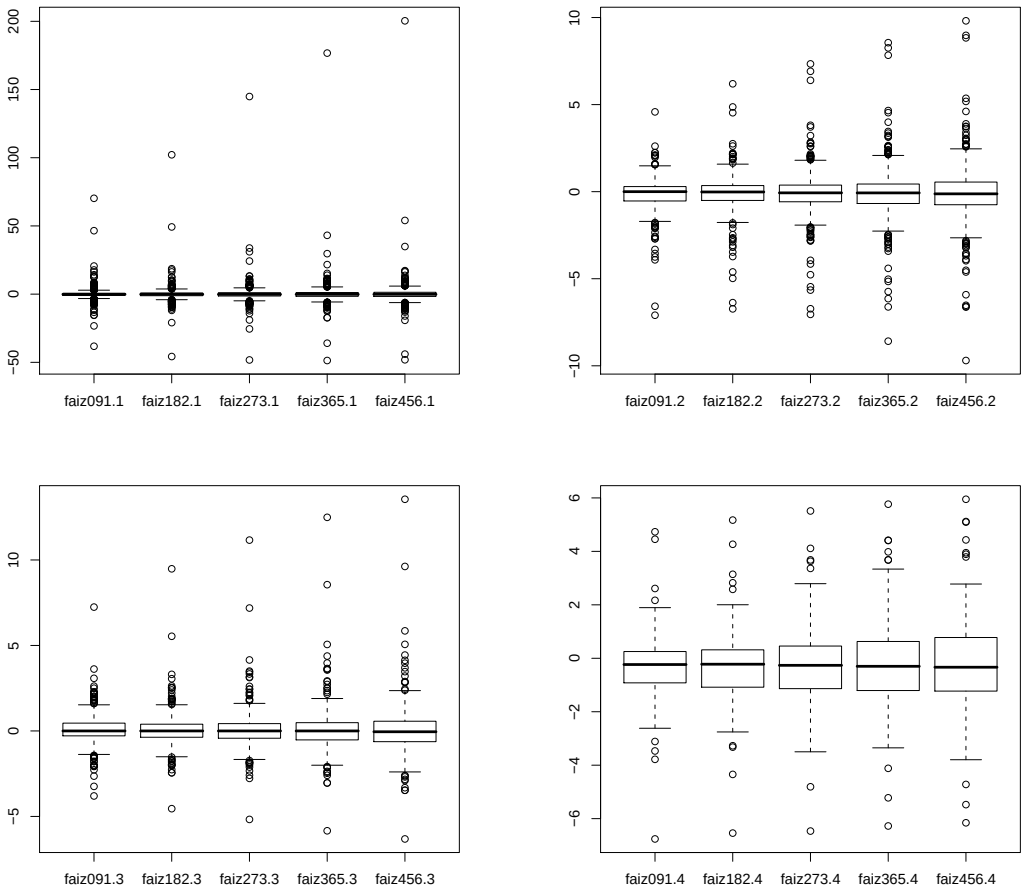

Figure 2: Boxplots of interest rate changes, four periods

- The days when minima (maxima) occurred is always the same or very close in periods 1, 3, and 4. This is not the case in period 2. This may have to do with the exceptionally low and stable volatility in period 2: There were no identifiable spikes occurring simultaneously in all five series.

Our goal in the present paper is an evaluation of the interest rate risk. Therefore, the two most important items in the previous list are the variance and the kurtosis.

4 Structural Breaks in the Interest Rate Series

It was argued in Section 2 that, due to economic and political events in Turkey, it is justified to divide the time period January 2001 through August 2008 into three sub-periods. We shall now approach this question more formally and apply a statistical test for structural changes to the time series of daily interest rates. This will provide further arguments for a separate risk analysis in the three sub-periods.[9] In addition, we will clearly see the limitations of regression models when applied to the interest rate series.

The method we use will find breakpoints in a regression relationship, with interest rates as dependent variable and time (i.e. day) as independent variable. This method is based on Bai and Perron (2003; its implementation is described in Zeileis et al. (2003. Breakpoints are computed with the objective of minimizing the residual sum of squares under the constraint that no segment should be shorter than 15% of total time period considered. (Our time series, beginning with January 2001 and ending in August 2008, is 1930 days long.) The number of breakpoints is not predetermined, but results from the procedure.

The test for structural changes finds four breakpoints in the series faiz091, which we chose for this purpose to represent interest rate evolution. The results of the breakpoint analysis are displayed in Figure 3. In our subsequent analysis, we shall ignore the first breakpoint and form period 1 with 2003-10-06 as last day. This is justified because of the relative homogeneity of circumstances and events in this period. We are therefore led to a definition of sub-periods and their characterization as shown in Table 3.

