APPLICABILITY OF THE EWMA MODEL TO ESTIMATE THE VOLATILITY OF ISTANBUL STOCK EXCHANGE BONDS AND BILLS MARKET

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1. Introduction

Extreme volatilities in financial markets lead to uncertainties with respect to taking forward looking decisions and negatively affect the accuracy of forward looking predictions to a large extent. Especially a particular volatility process referred as “volatility clustering”, in which a succession of large or small scale variations ensue, directly influences the financial market players. Several volatility models are currently used in future projections in financial markets. However, the main question is about which volatility model possesses a stronger predictive power or concerns the sufficiency of the calculated volatility outcomes. In this day and age, financial analysts recognize the significance of volatility prediction methods used in decision making regarding future projections.

In ISE Bills and Bonds Market, primarily Central Bank of Republic of Turkey (CBRT), followed by the exchange members and the banks which were granted permissions from Capital Markets Board (CMB) conduct most of the trading. As the parties participate in the trades, they would like to come up with the right and coherent investment decisions by performing forward looking volatility predictions. From this point of view, the daily and annual volatilities of the TL-denominated interest rates on 6-month and 12-month GDS that were traded in ISE Bills and Bonds Market for the period between 12.28.2005 and 12.31.2007 have been calculated in this study from their EWMAs (Exponential Weighted Moving Averages), which were plotted in accordance with the Nelson-Siegel Model. The reliability level of the calculated volatility values has been back tested, which has demonstrated that the volatilities in financial markets might be successfully estimated by the EWMA model.

2. The volatility concept and development of the Ewma model

Volatility is the statistical measure of the fluctuation in the price of a financial instrument (Butler, 1999: 190). According to another definition, volatility is described as the measure which depicts the magnitude of the price movements in stocks, futures contracts or other financial instruments (Hampton, 2005: 3). In this day and age, volatility estimations carry vital importance for both real sector firms and financial institutions. Volatility is also perceived as the degree of variation that takes place in financial markets in time and analysis of the standard deviation or variance can be used as the methodology for measurement of this variation. Besides, as much as volatility is a measure of risk, it is also thought to be reflecting the expectations with respect to the direction of the market. Among the primary models used in volatility projections; historical models, implied models and conditional volatility models such as WEMA and GARCH (Generalized Autoregressive Conditional Heteroskedasticity) could be listed. In this study, explanations and practices based on the EWMA model have been presented.

3. The Ewma model

The EWMA is one of the time-series volatility models that estimate the future volatility by taking the past average volatility into consideration, which are also widely employed in risk calculations[1]. The model has been devised on the assumption that asset returns are symmetrical and independently distributed, and proceeds from the presumption of the validity of time-dependant volatility (Bolgün and Akçay, 2005). Exponential weighting is related to how long ago the observations have been made. The weight assigned to an observation *t* times ago is lambda (λ) times that of the weighting of time *t-1* (Akçay, Kayahan and Yürükoğlu, 2009: 77). While the weights of the observations tend to equalize as lambda approaches unity, the weights of latest observations increase as it approaches zero. RiskMetrics[2] use the EWMA model to estimate the variance and covariance (volatility and correlation) of multi-variable normal distribution. In the EWMA model, the volatility of the next day explains the volatility of the previous (n^{th}) day. This approach constitutes a better predictive power compared to the traditional methods, which take equally weighted mean variation into account (RiskMetrics, 1996: 81). Taking the exponential moving averages of historical data by assigning the highest weights to most recent observations serves to grasp the dynamic characteristics of volatility and to rapidly reveal small changes. This model incorporates two significant superiorities compared to the equal weighting model. First of all, in case of weighting data from the recent past more heavily, the volatility generates a faster response to market shocks. Secondly, following a shock fall in the markets, exponentially weighted mean volatility also drops, because the highest weight is given to the closest data point. The EWMA graph behaves as if it has a memory that fades in time.

EWMA is intensively employed in mostly risk management calculations, pricing of derivatives and estimations of forward-looking forecasts. This model is driven by the values of two principal parameters, time (t) and lambda (λ). The (λ) coefficient used by the model is also named as “constant adjustment” or “decay factor” (smoothing constant) as well (Butler, 1999: 199) and indicates the strength of the related period (time course). The (λ) coefficient takes on a value between 0 and 1 (inclusive) and determines the effective depth of data being used in estimating volatility and the relative weighting that will be applied to the data. The EWMA model performs estimations by incorporating the coefficient of lambda for the most recent returns and a weighted average of the prior projections (Jorion, 2005: 362).

