

**THE TERM STRUCTURE OF VOLATILITY
IN THE TURKISH STOCK MARKET**

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JEL: G11, G12, G14.

I. INTRODUCTION

Volatility in financial markets has always been a key element in investment decisions and modelling financial markets. Financial market volatility has recently been investigated, among others, by Shiller (1989), Turner and Weigel (1990), Scott (1991), and Peters (1994). However, resources, in general, seem to have been devoted to studies concerning developed financial markets. The present paper attempts to investigate stock market volatility in an emerging market of a developing country namely Turkey.

¹ Any opinions expressed herein are strictly those of the author and not necessarily those of the Central Bank of the Republic of Turkey.

Risk-return relationship in the Turkish stock market for different return periods has recently been investigated by Balaban (1995a, b, c, d, e). Those papers concentrate on some empirics of the Turkish stock market in addition to daily and monthly anomalies. However, they remain silent to answer how volatility differs across investment horizons. This paper primarily aims to investigate the *term structure of volatility* in the Turkish stock market for the period January 1988-June 1994. To my knowledge, this is a first effort to study volatility differences across investment horizons in the Istanbul Securities Exchange (ISE).

II. DATA AND METHODOLOGY

This study is based on Peters' (1994: 27-31) work on the term structure of volatility in the U.S. stock market. Peters (1994) tests whether volatility measured by standard deviation scales according to the square root of time. This scaling of volatility is derived from brownian motion, a primary model for a random walk process. Einstein's (1908) work on brownian motion finds that the distance that a random particle covers increases with square root of time used to measure it. In Peters' (1994: 55) work, this is formulated as follows:

$$R = T^{0.5} \quad (1)$$

where R and T denote the distance covered and a time index, respectively. The so-called *T to the one-half rule* is extensively used in financial economics to find, say, annual volatility given standard deviation of, say, monthly returns. Peters (1994: 27), among others, notes that annualized risk is simply found by multiplying the standard deviation of monthly returns by the square root of 12.

Daily observations of the Istanbul Securities Exchange Composite Index (ISECI) provided by the Capital Market Board and

the Central Bank of the Republic of Turkey range between January 4, 1988-June 2, 1994. Daily logarithmic returns on ISECI that amount to 1,600 observations are calculated as follows:

$$R_t = \log (I_t / I_{t-1}) \quad (2)$$

where I_t and R_t denote the index number and return on day t , respectively. Then, the ISECI return series is divided into series of subperiods, ${}_i Y_T$, such that

$$n_i * T_i = N \quad (3)$$

where n_i and T_i refer to the number and length of subperiods in series i , respectively. The length of the total sample size, N , is 1,600. ${}_i Y_T$ refers to the i^{th} series where the subperiods have a length of T . Thus, 16 different series are constructed; i.e., $i = 1, 2, 3, \dots, 16$. In these series, the associated T values are as follows: 1, 2, 4, 5, 8, 10, 16, 20, 25, 32, 40, 50, 64, 80, 100 and 160 days. Note that these T values can also be considered as investment horizon. The T -day returns for the contiguous subperiods are also calculated in the same way. Upon completion of the construction of the return series in the way described above, descriptive statistics is calculated for each ${}_i Y_T$. The special emphasis is put on the standard deviation. Note that the calculated standard deviations for each investment horizon indicate realized volatility for that horizon.

Implied volatility under random walk theory is derived according to the T to the one-half rule as follows:

$$SD_T = SD_1 * T^{0.5} \quad (4)$$

where SD_T refers to the standard deviation of T -day returns. SD_1 is daily volatility; i.e., T is equal to one. For each series, implied volatility

is calculated in the same way. Note that the realized daily volatility is taken as base point in calculation of all T -day implied volatilities.

Percentage difference between realized volatility and implied volatility for each T -day series is computed to emphasize deviations, if any. In addition, coefficient of variation and studentized range are calculated to see how standardized volatility changes through time. Finally, the following regression is run to test whether the realized volatility increases by the square root of time:

$$\log SD_T = C + X * \log T \quad (5)$$

Note that the null of random walk is rejected if X significantly differs from 0.5.

III. EMPIRICAL RESULTS

Table 1 provides summary statistics concerning different investment horizons. Note that mean returns increase proportionately with time, as expected. What is also expected is that volatility must increase at *some* rate to be compatible with the risk-return relationship. It is well known in financial literature that investors must bear higher risk to obtain higher return. It is completely what is found in the Turkish stock market for all investment horizons except 64-day returns. If volatility is measured by standard deviation, realized volatility increases from one-day returns to 50-day returns. Interestingly, realized volatility or risk declines for 64-day returns. Then, it continues to increase. A similar observation is also valid for range values. 8-day returns exemplify another interesting investment horizon. Note that this investment horizon seems to offer investors a better risk-return relationship than 5-day and 10-day horizons do.

Table 2 compares realized and implied volatilities across investment horizons and presents such standardized measures of

dispersion as coefficient of variation and studentized range. It is expected that realized volatility increases by the square root of time under random walk assumption. Note that realized volatility is higher than implied volatility for all horizons. The calculated deviations range between 8.6% and 56.4%, with an average value of 30%. Note that deviation for 64-day horizon is smaller compared to those for the previous and subsequent periods.

Coefficient of variation and studentized range inversely changes with the length of investment horizon; i.e., they both decrease as investment horizon becomes longer. The same is valid if range per unit of volatility is taken into consideration. Therefore, long-term investors face less risk per unit of return compared to short-term investors.

Table 3 presents regression results for the so-called *T to the one-half rule*. Note that volatility increases by the 1.79 (1/0.5594) root of time in the Turkish stock market. Therefore, it is found that volatility increases faster than the square root of time. This is in strict conflict with random walk theory derived from brownian motion.

