# WEAK FORM EFFICIENCY OF THE TURKISH GOLD MARKET

MBA THESIS

Jamel CHAFRA

Ankara, June 1996

# WEAK FORM EFFICIENCY OF THE TURKISH GOLD MARKET

## MBA THESIS

JAMEL CHAFRA

Ankara, June 1996

# WEAK FORM EFFICIENCY OF THE TURKISH GOLD MARKET

A Thesis
Submitted to The Faculty of Management and
The Graduate School of Business Administration
of Bilkent University

In Partial Fulfillment of The Requirements
For The Degree of Master of Business Administration

**MASTER OF BUSINESS ADMINISTRATION**

by

Jamel CHAFRA
June 1996

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

Dr. Gulnur MURADOGLU

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

Dr. Nese AKKAYA

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

Dr. Yesim CILESIZ

Approved by the Graduate School of Business Administration

Director: Dr. Subidey TOGAN

# ABSTRACT

## WEAK FORM EFFICIENCY OF THE TURKISH GOLD MARKET

Jamel Chafra
MBA
Supervisor : Assoc. Prof. Dr. Gulnur Muradoglu
June 1996

In this study, the Weak Form Efficiency Hypothesis of the Turkish gold market is examined. The period of the study runs from 01/01/1992 to 20/03/1996. This period is divided into four mutually exclusive sub-periods reflecting different stages of the Turkish gold market. Each sub-period's series of gold returns is examined for autocorrelation structure, randomness, and normality. Furthermore, the Weak Form Efficiency hypothesis is conducted on the overall series of gold returns. The result obtained is that the Efficient Market Hypothsis of the Turkish gold market does neither hold for the series of gold returns of the sub-periods nor for that of the overall series. The implications of this result for the current state of the Turkish gold market and the Istanbul Gold Exchange (IGE) are discussed.

Key Words: Weak Form Efficiency, Turkish Gold Market, Istanbul Gold Exchange.

# ÖZET

## TÜRK ALTIN PAZARININ ZAYIF PAZAR ETKİNLİĞİ

Jamel Chafra

Yüksek Lisans Tezi, İşletme Fakültesi

Tez Yoneticisi: Yd. Doç. Dr. Gülnur Muradoğlu

Haziran 1996

Bu çalışmada, Türk Altın Pazarının Zayıf Pazar Etkinliği Hipotezi incelenmiştir. Çalışma 01/01/1992 den 20/01/1996 periyodunu kapsamaktadır. Bu periyod, birbirinden bağımsız, Türk Altın Pazarının değişik zamanlarını yansıtan dört alt periyoda bölünmüştür. Her bir alt periyoddaki altın getirileri serisi otokorelasyon, raskgelesellik (ramdomness) ve normallik açısından incelenmiştir. Daha sonra, zayıf pazar etkinliği hipotezi bütünsel altın getirileri serisi için uygulamıştır. Türk Altın Pazarının Etkinliği Hipotezi ne alt periyodda ne de bütünsel periyodda altın getirileri serileri için tutmadığı sonucu elde edilmiştir. Bu sonucun Türk Altın Pazarı ve İstanbul Altın Borsası için etkileri tartışılmıştır.

Anahtar Kelimeler: Zayıf Pazar Etkinliği, Türk Altın Pazarı, İstanbul Altın Borsası

To my Family

# TABLE OF CONTENTS

# INTRODUCTION

The Efficient Market Hypothesis has attracted, through time, the attention of many researchers who tried to apply this notion, through various studies, on several financial markets. As far as the Turkish financial market is concerned, studies concerning market efficiency were not numerous. Moreover, most of these studies were geared towards testing the Weak Form Efficiency of the Turkish stock market. This study aims to test the Weak Form Efficiency of the Turkish gold market, for 3 main reasons:

**1.** Studies conducted on the efficiency of gold markets are very few. Moreover, no detailed study has been conducted concerning the Turkish gold market.

**2.** Investors are usually investigating inefficiencies in financial markets simply because they are looking forward to gaining riskless profits. Hence, this study will give implications of whether such profits are possible in the Turkish gold market.

**3.** This study tries to find out if the opening of Istanbul Gold Exchange has any effect on the whole Turkish gold market as far as efficiency is concerned.

In the sequel, a brief history of gold and gold markets, along with the demand and supply of gold in Turkey, is presented followed by a literature survey on the Efficient Market Hypothesis. In the methodology section, the set of assumptions under which the study is conducted is listed, the relevant hypotheses tests are conducted. The findings concerning the Weak Form Efficiency of the Turkish gold market are summarized. Finally, in the conclusions section, a summary of the Market Efficiency hypotheses results and their implications is given along with recommendations for further research.

Gold is a rare, shining precious metal, which transfers heat and electricity and can easily be shaped. In addition, it is durable against chemical substances, not subject to corrosion and oxidization[1]. That is why people assign gold a very high value. In fact, for centuries, gold has been used not only as an instrument of exchange against other goods and commodities, but also as a way of preserving one's wealth. Troy, ounce and kilogram are the standard measures used in the international gold trade[2]. Carat is a measure of gold purity[3] and buyers are willing to pay the highest premium for 24 carat gold, simply because it contains 100 % gold.