In the model, σ_n is calculated from the n^{th} day’s (calculated n-1 days ago) volatility (σ_{n-1}) and (u_{n-1}) denotes the last returns in the markets. The return change is calculated in the form of $\ln(P/P_{n-1})$. As the calculations are performed, a new (u^2) should be calculated and used in variance estimations when a new market observation is made or a fluctuation occurs. Ultimately, the old variance levels or variation of the old market returns will become meaningless. From this point of view, the EWMA model is presented as follows:

$$\sigma_n^2 = \lambda \sigma_{n-1}^2 + (1-\lambda) u_{n-1}^2 \quad (1)$$

EWMA model has been devised to keep track of fluctuations in financial markets. Let’s suppose that there was a

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[1] http://www.pricingtools.eu/sigmamodels/ewma.htm (04.12.2008).

[2] Riskmetrics has been founded by JP Morgan in 1994 and conducts research about risk management, corporate governance and financial markets. In 1996, this organization type has become a standard for financial markets and 2 years later, Riskmetrics has become a separate company.

large fluctuation in market variance n-1 days ago, which leads to the expansion of (u^2_{n-1}) value. Afterwards, the market volatility for n days is calculated. As the (λ) coefficient used in the calculations diverges from unity, more recent historical data are weighted more heavily (used for short-term projections). This weighting strategy helps to apprehend the dynamic properties of the input data. Riskmetrics recommends using a general decay factor in volatility calculations for all assets within particular time periods. The recommended adjustment coefficient is 0.94 for daily data and 0.97 for monthly data. When the same decay factor is used in all calculations, the model simplifies computations involving a sizeable covariance matrix and resolves the problems associated with the scope of volatility estimation (Suganuma, 2000: 4). In the EWMA model, designation of the optimum value for (λ) coefficient is of vital importance since it is the most significant controllable parameter. Coefficients of lambda recommended by RiskMetrics depending on country are displayed in Table 1.

Table 1: The optimum coefficients of lambda by country

COUNTRIES	LAMBDA
ARGENTINA	0.972
INDONESIA	0.992
PHILIPPINES	0.925
SOUTH AFRICA	0.938
SOUTH KOREA	0.956
MALASIA	0.808
MEXICO	0.895
THAILAN	0.967
TURKEY	**0.970**

Source: Bolgün and Akçay, 2005: 330.

Another significant parameter that needs to be determined in the EWMA model along with lambda value is the number of effective observations, because exponential weighing will largely affect the effective number of observations used. In other words, the calculation for each day’s volatility is based on the average volatility for a particular number of days past (such as the previous 100 working days). The primarily required step at this point is to determine of the weighting coefficients that will be assigned to each one of the past 100 days. The weighting (w) formula could be defined as follows:

$$w_t = \lambda^{(T-t)} = 0{,}90^{(100-t)}$$

According to this formula, weight of the data belonging to the first day of the past 100 days will be calculated as:

$$0{,}90^{(100-1)} = 0{,}000029513$$

Whereas, the volatility estimate of the 2nd day be assigned the following weight:

$0.90^{(100-2)} = 0{,}000032792$

The weighting will approach unity towards the last day ($0.90^{(100-100)} = 1$). As is seen, the forward-looking volatility estimation will be performed in accordance with the estimated exponentially weighted average volatility of the past 100 days. For instance, at the lambda value of 0.90, the number of effective days equals 9.99 with respect to weighting a total of 100 days. At a much higher lambda value (0.98), the number of effective observations will rise to 43.37. Hence, the lambda value corresponding to a number of effective observations (Q) could be calculated as given by the equation:

$$Q = \frac{1-\lambda^{veriaral\imath e\imath}}{1-\lambda}$$

An approximate decay coefficient (λ) should be selected in volatility and correlation estimations by using the EWMA model. Besides selecting this coefficient, the number of effective observations whose volatility and correlations will be estimated should also be specified. In Table 2, the coefficients used in EWMA model depending on historical data are exhibited. For example, at a reliability level of 0.99 and (λ) coefficient of 0.98, approximately 228 historical data points should be used to estimate the forward-looking volatility and correlation.

Table 2: The number of effective historical data points used in the EWMA Model

Decay factor	0.001%	0.01%	0.1%	1 %
0.85	71	57	43	28
0.86	76	61	46	31
0.87	83	66	50	33
0.88	90	72	54	36
0.89	99	79	59	40
0.9	109	87	66	44
0.91	122	98	73	49
0.92	138	110	83	55
0.93	159	127	95	63
0.94	186	149	112	74
0.95	224	180	135	90
0.96	282	226	169	113
0.97	378	302	227	151
0.98	570	456	342	228
0.99	1146	916	687	458

Source: RiskMetrics Technical Document, 1996: 94.