[9] We analyzed the period January 2001 through August 2008, based on structural breaks. The subsequent period, here called *Period 4*, was adjoined on reasons other than breakpoint analysis; see **. . . here economic reasons/references for adjoining a fourth period, or reasons for not simply letting Period 3 continue down to March 2009!**.

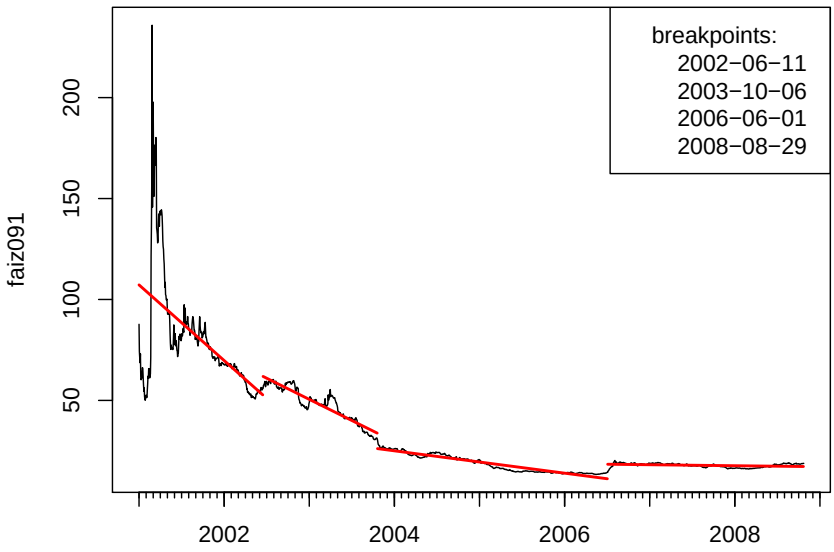

Figure 3: Breakpoint analysis of faiz091

	starts	ends	characteristics
period 1	2001-01-02	2003-10-06	high interest rates, decreasing rapidly after peak; large daily fluctuations
period 2	2003-10-07	2006-06-01	more moderate interest rates, decreasing; small daily fluctuations
period 3	2006-06-02	2008-08-29	moderate interest rates at a relatively stable level; moderate daily fluctuations

Table 3: Dividing the period January 2001 – August 2008 into sub-periods

5 GPD-Based Interest Rate Risk Measurement

5.1 The Generalized Pareto Distribution (GPD)

The GPD is a model for excesses of a random variable. The rationale behind using the GPD is a limit theorem which states[10]: Let $R_1, \ldots, R_n$ be iid random variables, and let R be distributed like R_i. Then, for large n and u, there are ξ and σ such that the distribution function of the excess

$$R - u, \quad \text{conditional on} \quad R > u,$$

is approximately given by

$$F(x;\xi,\sigma) = \begin{cases} 1 - \left(1 + \xi\dfrac{x}{\sigma}\right)^{-1/\xi} & \text{if } \xi \neq 0, \\ 1 - \exp\left(-\dfrac{x}{\sigma}\right) & \text{if } \xi = 0. \end{cases}$$

Here, $\sigma > 0$ is a scale parameter; it depends on the threshold and on the probability density function of R_i. The shape parameter ξ is called the tail index, since it characterizes the tail of the density function:

- The case $\xi > 0$ corresponds to fat-tailed distributions; in this case, the GPD reduces to the Pareto distribution.
- The case $\xi = 0$ corresponds to thin-tailed distributions; the GPD then reduces to the exponential distribution with mean σ.
- The case $\xi < 0$ corresponds to distributions with no tail (i.e. finite distributions). When $\xi = -1$, the GPD becomes a uniform distribution on the interval $[0, \sigma]$.

5.2 Empirical Results

A typical example of fitting the GPD to the upper tail of one of our data series is shown in Figure 4. The histogram represents the upper tail of the empirical

[10] For example, see Coles [**?**].

