Weak Form Efficiency Tests In Istanbul Stock Exchange By Using Moving Averages

A Thesis
Submitted To The Graduate School Of
Business Administration
Of Bilkent University
In Partial Fulfillment Of The Requirements
For The Degree Of
Master Of Business Administration

BY
H. Serkan YILMAZ

JANUARY, 1996

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BY USING MOVING AVERAGES

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to Hadiye Yılmaz

I certify that I have read this thesis and that in my opinion it is fully adequate, in scope and quality, as a thesis for the degree of Master of Business Administration.

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ABSTRACT

WEAK-FORM EFFICIENCY TESTS

IN İSTANBUL STOCK EXCHANGE

BY USING MOVING AVERAGES TECHNIQUES

H.Serkan Yılmaz
M.B.A.
Supervisor: Assoc. Prof. Gülnur Muradoğlu
January 1996

This study tests the weak-form efficiency in İstanbul Stock Exchange by forming portfolios of randomly selected stocks and applying moving averages methodology on these portfolios. Differing moving average rules are applied on random portfolios for the time period 1/1/1988-30/9/1995. Finally, returns of the selected strategies are compared with naive buy hold policy by computing excess returns and t ratios.

This study shows that İstanbul Stock Exchange is not weak-form efficient. The returns of certain strategies brought returns significantly higher than the naive buy-hold policy.

ÖZET

İSTANBUL MENKUL KIYMETLER BORSASI'NIN
ZAYIF ETKİNLİĞİNİN
HAREKETLİ ORTALAMALAR YÖNTEMİYLE ÖLÇÜLMESİ

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Bu çalışma İstanbul Menkul Kıymetler Borsası'nın zayıf etkinliğini bilgisayar destekli rastsal portfolio oluşturarak ve hareketli ortalamalar metodunu bu portfoliolar üzerinde deneyerek test etmektedir. Her bir portfolioya hareketli ortalamala yöntemi 1/1/1988-30/9/1995 tarihleri arasında uygulanmıştır. Son olarak, t oranları kullanılarak,hareketli ortalama-portfolio stratejisinin getirisi, portfolioyu dönem başında alıp dönem sonuna kadar tutmanın getireceği getiriyle karşılaştırılmıştır.

Yapılan analizler, istatiksel sınırlar içerisinde İstanbul Menkul Kıymetler Borsası'nın zayıf olarak etkin olmadığını ortaya koymuştur. Belirlenen stratejilerin getirileri, portfolionun sadece elde tutulmasıyla elde edilen getirilerden istatiksel anlamlı olarak daha fazla olmuştur.

ACKNOWLEDGMENTS

I would like to express my gratitude to Assoc. Prof. Gülnur Muradoğlu for her guidance, support and encouragement for the preparation of this thesis.

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I. INTRODUCTION

If an investor can not earn above average returns simply by considering the past price series, the market is said to be weak-form efficient. The purpose of this study is to investigate whether an investor can earn above average returns in İstanbul Stock Exchange by applying a strategy which uses only past price series as input. Specifically, the strategy used in this study is moving averages technique. Past price series are the daily closing prices of selected stocks.

Even though the first studies to test the weak form efficiency of stock markets started at the beginning of the 1900's, the efforts gained momentum during 1960's. The use of a trading rule, as used in this study, goes as far as to Alexander (1961). Alexander (1961) academically was first to devise a trading rule to determine the inefficiency of the market. The (x,y) filter rule, named after him, gives buy signal when the share price increases x percent from a subsequent low, and gives sell signal when the price decreases y percent from a subsequent high. Using this filter technique Alexander (1961) showed that substantial abnormal profits can be earned.

However, Fama (1965) argued that Alexander didn't take into consideration the transaction costs, which may affect profitability, especially when x and y are low values so that the number of transactions are high. With transaction costs taken into account Alexander's (1961) filter technique didn't produce statistically significant abnormal returns.

Other than testing Alexander's (1961) rule, in this classical study Fama (1965) reached to the conclusion that the data he studied presented strong support for the random walk model. Random walk model consists of independent and identically distributed random variables. To test the independence, Fama (1965) used the serial correlation model, runs tests, Alexander's (1961) filter technique and distribution of successors to large values. None of these tests he performed gave any important dependence in the first differences of the logs of stock prices. To test the identical distribution, he demonstrated by using frequency distributions and normal probability graphs that the price differences don't follow

normal distribution as central Limit theorem suggested, but instead they followed stable Paretian distributions.

The subjects of the studies of 1960's were almost only New York and London Stock Exchanges. However, in 1980's the stock markets of Eastern Asian and Developing, as well as other European countries started to attract attention. Since İstanbul Stock Exchange shows different characteristics than New York Stock Exchange in terms of trading volume, regulations, and culture, we shall investigate the literature on markets with traits similar to İstanbul Stock Exchange.

Panas (1990) investigated the behavior of Athens stock prices following almost the same procedures and tests used by Fama (1965). He examined independence by serial correlation analysis, runs analysis, and Kolmogorov-Smirnov tests. He then investigated the distribution of monthly returns by tests of normality. His conclusions were in favor of independence and identical distribution. He showed that stock price differences followed a heavy-tailed non-Gaussian distribution.

Different from Panas (1990), K.A. Wong and K.S. Kwong (1984) investigated only the independence of the Hong Kong Stock Market. They applied serial correlation tests and runs tests. They found that the magnitude of statistical dependence in successive stock price changes in the Hong Kong Stock Market was larger than those found by Fama (1965) in NYSE and by Dryden (1970) in London Stock Exchange. This evidence led them to conclude that the Hong Kong Stock Market was not weak-form efficient.

Solnik (1973) tested the adequacy of random walk hypothesis for European stock prices by studying serial correlation coefficients. Even though the serial correlation coefficients were larger than the ones in New York Stock Exchange, they were still quite small with R^2 of less than 4%. He proposed to explain this minor increase in R^2 -of European markets' correlation coefficient compared to New York Stock Exchange's correlation coefficient- by loose requirements for disclosure of information, no control on insiders' trading, thin markets and discontinuity in trading.

Fama and French (1988) showed that 25 to 40 percent of the variation of 3 to 5 year stock returns can be predicted from past returns. To prove this, they used the auto-correlation tests and explained the predictability by slowly decaying price components.

Jegadeesh (1990) presented empirical evidence of predictability of individual stock returns. Using regression he formed different portfolios with different expected returns and then tested whether the abnormal returns were all equal to zero by F statistic, and whether each one was equal to zero by t statistic. He found significant predictability. He tried to explain this predictability by size-based risk adjustment, time varying market risk, bid-ask spread and thin trading.