Riskmetrics generates its volatility and correlation estimates from 480 different times-series simulations. This method requires a total of 480 variance and 114,900 covariance estimations. By the virtue of this derived covariance matrix comprising these parameters, the optimal decay factor for each variance and covariance level is chosen. This coefficient values should be periodically optimized by IGARCH[5] method. In this study, the optimal decay factors have been reoptimized by using the financial analysis software called Financial Instrument Analyzer (FIA).

3. Generation and application of the data set in Ewma model

In emerging countries like Turkey, substantial uncertainty with respect to interest rates exists as a result of economic and political developments arising from either domestic or external dynamics. In this context, fluctuations and the volatility in ISE Treasury Bills and Government Bonds market needs to be analyzed. Especially, determination of the yield curves regarding the bills and bonds issued by the state and traded among intermediary institutions with respect their times to maturity is of capital importance. As can be seen in Table 3, TL-denominated GDS are predominantly traded in the Treasury Bills and Government Bonds market.

Table 3: Distribution of finalized transactions in ISE Treasury Bills and Government Bonds market for the period between 01.01.2008-11.21.2008

Finalized transactions in ISE Treasury Bills and Government Bonds market * (1.000.000 YTL)								
	Individual Buyers		Investment Trust – Mutual Fund		Portfolios of Intermediary Institutions		Total	
	Volume	Proportion	Volume	Proportion	Volume	Proportion	Volume	Proportion
TL-denominated GDS	13.104	2.38%	85.436	15.51%	451.527	81.96%	550.067	99.85%
FX- denominated GDS	1	0.00%	54	0.01%	444	0.08%	500	0.09%
Private Sector Securities	0	0.00%	0	0.00%	303	0.05%	303	0.06%
CBRT Securities	0	0.00%	14	0.00%	14	0.00%	29	0.01%
TOTAL	**13.106**	**%2,38**	**85.505**	**%15,52**	**452.288**	**%82,10**	**550.899**	**%100,00**

Source: http://www.imkb.gov.tr/veri.htm (12.25.2008).

In the study, calculations based on the EWMA model have been deduced from FIA[3] (Financial Instrument Analyzer) and the statistical tests were obtained from e-views 5.0. Before proceeding with volatility calculations based on the EWMA model, the yield curve graphs of the GDS interest rates to be used should be plotted with the appropriate model, because considerably different financial instruments with various maturities are traded in the GDS market. Therefore, a disagreement may arise between maturities and interest rates. The correct action here is to estimate the interest rates at the intermediate maturities by assistance of the convenient yield curve model (Teker, Akçay and Akçay, 2008: 5). The Nelson-Siegel model has been used in estimation of the yield curve, because it is the model that produces the projections closest to the actual interest rates observations (Nelson and Siegel, 1987: 473-489). This model assumes that instantaneous forward rates fluctuate in time in the manner implied by the quadratic difference equation (Akıncı et. al., 2006: 10). Other than that, linear interpolation, logarithmic interpolation, cubic interpolation, cubic spline, quadratic interpolation, Nelson-Siegel Model and OLS Echols-Elliot Model are the other models used for estimation of the yield curve (Teker, Akçay and Akçay, 2008: 5). However, deviation of each model from the actual values is different. According to the studies conducted within a period of one year, the model with the lowest deviation between the estimated and actual values is the Nelson-Siegel Model. Consequently, Nelson-Siegel model has been used in many studies about determination of the yield curves in Turkey. Among such studies, Nelson-Siegel Model has been used by Teker and Gümüşsoy (2004: 2) to obtain the interest rate yield curves for Treasury Bills and Eurobonds, by Yılmaz (1999: 60) in the analysis of ISE Bills and Bonds Market interest rate yield curve and by Akıncı et. al. (2006: 1) for obtaining the yield curves of GDS. In Table 4 below, the yield curve analysis of the government debt securities on the date of 12.31.2004 with maturities of 1 month, 3 months, 6 months and 1 year, graphed in

[3] Financial Instrument Analyzer is a financial decision supporting system developed by RiskActive, a financial consulting firm, which can perform calculations pertaining to various fixed or variable income financial instruments and derivates by utilizing internationally accepted financial engineering models and techniques (www.riskactive.com).

accordance with different methodologies are displayed, with the actual values additionally presented (Vobjektif, 2004: 25).