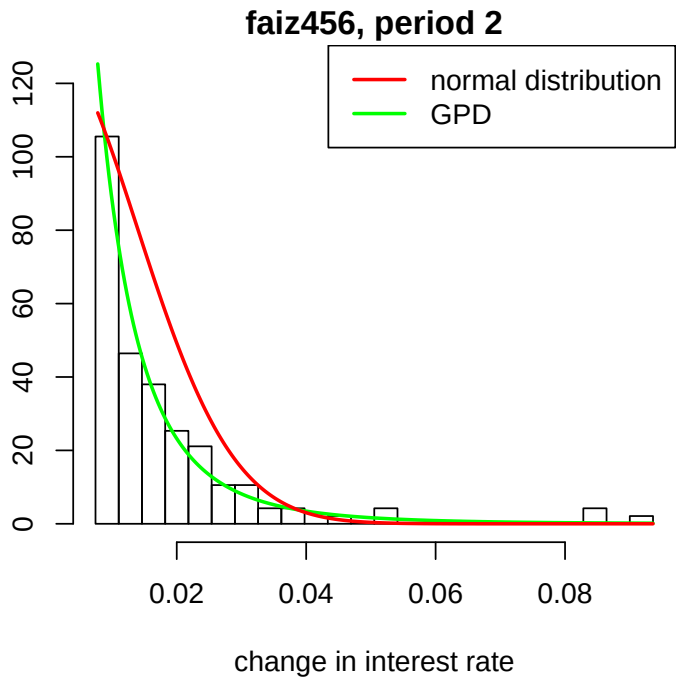

Figure 4: Fitting the GPD to data

distribution of daily changes in the series faiz456 during period 2, where we used the 80% quantile as cutoff point. (This quantile was used as cutoff point throughout our study.) The red line is the density of the normal distribution with the same mean and variance as faiz456 in period 2, and the green line is the density of the GPD fitted to the data. It is obvious that the normal distribution overestimates the probability of moderate changes and underestimates the probability of large changes. This makes it inappropriate for risk analysis.

The estimation results are reported in Table 4. In our context of risk measurement, the estimated tail index $\hat{\xi}$ is more important than $\hat{\sigma}$. As stated above, a positive tail index indicates that the distribution of interest rate changes has a heavy upper tail. Table 4 shows:

- estimates of the GPD parameters ξ and σ, together with their standard errors, based on daily interest rate changes (computed as $r_t = \ln(i_t/i_{t-1})$) above their empirical 80% quantile (that is, based on threshold exceedances of the 80%

quantile) for each period,

- 95% and 99% quantiles of the interest rate changes (the columns designated as $q_{.95}$ and $q_{.99}$, respectively),

- the corresponding quantiles, obtained by adding a GPD-based quantile to the empirical 80% quantile (which served as the threshold).

The relatively close agreement between the latter pairs throughout the periods we considered and across the interest rate *vadeleri* can be seen as a confirmation of the model accuracy.

A comparison of the four periods with respect to the tail properties of the interest rate change distribution leads to the following remarks:

- Period 1 has exceptionally high values of ξ for each interest rate series considered: All five tail indices are significantly positive (which indicates heavy tails, here: an elevated risk that tomorrow's interest rate is much higher than today's) at the 5% level of significance.

- There is little difference between Periods 2 and 3, as far as the tail index is concerned. None of the interest rate change distributions is heavy-tailed, with the exception of faiz456. This points to an elevated overnight increase in interest rate only for long-term bonds.

- The exceptional status of faiz456 seems to have disappeared in Period 4. However, any statistical statement about Period 4 may have a small power, because of the small number of observations in this period (20% of about 130 observations used in the estimation of the parameters ξ and σ).

5.3 Using the GPD: Conclusions

The normal distribution is not appropriate to measure the risk associated with interest rates in Turkey. The GPD, derived as an explicit model for distribution tails,

	$\hat{\xi}$	std.err.$\hat{\xi}$	$\hat{\sigma}$	std.err.$\hat{\sigma}$	$q_{.95}$	5% VaR	$q_{.99}$	1% VaR
period 1 (2001-01-02 – 2003-10-06):								
faiz091	0.6229	0.1413	0.0121	0.0019	0.0352	0.0347	0.1189	0.1139
faiz182	0.5160	0.1283	0.0145	0.0021	0.0409	0.0405	0.0998	0.1147
faiz273	0.4898	0.1274	0.0169	0.0025	0.0521	0.0476	0.1029	0.1290
faiz365	0.4202	0.1173	0.0210	0.0029	0.0575	0.0554	0.1046	0.1420
faiz456	0.3996	0.1138	0.0237	0.0033	0.0614	0.0610	0.1153	0.1541
period 2 (2003-10-07 – 2006-06-01):								
faiz091	0.0000	0.0546	0.0046	0.0004	0.0103	0.0106	0.0199	0.0180
faiz182	0.0000	0.0437	0.0059	0.0006	0.0116	0.0124	0.0214	0.0219
faiz273	0.0000	0.0432	0.0075	0.0009	0.0148	0.0154	0.0277	0.0275
faiz365	0.0000	0.0439	0.0090	0.0010	0.0182	0.0187	0.0335	0.0331
faiz456	0.2579	0.1078	0.0075	0.0010	0.0210	0.0200	0.0373	0.0415
period 3 (2006-06-02 – 2008-08-29):								
faiz091	0.0000	0.0430	0.0061	0.0006	0.0123	0.0134	0.0223	0.0232
faiz182	0.0000	0.0297	0.0062	0.0007	0.0116	0.0137	0.0249	0.0237
faiz273	0.0000	0.0287	0.0070	0.0008	0.0128	0.0152	0.0309	0.0265
faiz365	0.0000	0.0295	0.0080	0.0009	0.0152	0.0173	0.0352	0.0301
faiz456	0.2431	0.1011	0.0066	0.0009	0.0164	0.0181	0.0373	0.0364
period 4 (2008-09-01 – 2009-03-13):								
faiz091	0.0000	0.1706	0.0091	0.0026	0.0150	0.0172	0.0391	0.0318
faiz182	0.0000	0.2040	0.0098	0.0029	0.0173	0.0208	0.0391	0.0365
faiz273	0.0000	0.2567	0.0104	0.0036	0.0255	0.0245	0.0393	0.0412
faiz365	0.0000	0.3276	0.0126	0.0042	0.0308	0.0291	0.0432	0.0494
faiz456	0.0000	0.3350	0.0130	0.0043	0.0348	0.0329	0.0498	0.0538