Fama (1991) in his seminal work on efficient markets hypothesis, summarized all the developments in the research of market efficiency after 1970. He stated that the data used in the definition of weak form of efficiency was enlarged from past stock prices alone to dividend-earning, price-earning ratios and other economic structural variables such as inflation as well. He also stated that the horizon for prediction was enlarged from short to long term since 1970. In this study he also investigated seasonality in returns, the Sharpe-Litner-Black Model, consumption based asset pricing models.

Today, the studies testing the weak-form efficiency in stock markets continues. Goetzmann (1993) applied auto-regression and rescaled range statistics to very long stock market series to test the hypothesis that long-term temporal dependencies were present in financial data. He used the rescaled range, or R/S statistic to detect non-periodic and non-consistent dependencies caused probably by fundamental historical changes. He found evidence of persistence in raw returns greater than five years for London Stock Exchange but not for New York Stock Exchange.

Goetzmann and Jorion (1993) examined the ability of dividend yields to predict long-horizon stock returns. They utilized regression equations using dividend yields as independent variables, although they stated that dividend yields cannot be independent since they are dependent to the prior dependent variable, to stock price. To prevent that right-hand-side variables were correlated with lagged dependent variables, they created new price series using bootstrap

methodology which was basically a simulation system to create random variables from the already existing empirical distribution. Overall, they found no statistical evidence indicating that dividend yields can be used to forecast stock returns.

Richardson and Smith (1993) investigated whether stock returns conformed to a normal distribution. They performed skewness and kurtosis statistics tests and found highly significant evidence that stock returns were non normal.

Nelson and J. Kim (1993) analyzed biases on small samples. They found that the t ratios from predictive regressions of stock returns on the lagged values of financial fundamentals or macroeconomic indicators are subject to two small sample biases: First, the coefficient estimate of the predictive regression is biased if the predictor is endogenous. Second, asymptotic standard errors are biased in the case of overlapping periods. They took dividend yields as the predictor of stock returns and used Stambaugh's (1986) approach to show that small sample bias is significant.

Brock , Lakonishok and Lebaron (1992) analyzed moving average and trading range break by utilizing the Dow Jones Index from 1897 to 1986. Their results provided strong support for the technical strategies. The returns obtained from these strategies are not consistent with four popular null models which are the random walk, the AR(1), the GARCH-M, and the Exponential GARCH. Buy signals consistently generate higher returns than sell signals, and further the returns following buy signals are less volatile than the returns following sell signals. Moreover, returns following sell signals are negative, which is not easily explained by any of the existing equilibrium models.

Ünal (1992), in his unpublished M.B.A. thesis, tests the weak-form efficiency of İstanbul Stock Exchange by statistical tests and trading rules such as filtering. He also tested weak-form efficiency by examining independence, randomness and distribution of price series. He found that İstanbul Stock Exchange was weak-form inefficient.

The remainder of the study is organized as follows: Data and the methodology used will be described, next findings of the study and their discussions will succeed. A summary and results of the study will be reported in conclusion.

II. DATA and METHODOLOGY

II.A. DATA

The sample of this study consists of 23 stocks (Appendix I) from 1.1.1988 to 30.9.1995 chosen according to the following criteria: (1) These stocks are traded in İstanbul Stock Exchange in more than 97% of the trading days . (2) The selected stocks' daily trade volume is higher than the average daily trading volume of all stocks in İstanbul Stock Exchange

The price series is constructed for each stock in the sample by taking the previous day's closing price for those days in which there was no trade for a particular stock. All prices are adjusted for cash dividends, and rights offerings. For stock dividends and rights offerings adjustment is made as follows:

$P_{adjusted} = (P_{old} + N.n_{sold}.k) / (1 + n_{sold} + n_{free})$

For cash dividends the following adjustment is made:

$P_{adjusted} = P_{old} - 1000*Dividend(\%)$

where,

n_{free} : number of shares distributed as dividend, per existing share

n_{sold} : number of shares distributed with nominal value, per existing share.

N : Nominal value of a share

k =1 is used on the day where a major price change is observed due to stock dividend; otherwise k = 0.

$P_{adjusted}$: Adjusted price of P_{old}.

P_{old} : Unadjusted price

Dividend(%) : percentage of the nominal value of the share(TL 1000) distributed as dividend.

(An example of price adjustment is given at Appendix II)

II.B. METHODOLOGY

The methodology used in the study is the application of moving averages technique (with different parameters) on portfolios through a computer program. In this chapter, moving average terminology will be introduced. Second, the reason for why moving average technique is used in this study, will be explained. Third, conditions requiring the application of a computer program will be described. Finally, the rationale behind the selection of parameters (stma,ltma and n)[1] used in the technique will be described.

Simple Moving Averages Technique

Moving Average Methodology: Basic moving average of time series for n days is the arithmetic mean of the last n data of series. Moving average technique, as applied in this context, is a rule giving buy and sell signals according to the continuous relative position of two different moving averages of the same series.

According to the method, buy and sell signals are generated by two moving averages with different n : a long-period moving average with ltma days (described below) and a short-period average with stma days where ltma> stma. In its simplest form, this strategy is stated as buying when the short-period moving average rises above the long-period moving average or selling when the short-period moving average falls below the long-period moving average.

The basic idea behind computing moving averages is to smooth out an otherwise volatile series. If the short-period moving average penetrates the long-period moving average, a trend is considered to be initiated.

Long Term Moving Average (ltma): # of days used in moving average technique for long term moving average.
Short Term Moving Average (stma): # of days used in moving average technique for short term moving average.

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[1] the description of the parameters is given in the next section.

Number of Stocks (n): # of stocks used in portfolio subject to moving average technique.

Commission (com): Commission rate used by the broker for a transaction.

Strategy: Any moving average technique with given stma, ltma and n.

r_b : Return (as percentage) obtained by simply holding the stocks in the portfolio throughout the time period covered.

r_s : Return (as percentage) obtained by applying the strategy described in this study throughout the time period covered.

Time period covered: January 1, 1988 - September 30, 1995

Excess Return (ER): Average excess return of applying the strategy with parameters stma, ltma, n compared to the return of naive buy and hold policy over the time period January 1, 1988 - September 30, 1995. Mathematically,

$$ER_{stma,ltma,n} = \left(\sum_{run=1}^{30} r_s - r_b \right) / 30$$

We selected the number of runs required to obtain an average excess return as 30. To determine the excess returns, we applied t test. t test performs accurately for data larger than 20 (according to introductory statistics books[2]). Therefore, the minimum number of runs required is 20. However, as the number of runs increases, the computer time required to reach an outcome increases accordingly. Therefore, we considered that 30[3] runs is appropriate.