Tablo 4. Yield curve analysis for TL-denominated Government Bonds on 12.31.2004

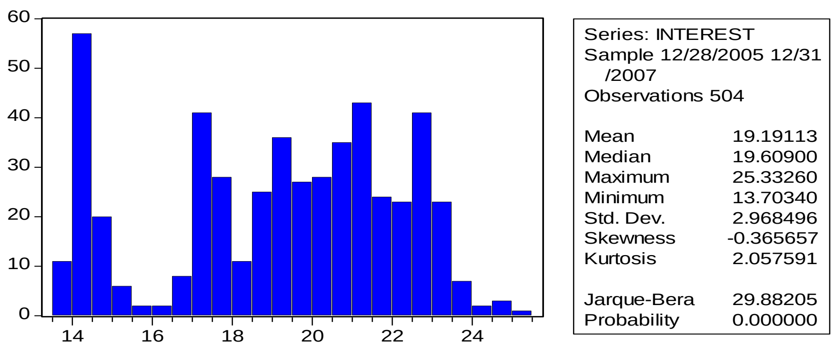
Verim Egrisi Modeli	1M	3M	6M	9M	1Y
Gerçek Gözlemler	16.360	18.070	19.690	20.160	20.160
NelsonSiegel	16.312	18.238	19.652	20.192	20.217
Ols4	16.413	18.252	19.195	19.875	20.494
Quadratic	16.479	17.841	19.737	20.092	20.322
Cubic Spline	16.702	17.910	19.737	20.097	20.488
Cubic	16.461	17.830	19.736	20.092	20.311
Logarithmic	16.595	17.968	19.752	20.070	20.570
Linear	16.498	17.852	19.737	20.091	20.335
Verim Eğrisi Modeli	**1M**	**3M**	**6M**	**9M**	**1Y**
NelsonSiegel	0.0476	0.1678	0.0378	0.0323	0.0573
Ols4	0.0530	0.1817	0.4951	0.2849	0.3344
Quadratic	0.1188	0.2289	0.0466	0.0681	0.1624
Cubic Spline	0.3415	0.1597	0.0473	0.0634	0.3275
Cubic	0.1013	0.2400	0.0461	0.0676	0.1506
Logarithmic	0.2348	0.1021	0.0621	0.0903	0.4097
Linear	0.1375	0.2179	0.0471	0.0686	0.1745
	0.0476	0.1021	0.0378	0.0323	0.0573

Source: Akçay, 2005: 36.

As seen in Table 4, the Nelson-Siegel model is a yield curve analysis method that provides a close value to the actual observations. Therefore, the interest rates used in this study have been derived by this model. The ultimate goal of the Nelson-Siegel model is to conduct yield estimations of long maturity bonds by projecting them farther in the future than their period of observation (Teker and Gümüşsoy, 2004: 3).

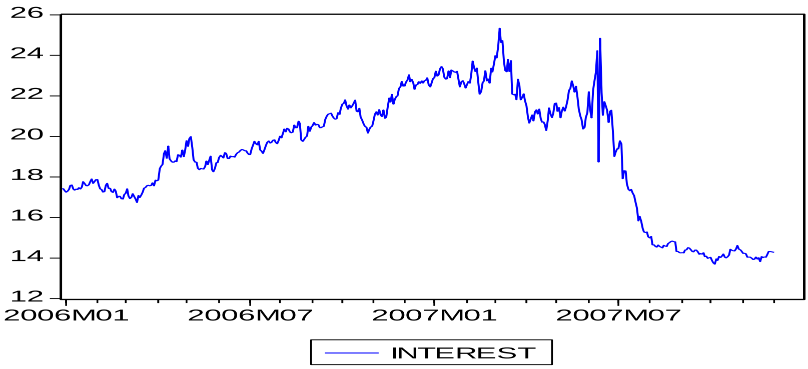
When the data in Table 5 is examined, it is seen that the errors are not normally distributed according to the Jargue-Bera normal distribution test; since the value of 29.88205 > $X^2_{0,05}$ = 5.991. For this reason, logarithmic deviations of foreign exchange rates have been taken as inputs for the conducted analyses. In addition to this, the skewness (S) and kurtosis (K) values show in Table 5 also describe whether the data is normally distributed or not. Accordingly, the magnitude of skewness is 0 and kurtosis is 3 in the case of normal distribution. When these parameters take on fairly different values, the distribution has a skewed or flattened shape and therefore deviates from normality.