Table 4: Parameters of fitted GPDs

fits very well and provides a close fit between the theoretical VaRs and empirical quantiles.

6 Turkish Interest Rates and the USD/TL Exchange Rate

What can be said about the joint behaviour of changes in Turkish interest rates and the USD/TL exchange rate? It is in line with our approach to interest rate risk assessment to investigate the occurrence of joint daily threshold exceedances. For each period, we define indicator variables as follows:

$$X_t = \begin{cases} 1 & \text{if a USD-return exceedance happened on day } t, \\ 0 & \text{otherwise,} \end{cases}$$

$$Y_t = \begin{cases} 1 & \text{if an interest rate change exceedance happened on day } t, \\ 0 & \text{otherwise.} \end{cases}$$

Here, we speak of a USD-return exceedance if the change in price of a USD in TL was larger than its 90% quantile or lower than its 10% quantile, where the quantile is period-specific. Likewise, an interest rate change exceedance is said to happen if the change in interest rate is larger than its 90% quantile or lower than its 10% quantile, where quantiles are again period-specific.

Contingency tables for X and Y, together with their odds ratios, are shown in Table **??**. An odds ratio larger than 1 indicates a positive association of X and Y, that is, the main diagonal of the contingency table has higher frequencies than expected under the hypothesis that X and Y are independent. Table **??** reveals that the highest association is found in Period 1, while threshold exceedances were negatively associated in Period 4. Furthermore, the odds ratios for Periods 1, 2, and 3 are all significantly larger than 1 (their respective confidence intervals do not contain 1), while no significance was found for Period 4.

Period 1: 2001-01-02 — 2003-10-06

		Y 1	0		
X	1	34	72	odds ratio:	2.99
	0	72	349	95% confidence interval:	[1.42,3.69]

Period 2: 2003-10-07 — 2006-06-01

		Y 1	0		
X	1	34	94	odds ratio:	1.60
	0	94	416	95% confidence interval:	[1.02,2.51]

Period 3: 2006-06-02 — 2008-08-29

		Y 1	0		
X	1	33	77	odds ratio:	2.06
	0	76	365	95% confidence interval:	[1.28,3.31]

Period 4: 2008-09-02 — 2009-03-13

		Y 1	0		
X	1	5	21	odds ratio:	0.87
	0	21	77	95% confidence interval:	[0.31,2.50]

Table 5: Joint threshold exceedances

7 Summary and Conclusions

The focus of this paper is an assessment of the risk associated with interest rates in Turkey. We used data from Istanbul Stock Exchange (ISE) Second Hand Bond Market, Government Bond interest rate closing quotations, for the time period January 2001 through March 2009. A risk analysis is important in this context because of several aspects:

- risk as a measure of portfolio risk,
- risk as a measure of financial risk,
- risk as a measure of decisional risk.

There are several approaches to measuring the interst rate risk: using the yield curve; using GARCH models; or one based on the Generalised Pareto distribution (GPD). We undertook our risk assessment efforts based on the latter one, leading to a value at risk at the 5% and 1% levels. This is in line with research documented in scientific literature, for example, Neftçi and Bali (2001).

We found economic as well as statistical arguments for dividing the period under investigation into four sub-periods, period 1 reaching from January 2001 through September 2003, period 2 from October 2003 through May 2006, period 3 beginning in June 2006 and ending in August 2008, and finally period 4 beginning in September 2008 and ending in March 2009. Estimating GPDs to the data resulted in a good fit between the model and our data for all periods and maturities. It turned out that the tail indices, indicating the weight of the upper tail of distributions of daily interest rate changes, became smaller and smaller, indicating that tails became thinner from period to period.

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