Advantages of Simple Moving Average Technique

1. *Less data requirement.* Other methods require more data as the lowest and highest prices, and trade volume of each day. In contrast moving averages methodology requires only closing prices of each day.

2. *Simple to Compute.* Only first order data and arithmetic operations of addition and division are used. In other methods, second order data and cross multiplication are used as calculating standard deviations in some methods. As

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[2]One of these books is Statistics for Management and Economics, W. Mendenhall, J.E.Reinmuth, R.Beaver

[3]For n=1 number of runs is 23, since there are only 23 stocks.

the method becomes more complex, the interpretation becomes more difficult, and handling time of data increases.

3. *Requires less computer time.* In accordance with less data requirement and simple computation, computer time required also is comparatively small. Considering the number of data to be processed and the limited capabilities of a PC, the comparatively small time demanded as described in the above section is due to simplicity of operations required by the simple moving averages technique.

4. *Easy to Interpret .* Short-period moving average's crossing of long-period moving average signifies a change in current price level compared to the past price level meaning the trend of prices has changed.

To summarize, since the aim of this study is to analyze the weak-form efficiency of the market and not to investigate the ways to make significant profits, simplicity and easiness of interpretation is preferred over sophistication.

Computer Application

The study uses approximately 45,000 stock price data in the study (23 stocks x 252 days/year x $7^{3/4}$ year = 44,919). Under the available software alternatives Microsoft Excel is used to process data, and Excel Macro is used to write the program. As hardware a 486 DX-66 PC is used. The time required to process one single run (selecting a random portfolio, making transactions according to moving averages technique from January 1,1988 to September 30,1995) is approximately 25 seconds. For one strategy (for a given n,stma,ltma) 30 runs are made. There are 6 different n, from 1 to 6, 2 different stma (1,2), 13 different ltma (2,3,4,5,6,7,8,9,10,20,30,40,50) and 2 different levels of commissions (0 and 0.25%). Therefore approximate rerun time of the study is 65 hours. (25 x 30 x 6 x 2 x 13 x 2 = 234,000 seconds or 65 hours)

First, the program generates a random portfolio from 23 stocks with number of stocks changing from 1 to 6. Then, for each day covered in the study, it calculates the total price of the portfolio, the short term moving average (stma)

and long term moving average (ltma) for the current day. Then, according to short term and long term moving averages position compared to previous day it sells the portfolio to obtain cash, it buys the portfolio by spending cash or it simply takes no action. For each transaction it pays some transaction fee stated as percentage. The flow chart of the program is given at Appendix IV. A simple example of how the program works is given at Appendix III.

Selection of Parameters

The parameters to be decided upon are stma, ltma and n. Even though differing rationales exist in choosing these parameters , since they cannot be mathematically proved we preferred to change these parameters over a range and see its implications. For stma we have taken 1 and 2. We did not increase stma further because the outcomes of the computer runs provided us enough evidence to reach a conclusion on the effects of stma over the profitability of the strategy. For ltma we have taken 2,3,4,5,6,7,8 ,9,10,20,30,40,50. After 10 days, increments of 10 day was used since the sensitiveness of single increments decreased as the base number (ltma) increased. Furthermore, the results of the calculations proved unnecessary the runs with higher ltma s. We increased n from 1 to 6. Again the outcomes from n = 1 to 6 provided us enough evidence to conclude on the behavior of the strategy.

In accordance with our prior discussion, since volatility is one of the most important characteristics of a stock, it is also the most important criteria in selection of parameters.

n (number of stocks in the portfolio):

Portfolio instead of a single stock is chosen for strategy to reduce volatility stemming from the independent behavior of a single stock, thus reducing the chance of incorrect transaction decisions.

Two components of time series are trend and volatility. The basic motive of moving average technique is to differentiate price changes due to volatility from price changes due to trend. As the volatility increases moving average technique becomes less successful in differentiating changes due to trend from changes

due to volatility. Therefore if the volatility can be reduced we can expect to obtain higher returns from the strategy.

Among possible others, two sources of volatility are time and type. Type volatility is the volatility due to special behavior of a particular stock. Time volatility is the price changes of each stock due to time.

To reduce time volatility, the time period used can be aggregated (as using weekly or monthly returns). To reduce type volatility, portfolios formed of different stocks can be generated.

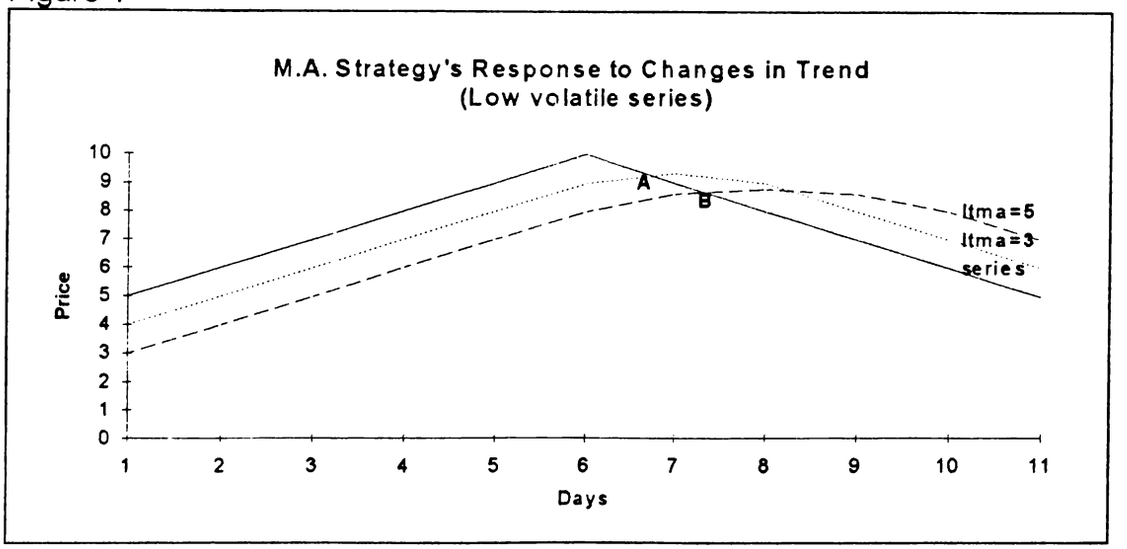
We decided to reduce type volatility by formation of portfolios. The reason for not selecting the reduction of time volatility by formation of weekly or monthly prices is its disability of stating the transaction price. Since the transaction price cannot be determined, it is impossible to determine exact return of the strategies selected. On the other hand, portfolio formation to reduce type volatility has shortcomings too. When the transaction signal is given, all the stocks in the portfolio are bought /sold. This may cause the strategy to sell profitable stocks with the unprofitable ones, or buy unprofitable stocks with the profitable ones.

stma and ltma:

Theoretically strategies with low stma and low ltma responds to price changes quickly and gives prompt transaction decisions assuming that the change occurred in the series is due to trend and not due to volatility. Therefore, in low volatile series strategies with low stma and low ltma result in higher returns by giving timely transaction decisions.