Tablo 5. Statistical Results for the GDS



Monthly graph of the time series of the interest rates have been prepared in e-views environment from the data given in App. 1. In this view, the interest rate movements display irregular rises and falls as can be seen in Table 6.

Table 6. Evolution of the GDS interest rates between 28.12.2005 – 31.12.2007



For all these reasons, when the stability test of the time series was carried out via ADF (Augmented Dickey-Fuller) test, it was found out that the data did not satisfy the stationary criteria and that the ADF test statistic **(0.335277)** was below the MacKinnon critical value as seen in Table 7. On the other hand, the fact that the ADF test result obtained from the first-order differences of the time series (**-22.71874)** is above the MacKinnon critical value shows that stationary has been maintained in the series. Therefore, the series have become convenient for volatility estimation based on the EWMA model.

Table 7. Stationarity results belonging to the GDS

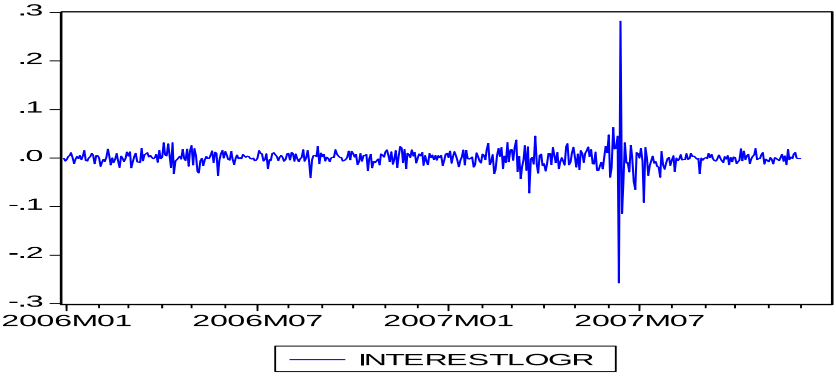
			t-Statistic	*Prob.**
Augmented Dickey-Fuller test statistic			**-0.335277**	**0.9168**
Test critical values:	1% level		-3.443175	
	5% level		-2.867089	
	10% level		-2.569787	
*MacKinnon one-sided p-value				

Table 8. Stationarity results for the first-order differences of the time series belonging to the GDS

			t-Statistic	*Prob.**
Augmented Dickey-Fuller test statistic			**-22.71874**	**0.0000**
Test critical values:	1% level		-3.443175	
	5% level		-2.867089	
	10% level		-2.569787	
*MacKinnon one-sided p-value				

As can been realized from the graph in Table 9 displaying the evolution of interest rate yields, taking the first-order differences of the data has proved sufficient to maintain stationary of the time series.

Table 9. Evolution of the interest yields on the GDS between 12.28.2005–12.31.2007



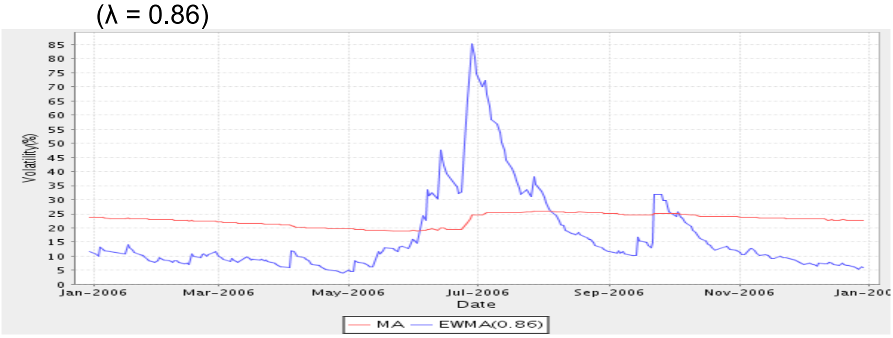
It has already been mentioned that the lambda coefficient is the most important parameter that needs to be determined to predict the volatility in accordance with the EWMA model. The lambda coefficients that have been used in this study have been updated by the FIA (Financial Instrument Analyzer) software of RiskActive, because the coefficient of lambda is not constant and varies with time. Thus, it has to be reoptimized periodically for all financial markets. In this study, the "Lambda Optimizer" feature in FIA has been employed for this purpose. The calculations made as per the algorithm and the obtained optimum lambda figures are displayed in Table 10. Estimations of the 6-month and 12-month volatilities according to the EWMA model are displayed in Tables 11-12 and Tables 13-14, respectively.