IV. CONCLUSION AND FURTHER RESEARCH

The primary contribution of this paper is that the term structure of volatility in the Turkish stock market is not consistent with the implications of random walk theory. ISECI returns change proportionately with time whereas risk increases faster than the square root of time. It is also found that long-term investments are less risky than short-term investments.

One interesting result found for 64-day horizon is that realized volatility declines and approaches implied volatility. After this point, increasing investment horizon only marginally improves risk-return

trade-off. In my opinion, this is not coincidence. 64 days (12-13 weeks or 3 months) closely represents investment horizon of average Turkish investor.² There are some reasons to support 3-month investment horizon of Turkish investors. First, Turkey is a high-inflationary developing country. Inflation that disturbs whole economic activity has dramatically increased uncertainty in Turkish financial market. As such, economic agents have obviously been prevented to make long-term plans. Second, financial market has been dominated by public sector securities to finance budget deficits. It should be noted that government borrowing in Turkey has heavily concentrated in 3-month maturity. Third, generally speaking, banking credits to private sector have also been extended for 3 months. Fourth, financial intermediaries have usually announced a 3-month period for portfolio management. The last but not the least important one is that financial statements which provides useful information for investors and decision-makers are published quarterly. Obviously, the above list is nonexhaustive and open for further discussion.

The findings of this paper have some implications for academicians, practitioners, and investors. For example, academicians studying on the Turkish financial markets should search some other possible models to estimate volatility. Practitioners and investors should not depend on volatility estimates derived according to the *T to the one-half rule* as these may have a downward bias in estimation of risk. In addition, investors should keep in mind that they may be better off in the long term. Certainly, long-term is not as long as Keynes' long-run in which all we are dead. It only amounts to three months.

² See, for example, Özçam and Üreten (1995) for general characteristics of Turkish investors.

Table 1. *Summary Statistics (Y_T)*

	Y_1	Y_2	Y_4	Y_5	Y_8	Y_{10}	Y_{16}	Y_{20}
n	1,600	800	400	320	200	160	100	80
Mean	0.08	0.17	0.34	0.42	0.68	0.85	1.36	1.70
Median	0.02	0.12	0.26	0.24	0.68	0.57	0.64	0.50
Mode	0.00	0.12	0.25	0.21	0.62	0.32	0.53	0.32
Standard deviation	1.35	2.08	3.09	3.68	4.66	5.44	6.98	7.76
Maximum	4.46	7.74	11.18	13.74	15.26	17.70	22.19	23.54
Minimum	-5.47	-8.37	-12.59	-13.56	-12.70	-17.51	-14.88	-16.07
Range	9.93	16.11	23.77	27.31	27.96	35.21	37.07	39.61
Lower quartile	-0.65	-0.95	-1.71	-1.78	-2.15	-2.30	-3.09	-3.46
Upper quartile	0.81	1.30	2.01	2.44	3.13	4.23	6.21	7.57

	Y_{25}	Y_{32}	Y_{40}	Y_{50}	Y_{64}	Y_{80}	Y_{100}	Y_{160}
n	64	50	40	32	25	20	16	10
Mean	2.12	2.72	3.40	4.25	5.44	6.80	8.50	13.59
Median	0.37	1.48	1.67	2.07	4.99	9.56	11.78	5.55
Mode	-0.18	6.85	0.73	0.67	0.69	7.17	8.27	3.24
Standard deviation	9.53	9.71	11.06	14.20	12.86	15.63	19.67	26.72
Maximum	29.42	31.72	32.42	44.10	31.82	37.06	45.95	52.11
Minimum	-14.89	-18.06	-15.96	-22.89	-15.70	-13.96	-18.75	-24.40
Range	44.31	49.78	48.38	66.98	47.52	51.02	64.69	76.51
Lower quartile	-4.86	-3.14	-2.78	-7.17	-5.49	-7.41	-10.48	2.63
Upper quartile	8.42	8.86	8.27	15.74	16.84	14.05	19.91	44.64

All figures except n, the number of subperiods, are in percentages.

Table 2. The Term Structure of Volatility

	(A) Realized Volatility	(B) Implied Volatility	Difference between (A) & (B)	Coefficient of variation	Studentized Range
Y ₁	1.35	-	-	15.89	7.35
Y ₂	2.08	1.91	8.90	12.24	7.74
Y ₄	3.09	2.70	14.44	9.09	7.69
Y ₅	3.68	3.02	21.85	8.66	7.41
Y ₈	4.66	3.82	21.99	6.86	5.99
Y ₁₀	5.44	4.27	27.40	6.40	6.47
Y ₁₆	6.98	5.40	29.26	5.13	5.31
Y ₂₀	7.76	6.04	28.48	4.57	5.11
Y ₂₅	9.53	6.75	41.19	4.49	4.65
Y ₃₂	9.71	7.64	27.09	3.57	5.13
Y ₄₀	11.06	8.54	29.51	3.25	4.37
Y ₅₀	14.20	9.55	48.69	3.34	4.72
Y ₆₄	12.86	10.80	19.07	2.37	3.69
Y ₈₀	15.63	12.07	29.49	2.30	3.27
Y ₁₀₀	19.69	13.50	45.85	2.32	3.29
Y ₁₆₀	26.72	17.08	56.44	1.97	2.86

All figures except coefficient of variation and studentized range are in percentages.

Table 3. Regression Results

$\log SD_T = C + X * \log T$		
	C	X
Estimate	0.0098	0.5594
Standard error	0.0547	0.1446
t-value	0.1785	3.8687
p-value	0.8611	0.0019
$r^2 = 73.2\%$		
$R^2 = 53.5\%$		

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