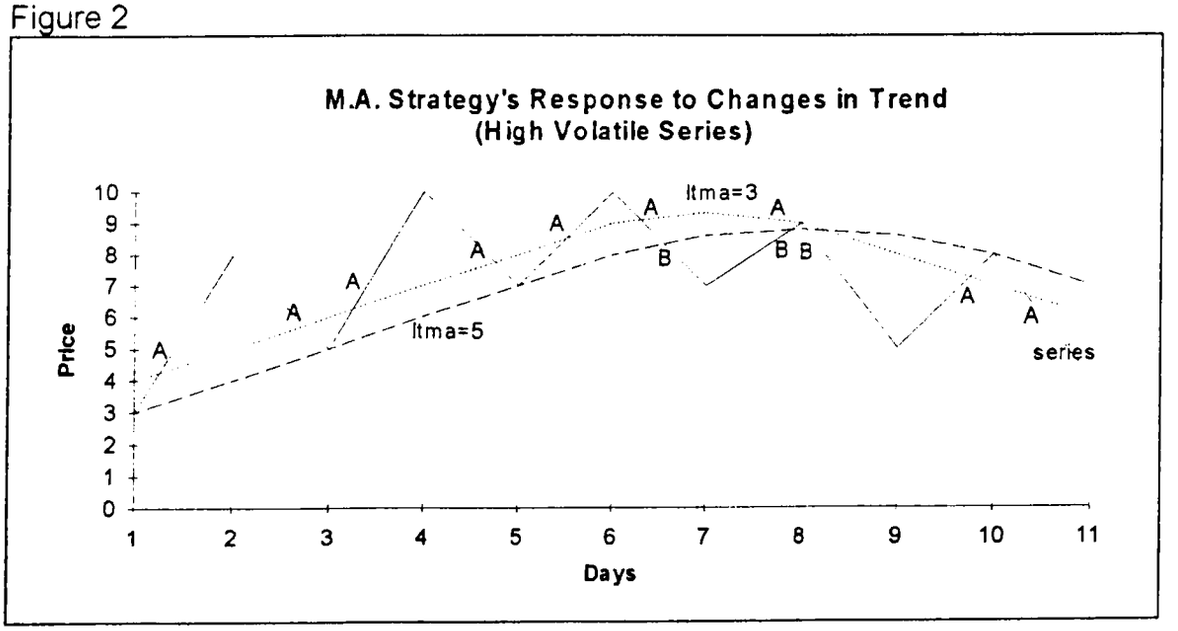
For instance, Figure 1 shows the behavior of a non-volatile series. If stma=1 (or the series itself), strategy with higher ltma (ltma=5) becomes late to sell the stock (point B in the figure) compared to strategy with lower ltma (ltma=3) (point A in the figure)

Figure 1



However, as volatility increases, strategies with higher ltma becomes more successful in differentiating price changes due to trend from those due to volatility. In Figure 2, strategy with lower ltma (ltma=2) gives transaction decisions incorrectly even though the trend is positive and incorrect buy decisions even though the trend is negative (point A in Figure 2). However, strategy with higher ltma (ltma=5) gives less but more appropriate transaction decisions (Point B in Figure 2). In a real environment where transaction costs exist, this will cause higher excess return for the strategy.

Figure 2



Changes in stma should have similar outcomes to the changes in ltma. As stma increases, the response time of the strategy will lengthen and the strategy will give less transaction decisions. With higher stma, the strategy will prevent losses at a volatile environment, for the sake of not being able to make significant excess returns at non-volatile environments.

As a conclusion, what we can expect from the findings are that, first as n increases, due to decrease in volatility, higher excess returns will be obtained from the moving average strategies. Second, as the volatility is decreased by forming portfolios, strategies with lower stma and ltma will obtain higher excess returns than higher stma and ltma strategies. Third, when the commission rate is taken into consideration, since strategies with higher stma and ltma will give less buy sell decisions these strategies will obtain higher excess returns (or lower losses) than lower stma and ltma strategies.

III. FINDINGS

Table 1 gives the excess returns -as percent per year- of the moving average strategies compared to naive buy hold policies for stma=1 and Table 2 gives the excess returns of the moving average strategies compared to naive buy hold policies for stma=2 at zero commission rate. t ratios obtained from the application of these strategies are given at Appendix V.

We observe that excess returns from strategies with stma=1 are almost always higher than excess returns from strategies with stma=2. Since the volatility is already decreased by forming portfolios, the strategies with stma=2 turn out too conservative and detect the changes in trend too late. Furthermore, since the transaction cost is zero, strategy with stma=2 does not benefit from its lower number of transactions.

Table 1

Yearly Excess Returns of Strategies with stma=1 over Buy-Hold Strategy at 0% Commission Level

stma=1	*com=0%*											
	Portfolio Size											
ltma												
	stock=1	stock=2		stock=3		stock=4		stock=5		stock=6		
ltma= 2	45%	61%	*	74%	*	73%	*	72%	*	88%	*	
ltma= 3	23	35	*	56	*	66	*	65	*	72	*	
ltma= 4	14	41	*	50	*	49	*	63	*	62	*	
ltma= 5	13	23	*	40	*	49	*	58	*	61	*	
ltma= 6	10	21	*	31	*	48	*	54	*	50	*	
ltma= 7	0	20	*	31	*	42	*	40	*	49	*	
ltma= 8	0	21	*	30	*	33	*	42	*	47	*	
ltma= 9	3	13		28	*	35	*	39	*	45	*	
ltma= 10	1	6		18	*	33	*	31	*	37	*	
ltma= 20	-11	1		17	*	13	*	23	*	20	*	
ltma= 30	-23	3		4		12	*	9	*	5		
ltma= 40	-22	1		-2		-4		3		6		
ltma= 50	-15	-7		-2		1		5		3		

**Significant at 0.01 level.*

Table 2

Yearly Excess Returns of Strategies with stma=2 over Buy-Hold Strategy at 0% Commission Level