Table 10: The calculated lambda coefficients by year

OPTIMUM LAMBDA	2006	2007
6-Month Interest Rate	0.86	0.79
12-Month Interest Rate	0.81	0.93

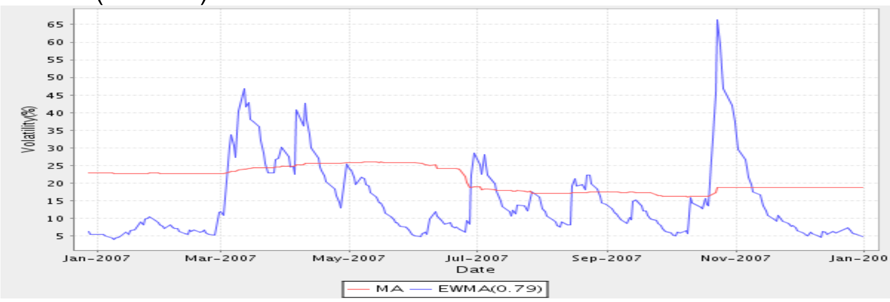
Source: FIA

Table 11: 6-month volatility estimates as per the EWMA model for year 2006 (λ = 0.86)



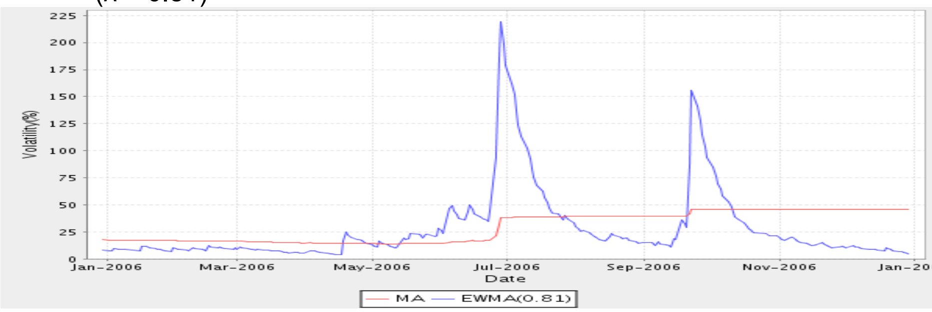
Source: FIA

Table 12: 6-month volatility estimates as per the EWMA model for year 2007 (λ = 0.79)



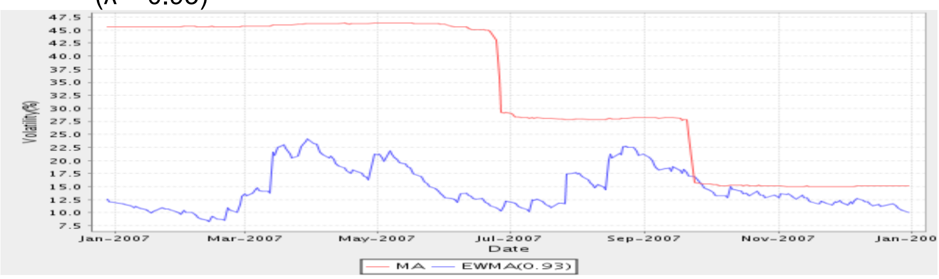
Source: FIA

Table 13: 12-month volatility estimates as per the EWMA model for year 2006 (λ = 0.81)



Source: FIA

Table 14: 12-month volatility estimates as per the EWMA model for year 2007 (λ = 0.93)



Source: FIA

As seen in the tables, the volatility figures vary with the different lambda coefficients obtained from IGARCH calculations. As the calculations were performed, daily volatilities of the 6-month and 12-month GDS had been calculated. Summary of the volatility results for all of the performed estimations are presented in Table 15. In respect of these results, the spread between maximum and minimum daily values of the 6-month volatilities for 2007 is on the order of 4%, whereas the daily deviations have remained relatively lower in 12-month volatility estimates. In the case of 2006, especially traces of the financial turmoil seen in the month of June were dominant and the maximum bounce in daily volatilities of 12-month GDS was in excess of 13%.

Table 15: Summary of the volatility estimation results as per EWMA

Year	EWMA Estimate (6-month)	EWMA Estimate (12-month)
2007 (maximum)	0.0419 (10.10.2007)	0.0152 (03.30.2007)
2007 (minimum)	0.0025 (01.09.2007)	0.0052 (13.02.2007)
2007 (mean)	**0.009521**	**0.00928**
2006 (maximum)	0.0538 (06.28.2006)	0.1381 (06.28.2006)
2006 (minimum)	0.0025 (04.28.2006)	0.0025 (04.17.2006)
2006 (mean)	**0.010821**	**0.01789**

4. Back testing of the ewma estimations

Back testing is the process of testing the validity of the risk model or the volatility figures used by financial institutions in the measurement of the value at risk. It is mainly used for testing the accuracy of risk calculation results and eliminating the model risk. In risk management, the presence of a model risk is tried to be detected through employment of different models. Kuipec (1995) and Crisfersen (1998) are two of the methodologies that most intensively utilize back testing. The fundamental logic in back testing is the comparison of the theoretically estimated and the actually observed values for the following day. Encountering a value outside the range of estimations is recorded as an exception. This operation is performed for each working day. In this way, reliability of the estimations or calculations is determined. Overestimating the volatility as a consequence of inaccurate modeling leads to the financial institutions holding more than adequate capital reserves, whereas underestimating the volatility creates mistrust towards the model used by the institution. If the actual volatility is below the calculated volatility, an exception is recorded in the model's results. If we assume that there are 250 working days in a year, a number of total exceptions between 0 and 13 is considered normal at a confidence interval of 95%, whereas in the case of a higher exception count, the multiplier used in the calculation of capital requirement could be gradually increased for the related financial firm. Other than that, the regulatory institution could demand the review or reconfiguration of the model from the financial institution in cases where the number of deviations exceeds 13 (red area). The distribution of the model with respect to the number of deviations is given below.

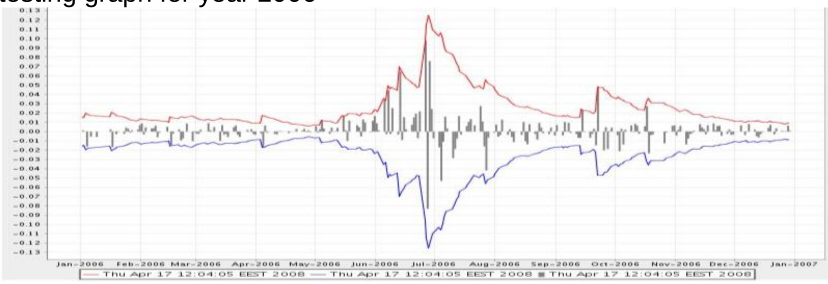
Figure 1: Back testing results

Deviation number		
1-2-3-4	Green area	3
5		3+0.4
6		3+0.5
7		3+0.65
8	Yellow area	3+0.75
9		3+0.85
10+	Red area	3+1.00

Source: Akçay, Kayahan and Yürükoğlu, 2009: 26.

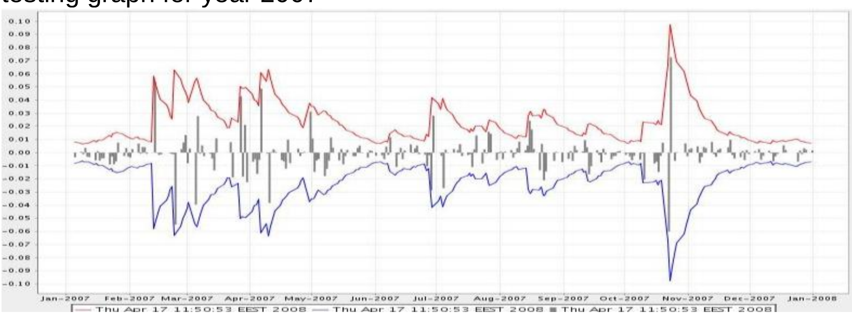
As a result of back testing the values obtained from the tables above, it has been verified at a 99% confidence level that the calculations based on the EWMA model generate successful estimations. Accordingly, the estimated volatilities and back testing graphs for the 6-month and 12-month GDS are exhibited in Tables 16-17 and Tables 18-19, respectively. Downward or upward deviations can also be traced in these graphs. The summary of results organized from these tables is given in Table 20. As seen in this table, all of the estimates are located in the green area and thereby attest to the acceptability of the model.