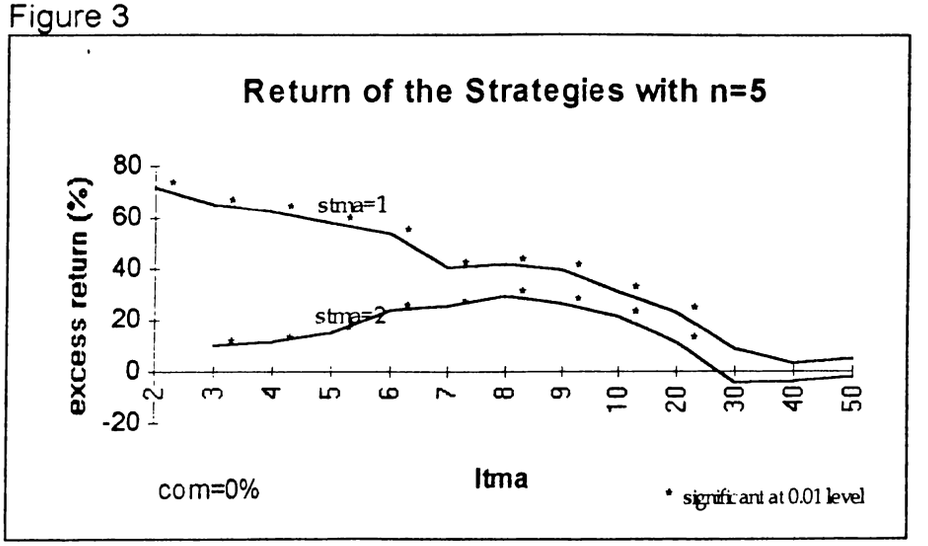
stma=2	*com=0%*											
	Portfolio Size											
ltma												
	stock=1	stock=2		stock=3		stock=4		stock=5		stock=6		
ltma= 2												
ltma= 3	-18%	-4%		9%	*	3%		10%	*	17%	*	
ltma= 4	-16	4		10	*	10	*	12	*	17	*	
ltma= 5	-7	3		7		16	*	15	*	20	*	
ltma= 6	-5	8		12	*	40	*	24	*	30	*	
ltma= 7	-6	3		24	*	30	*	26	*	36	*	
ltma= 8	-2	2		10		21	*	29	*	31	*	
ltma= 9	-2	16	*	19	*	18	*	26	*	26	*	
ltma= 10	0	20	*	14	*	20	*	21	*	27	*	
ltma= 20	-12	-3		12	*	8		11	*	11	*	
ltma= 30	-21	-9		5		-2		-5		-3		
ltma= 40	-19	0		-5		-5		-4		-5		
ltma= 50	-10	-10		3		-9		-2		-6		

**Significant at 0.01 level.*

Since strategies with stma=1 result almost always higher returns than similar strategies with stma=2, we concentrate our attention on strategies with stma=1 and on Table 1. What we observe from Table 1 is that the higher n, the higher the excess return obtained from the strategy. However, after n reaches 5, returns either do not increase as substantial as before, or decrease. Therefore n=5 can be taken as the optimal portfolio size.

stma=1 and n=5 are optimal or near optimal values for the two parameters of the strategy. To see more clearly the third parameter's -ltma- effect on the strategy we look at Figure 3 (To describe more clearly the above argument about stma's effect on excess returns, the graph is given for stma=2 also).

Figure 3



As can be observed from Figure 3, as ltma increases the excess return of the strategy decreases. Increase in ltma delays the response time of the strategy and since the volatility is already decreased -by forming portfolios of size 5- the delay in response time has no benefit at all.

At İstanbul Stock Exchange the standard commission rate of brokerage houses is between 0.5% and 0.8% per transaction amount. However, for transactions larger than 1,000,000,000 TL the commission rate is 0.35% and for transactions larger than 5,000,000,000 TL the commission rate is 0.15%. Considering enough capital can be provided by the strategy a commission rate of 0.25% is

considered appropriate. To see how the previous best strategies (with stma=1, and n=5) perform with 0.25% transaction cost, we consider Table 3 and Figure 4.

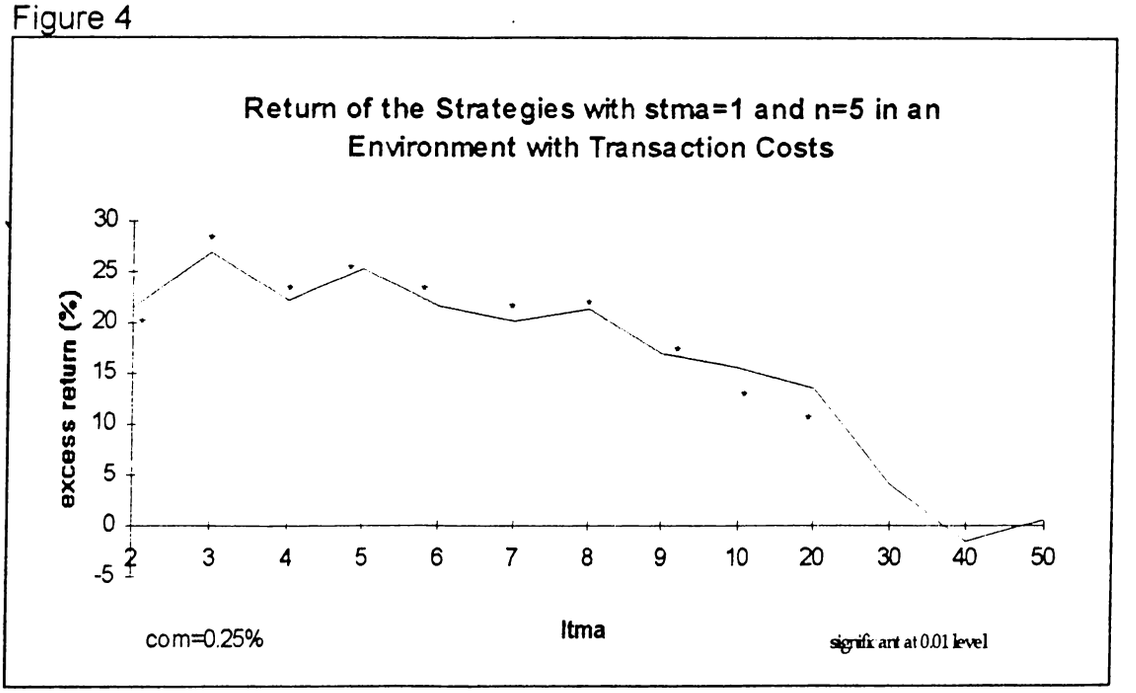
Table 3

Yearly Excess Returns of Strategies with stma=1 over Buy-Hold Strategy at 0.25% Commission Level