Table 16: 6-month volatility estimates by the EWMA model and the back testing graph for year 2006



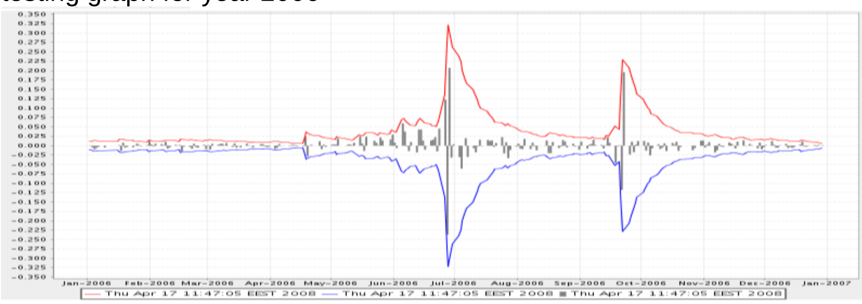
Source: FIA

Table 17: 6-month volatility estimates by the EWMA model and the back testing graph for year 2007



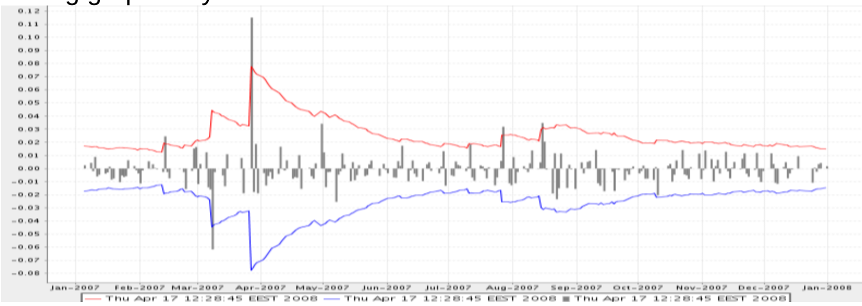
Source: FIA

Table 18: 12-month volatility estimates by the EWMA model and the back testing graph for year 2006



Source: FIA

Table 19: 12-month volatility estimates by the EWMA model and the back testing graph for year 2007



Source: FIA

Table 20: Back testing results

	2006	**2007**
6-month # of upward deviations # of downward deviations	Lambda (0.86) 2 (**0.99**) 1 (**0.99**)	Lambda (0.79) 0 0
12-month # of upward deviations # of downward deviations	Lambda (0,81) 2 (**0.99**) 1 (**0.99**)	Lambda (0,93) 4 **(0.98)** 1 **(0.99)**

Source: FIA

In parallel to the volatility tests conducted above, the accuracy of the EWMA model and the acceptability of its estimations have been recorded in the risk report published by Banking Regulation and Supervision Agency (BRSA). In this context, the EWMA model has become the most commonly employed model for estimating the market risks with a usage rate of 84.4%, as shown in Table 21. This figure lends credence to the reliability of the performed estimations and the results of the conducted tests.

Table 21: Usage rates of the **v**olatility estimation models to address market risks (%)

Volatility Estimation Model	**Usage Rate by the Banks (%)**
ARCH	12.5
GARCH	42.8
EWMA	84.4
STOCHASTIC VOLATILITY	3.2
IMPLIED VOLATILITY	18.0
OTHER	12.9

*The sum of the usage rates exceeds 100% since some of the banks employ multiple models

SOURCE: BRSA, 2009: 20.

5. General evaluation and conclusions

Today, the financial system is evolving and developing at a rapid pace. The most important factors driving this transformation are time and technology, which lead to the market data display a stochastic distribution rather than a deterministic one. As a consequence, a market structure possessing extremely low kurtosis, volatility clustering and leverage effect makes it much harder to accurately estimate volatilities. In financial markets, various models such as historical and predictive models, EWMA and GARCH can be utilized to estimate volatilities. However, there is not agreement about which one these models constitutes the highest predictive power. Nevertheless, according to 2009 data published by BRSA, the methodology most commonly employed by the banks is the EWMA model at 84.4%, though it was stated that some banks used multiple models. For instance, while the GARCH method and the implied volatility method is used by 42.8% and 20% of the banking sector, respectively, the usage level for the ARCH and the Stochastic Volatility methods are 12.5% and 3.2%, respectively. The current situation highlights the EWMA model's superiority compared to other volatility estimation models. In this day and age, accurately estimating the future volatility is essential for financial institutions in the first place and then for businesses operating real economy firms as well. In addition to this, estimation of volatility plays a major part in every field of the financial system from pricing of derivatives to determination of risk management and hedging strategies as well as calculation of portfolio risk.

In this study, 6-month and 12-month volatility estimates with respect to the interest rates in ISE Bonds and Bills Market for the period of 12.28.2005 to 12.31.2007 have been carried out. The performed calculations and the high level of reliability (99%) attained in back testing of the volatility estimates determined as per these calculations have predicated the usability and sufficiency of the EWMA model in analyzing the volatility of interest rates in ISE Bonds and Bills Market.

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