stma=1	*com=0.25%*											
	Portfolio Size											
ltma												
	stock=1		stock=2		stock=3		stock=4		stock=5		stock=6	
ltma= 2	-10%		1%		9%		7%		21%	*	18%	*
ltma= 3	-17		-4		5		17	*	27	*	32	*
ltma= 4	-20		-13		15	*	19	*	22	*	28	*
ltma= 5	-17		0		16	*	15	*	25	*	30	*
ltma= 6	-15		-2		11	*	14	*	22	*	39	*
ltma= 7	-21		-1		12	*	14	*	20	*	26	*
ltma= 8	-20		4		9		17	*	21	*	27	*
ltma= 9	-18		-11		9	*	13	*	17	*	24	*
ltma= 10	-18		-7		11		11	*	16	*	21	*
ltma= 20	-18		-3		2		9		13	*	11	*
ltma= 30	-28		-16		-8		-2		4		-1	
ltma= 40	-24		-22		-4		-4		-2		-4	
ltma= 50	-18		-5		-3		-4		1		-2	

**Significant at 0.01 level.*

Figure 4



From Figure 4 we see that, first the excess returns reaching near and above 70% for ltma=2 and ltma=3 in noncommissioned environment decreases to near 25% level at 0.25% commission level. Second at 0.25% commission level ltma=3 performs better than ltma=2. This can be expected since lower level ltma causes more transactions with more transaction costs, decreasing the level of excess returns. Third, ltma=40 and ltma=50 result in no excess returns both with and without commission environment. We can consider that ltma=40 and ltma=50 strategies are too slow to reply price changes and give few transaction decisions. Since strategies with ltma=40 and ltma=50 give minimal number of transaction decisions, existence of transaction costs don't differentiate excess returns obtained at noncommissioned environment from those obtained at commissioned environment.

IV. CONCLUSION

Inefficiency in stock markets is one of the most discussed topics in financial literature, and the methodologies developed to test the markets are numerous. In this study, the weak-form efficiency of İstanbul Stock Exchange is tested by applying moving average technique on randomly generated portfolios with the help of a computer program. Throughout the study, various moving averages techniques and their superiorities and shortcomings are described. It is explained that as the volatility of the series decreases by formation of portfolios short-horizon moving average rules should perform better.

The study had limitations. Trade price of the stock is assumed to be daily closing price of the stock. However, the stock could be traded at any price which occurred at that day. Second, it is considered that transaction cost as percentage is the same throughout the study period ; but transaction costs may change through time due to change in the risk of the broker. Finally, it is also assumed that all the stocks in the portfolio can be traded within the same day. However, as the number of stocks in the portfolio increases the possibility of a problematic stock (a stock that couldn't be traded at the specified date) increases.

Taking the above limitations into consideration, according to the results obtained from the study, İstanbul Stock Exchange is not weakly efficient, since an investor can earn above average returns by simply applying some specific moving average techniques to past price series both in a noncommissioned and in a 0.25% commissioned environment. For the period January 1, 1988 to September 30, 1995 with zero transaction costs, moving average technique with short term moving average equal to 1, long term moving average equal to 2 to 6 and portfolio size equal to 5 resulted in significant yearly excess returns of 54% to 72% over the buy-hold policy. For the same period with 0.25% transaction costs, moving average technique with short term moving average equal to 1, long term moving average equal to 3 to 8 and portfolio size equal to 5 resulted in significant yearly excess returns changing from 20% to 27% over the buy-hold policy.

According to the results summarized above, since we showed that the market is not weak-form efficient, traders in İstanbul Stock Exchange will benefit from considering past price series in giving transaction decisions. Furthermore, they will probably get higher returns, if they apply moving average strategy on random portfolios instead of single stock.

Further research is suggested on the application of other techniques to the same price series. Instead of simple, weighted moving average strategy can be used. Price oscillators, moving average convergence-divergence index, rate of change oscillator, commodity channel index are some of the possible other tools with which weak-form efficiency of İstanbul Stock Exchange can be tested. Since these are more sophisticated methods, possibly higher excess returns than those obtained by simple moving average technique can be obtained. Furthermore, instead of forming portfolios randomly, stocks in the portfolio can be chosen from different risk categories such as different industries. This will decrease the volatility of the portfolio's price, increasing the performance of the moving average strategy.

V. REFERENCES

Alexander, S. (1961) "Price Movements in Speculative Markets: Trends or Random Walks" *Industrial Management Review* , 2 , 7-26

Brock, William ; Lakonishok, Josef ; LeBaron, Blake (1992) "Simple technical trading rules and the stochastic properties of stock returns" *Journal of Finance* , 47 , 1731-1764

Brock-W. , Lakonishok-J , Lebaron-B. (1992) "Simple Technical Trading Rules and the Stochastic Properties of Stock Returns" *Journal of Finance* , 47 , 1731-1764

Fama, E. Eugene (1965) "Behavior of Stock Market Prices", *Journal of Business* , 38 , 34-105

Fama, F. Eugene ; French R. Kenneth (1988) "Permanent and temporary components of stock prices" *Journal of Political Economy* , 96 , 246-273

Fama F. Eugene (1991) "Efficient Capital Markets II" *Journal of Finance* , 46 , 1575-1617

Goetzmann, N. William (1993) "Patterns in three centuries of stock market prices" *Journal of Business* , 66 , 249-270

Goetzmann, N. William ; Jorion, Philippe (1993) "Testing the predictive power of dividend yields" *Journal of Finance* , 48 , 663-679

Jegadeesh, Narasimhan (1990) "Evidence of predictable behavior of security returns" *Journal of Finance* , 45 , 881-897

Krueger, M. Thomas ; Kennedy F. William (1990) "An Examination of the super bowl stock market predictor" *Journal of Finance* , 45 , 691-697

Panas, E. Epaminondas (1990) "The Behavior of Athen's stock prices" *Applied Economics* , 22 , 1715-1727
Richardson, Matthew ; Smith, Tom (1993) "A test for multivariate normality in stock returns" *Journal of Business* ,66 , 295-321

Solnik H.Bruno (1973) "Note on the validity of the random walk for European stock prices" *Journal of Finance* , 28 , 1151-1159

Ünal, Mustafa (1992) "Weak Form efficiency Test in İstanbul Stock Exchange" *Unpublished MBA Thesis, Bilkent University*

Wong, K.A. ; Kwong, K.S. (1984) "The behavior of Hong Kong stock prices" *Applied Economics* , 16 , 905-917

List of Illustrations

List of Appendices

APPENDICES

Appendix I

NAME OF STOCKS USED IN THE SAMPLE

1.Akçimento
2.Arçelik
3.Bağfaş
4.Çelik Halat
5.Çimento Sanayii (Çimsa)
6.Döktaş
7.Ege Gübre
8.Enka
9.Ereğli Demir Çelik
10.Goodyear
11.Güney Biracılık
12.Hektaş
13.İzmir Demir Çelik
14.Kartonsan
15.Kav
16.Koç Holding
17.Koç Yatırım
18.Kordsa
19.Metaş
20.Otosan
21.Pınar Süt
22.Sarkusyan
23.Siemens

Appendix II

AN EXAMPLE TO STOCK PRICE ADJUSTMENTS

	Daily Price
Day(n-3)	1940
Day(n-2)	1980
Day(n-1)	2000
Day(n)	1600

We assume that the company distributes 50% cash dividend at Day (n)

P_{old} = 2000
Cash dividend(%) = 50
$P_{adjusted} = P_{old}$ - 1000 * Cash dividend(%) / 100

$P_{adjusted}$ =2000 - 1000*50/100
$P_{adjusted}$ =1500

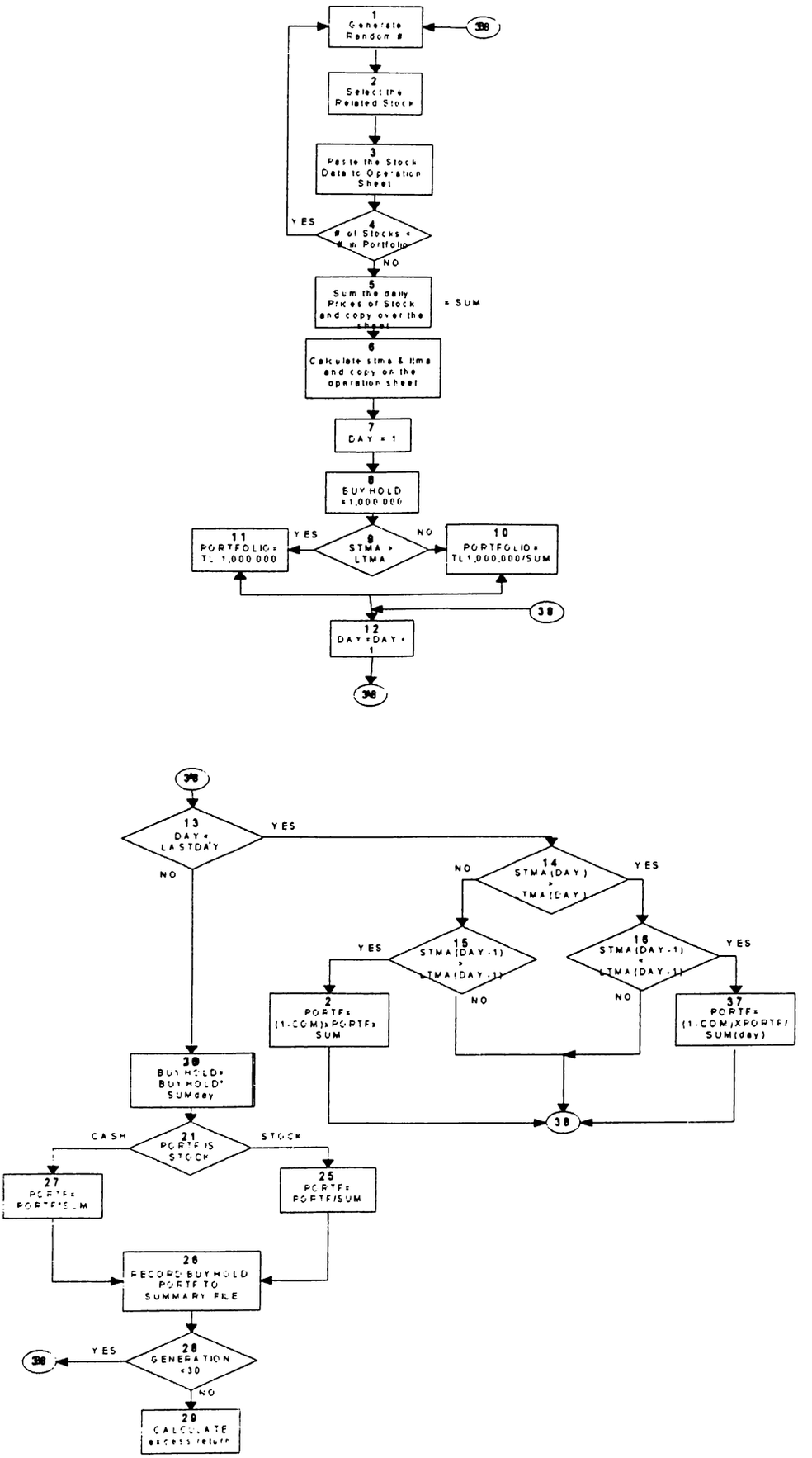
Older data are adjusted with same proportion as the first data is adjusted, i.e. adjusted price for day(n-2) is
1500/2000*1980 = 1485
adjusted price for day(n-3) is
1500/2000*1940 = 1455

Appendix III

FLOW CHART FOR THE COMPUTER PROGRAM APPLIED

The flow chart of the program is given below. First the program creates a random portfolio, then by checking the positions of stma and ltma each day it gives buy and sell decisions.

The variable Portfolio (or Portf) as shown in the flow chart stores both number of stocks as units and cash as TL. The program differentiates automatically whether portfolio is stock or cash from the current position of the stma relative to ltma. If stma<ltma portfolio must be cash and if stma>ltma portfolio must be stock.


1
Generate Random #
2
Select the Related Stock
3
Paste the Stock Data to Operation Sheet
4
# of Stocks < # in Portfolio
YES
NO
5
Sum the daily Prices of Stock and copy over the sheet
= SUM
6
Calculate stma & ltma and copy on the operation sheet
7
DAY = 1
8
BUY HOLD =1,000,000
9
STMA > LTMA
YES
NO
11
PORTFOLIO= TL 1,000,000
10
PORTFOLIO= TL 1,000,000/SUM
12
DAY=DAY+ 1
13
DAY< LASTDAY
YES
NO
14
STMA(DAY) > LTMA(DAY)
YES
NO
15
STMA(DAY-1) > LTMA(DAY-1)
YES
NO
16
STMA(DAY-1) < LTMA(DAY-1)
YES
NO
2
PORTF= (1-COM)xPORTF SUM
37
PORTF= (1-COM)XPORTF/ SUM(day)
38
BUY HOLD= BUY HOLD* SUMday
21
PORTF IS STOCK
CASH
STOCK
27
PORTF= PORTF$_{t-1}$M
25
PORTF= PORTF/SUM
26
RECORD BUY HOLD PORTF TO SUMMARY FILE
28
GENERATION <30
YES
NO
29
CALCULATE excess return

Appendix IV

AN EXAMPLE OF STRATEGY'S DATA PROCESS

An example of how a strategy (for stma=1, ltma=3, n=3 an com=0%) process data after randomly forming portfolio is given below. Here the portfolio is formed of three stocks A, B and C. Computer calculates sum of the prices, stma and ltma for each day. Then for the first day strategy compares stma with ltma (shown with A in the below table) and since stma>ltma it converts TL 1,000,000 to stocks with the current day's prices which is TL 175 (and TL1,000,000/TL175=5714units). Then each day it checks whether stma<ltma. The first day it meets this condition (shown with B in the table below) it converts stocks to cash with current day's prices (5714x270=TL 1,542,780).

							CASH	STOCKS
	A	B	C	SUM	stma	ltma		
Day 1	30	40	80	150	150		TL1,000,000	
Day 2	35	50	80	165	165		TL1,000,000	
Day 3	40	60	75	175	175	A 163		5714
Day 4	50	80	70	200	200	180		5714
Day 5	60	90	80	230	230	202		5714
Day 6	65	100	80	245	245	225		5714
Day 7	70	120	75	265	265	247		5714
Day 8	80	130	70	280	280	263		5714
Day 9	80	130	65	275	275	273		5714
Day 10	75	130	65	270	270	B 275	TL1,542,780	
Day 11	70	110	55	235	235	260	TL1,542,780	
Day 12	60	90	50	200	200	235	TL1,542,780	
Day 13	50	80	40	170	170	202	TL1,542,780	
Day 14	40	70	30	140	140	170	TL1,542,780	
Day 15	30	60	25	115	115	142	TL1,542,780	
Day 16	20	60	20	100	100	118	TL1,542,780	

For the hypothetical example given above the strategy concludes with TL 1,542,780. The buy hold policy return is calculated as follows:

In the first day of the study period = 5714 units

In the last day of the study period, stocks are converted to cash with that day's price: 5714units x TL100=TL571,400

In this hypothetical example while the buy hold policy caused TL1,000,000 to decrease to TL571,400 , the strategy earned profits by increasing the value it holds from TL1,000,000 to TL 1,542,780.

Appendix V

t RATIOS OF THE EXCESS RETURNS OBTAINED FROM STRATEGIES

t rarios for the Strategies with Parameter stma=1 at 0% Commission Level

	stma=1 com=0%					
	stock=1	*stock=2*	*stock=3*	*stock=4*	*stock=5*	*stock=6*
ltma= 2	-1,6	-3,2	-5,8	-7,6	-7,9	-6,9
ltma= 3	-1,4	-4,8	-7,5	-8,7	-7,5	-10,8
ltma= 4	-1,1	-5,2	-7,1	-5,9	-7,9	-8,7
ltma= 5	-0,9	-3,8	-6,8	-7,5	-8,9	-12,6
ltma= 6	-0,6	-3,0	-5,3	-5,5	-6,8	-12,7
ltma= 7	0,0	-3,7	-6,2	-10,1	-7,6	-7,8
ltma= 8	0,0	-4,0	-7,0	-6,6	-7,4	-8,1
ltma= 9	-0,2	-2,3	-4,3	-8,6	-9,2	-8,9
ltma= 10	-0,1	-0,9	-4,7	-7,2	-7,5	-11,9
ltma= 20	1,0	-0,1	-2,7	-3,5	-8,2	-6,4
ltma= 30	1,7	-0,5	-1,7	-2,8	-3,2	-1,4
ltma= 40	1,7	-0,1	0,4	1,1	-1,0	-1,8
ltma= 50	1,3	1,1	0,3	-0,4	-1,5	-1,0

t rarios for the Strategies with Parameter stma=2 at 0% Commission Level

			stma=2 com=0%			
	stock=1	*stock=2*	*stock=3*	*stock=4*	*stock=5*	*stock=6*
ltma= 3	-1,8	0,7	-2,8	-0,9	-3,7	-4,0
ltma= 4	-1,6	-0,9	-3,2	-3,6	-3,1	-5,7
ltma= 5	-0,7	-0,6	-1,4	-3,9	-3,6	-6,1
ltma= 6	-0,5	-1,4	-3,5	-7,0	-5,6	-6,4
ltma= 7	-0,6	-0,5	-5,0	-4,7	-5,1	-7,4
ltma= 8	-0,2	-0,4	-2,3	-5,3	-6,2	-6,4
ltma= 9	-0,2	-3,2	-4,1	-4,6	-6,5	-6,0
ltma= 10	0,0	-3,5	-3,6	-5,1	-5,6	-5,2
ltma= 20	-1,3	0,5	-3,1	-1,3	-3,6	-3,5
ltma= 30	-2,0	1,2	-1,1	-5,1	-5,6	-5,2
ltma= 40	-1,8	0,0	1,1	1,3	1,0	1,6
ltma= 50	-1,0	1,8	-0,8	1,7	0,6	1,7

t rarios for the Strategies with Parameter stma=2 at 0.25 % Commission Level

			stma=1 com=0.25%			
	stock=1	*stock=2*	*stock=3*	*stock=4*	*stock=5*	*stock=6*
ltma= 2	0,9	-0,3	-1,9	-1,8	-5,4	-5,4
ltma= 3	1,6	0,5	-1,1	-3,6	-5,0	-5,4
ltma= 4	1,9	2,0	-3,2	-4,4	-4,0	-6,9
ltma= 5	1,5	0,0	-3,0	-3,1	-4,9	-7,9
ltma= 6	1,3	0,4	-2,6	-2,7	-4,5	-7,5
ltma= 7	1,9	0,2	-2,4	-3,2	-5,0	-8,9
ltma= 8	1,8	-0,8	-2,3	-4,7	-5,1	-7,4
ltma= 9	1,6	1,3	-2,8	-4,3	-4,4	-4,9
ltma= 10	1,6	1,3	-1,8	-3,8	-5,3	-6,1
ltma= 20	1,7	0,5	-0,4	-1,8	-3,9	-4,0
ltma= 30	2,4	2,1	1,2	0,4	-1,3	0,3
ltma= 40	2,1	2,8	1,1	1,0	0,4	1,1
ltma= 50	1,8	1,2	0,8	1,1	-0,2	0,7