In spite of gold's historical monetary significance, an efficient freely functioning world market for gold is contemporary. After World War II, the price of gold was maintained by monetary authorities through central banks at a predetermined level, hence the gold market, at that time, served as a distribution mechanism rather than a price setting device. To illustrate, central banks refrained from dealing with gold on the basis of a free market ( i.c. market forces were not, at that time, the determinants of gold prices ). Rather, central banks agreed to transact in gold among themselves at a preset official price of $ 35 a fine ounce. Little by little, then, market forces started taking a driving role in the gold market. However, central banks kept on intervening, as to keep a fine ounce of gold fixed at $ 35. Yet, such an intervention could not be maintained forever. In fact, the US dollar's convertibility into gold was formally suspended in August 1971[4]. Since then, a global market for physical gold has developed on the basis of a floating price system (i.c. market forces are the "only" determinants of gold prices ). This market is, nowadays, open around the clock and use a full range of derivative paper instruments ( ex: options, forwards and futures ).

---

[1]Appendix A, Table 1.
[2]Appendix A, Table 2.
[3]Appendix A, Table 3.
[4]This is mainly due to loss of confidence of other countries, on the US currency $.

Before 80's, Turkey was well behind the global trend. In fact, at that time, gold was mostly a saving instrument. In addition to the negative real interest rates on deposits at Turkish banks, exchanging local for foreign currency was prohibited. Furthermore, a lack of alternative financial instrument and securities markets were the most important factors that increased the demand for gold.

In the 80's, the most important measure taken to increase foreign exchange reserves was to stop the leakage of foreign currency from the country. This was done through the introduction of stricter market regulations against foreign exchange trade. As a result, the general tendency was towards investing in gold by any means, even through unofficial imports of gold; as a consequence, the need for establishing rules aiding the transaction of gold in legal ways emerged. For this reason, in 1982, legal arrangements were established as to free gold market.

After 1984, the Turkish government initiated rules to control and arrange the domestic gold market. The central bank was given the authority to import and started, hence, importing gold ranging from 50 gr. to 1 kg bullion against TL. The central bank's authority also included the determination of exchange rates and gold prices. Central bank operations, using official rates in gold prices, caused the price of gold to be lower than the world average gold prices which resulted in excess demand. Consequently, the central bank abandoned this method and started determining gold prices on the basis of free market exchange rates. This time, local gold prices were higher than world average gold prices. Again, unofficial gold trade came into the scene. This situation prevailed until April 1989, when the "Gold Exchanged Against Foreign Currency" system was established ( Döviz Karsiligi Altin Piyasasi ). This had an effect of smoothing gold price differences between Turkey and other countries in the world. Moreover, unofficial

imports of gold were discouraged in the sense that the central bank was able to keep its Kg fixed costs as low as $ 18, which unofficial importers could not compete with. In this system, the central bank acts as the authorized gold importing agent while the price of standard weight purity bullion is determined by foreign sellers ( directly through other central banks or international intermediaries) and Turkish banks demanding an amount of gold at a certain price.

In this kind of transaction, foreign sellers and local banks are entitled, in advance, to open a gold account in the central bank. As soon as a "buy-order" gold price communicated to the central bank coincides with one of the sellers' prices, the central bank executes the offer on behalf of the buyer. Institutions who buy or sell gold can not take short positions.

With the introduction of Istanbul Gold Exchange IGE, it became possible to sell gold to, or buy gold from international markets immediately following gold price changes. IGE's transactions are held, daily, within two sessions: 11:00-13:00 in the morning and 14:00-16:00 in the afternoon[5].

As mentioned above, today, the gold system in Turkey is one in which prices are determined by market forces. This awakens the necessity for a closer look at the demand and supply of gold in Turkey.

[5]Sener N., Akman V., **Istanbul Borsasi ve Dunya Ornekleri**, pp. 70-71.

## Demand for gold in Turkey:

The high growth of gold demand in Turkey, mainly originating from households seeking to hold more gold as a traditional investment instrument, led Turkey to be one of the most important gold importers in the world. In general, the demand for gold in Turkey can be divided into five different categories:

1. Demand arising from savings.
2. Speculative demand.
3. Central bank's demand for gold.
4. Foreign demand.
5. Industrial demand.

## Supply for gold in Turkey:

Turkey's supply of gold is limited to 5,000 tons. This supply is partitioned mainly into five different categories:

1. Gold mining supply: According to gold experts, there exists around 6 million tons of raw gold in Turkey. Unfortunately, the non-existence of refineries deprive Turkey from a 42 - 73 tons of pure gold had production in refineries existed. Alternatives to such a potential gold production, is confined to firms such as Rabak, Sarkuysan, Etibank, Karadeniz, Bakir Isletmeleri etc. Such firms, just extract valuable metal blocks, send them to foreign refineries for separation of each valuable metal and receive back only 500 - 600 kg of pure gold from such an operation.

2. Central bank supply ( see Appendix A, Table 6 ).

**3.** Unofficial gold import [6]:

| Year | 85 | 86 | 87 | 88 |
|---|---|---|---|---|
| Official Gold Import ( tons ) | 28 | 8 | 8 | 2 |
| Unofficial Gold Import ( tons ) | 8 | 50 | 70 | 50 |

As seen from the above table, in the 1985 - 1988 period, unofficial gold imports exceeded official gold imports. This can be explained by the fact that the central bank's gold prices were higher than the world's average gold prices.

**4.** Gold exchange: This mainly comes from gold traded in Kapalicarsi.

**5.** Istanbul Gold Exchange ( IGE ): IGE is a market for gold where unprocessed rod and bullion that meets the necessary standard and purity requirements, and accepted by the London Exchange ( see Appendix A, Table 4 ) is transacted. Moreover, it is a market where buyers and sellers interact in a way as to minimize transaction costs.

[6] Sener N., Akman V., **Istanbul Borsasi ve Dunya Ornekleri**, pp. 74-75,

# LITERATURE REVIEW

The world, nowadays, is living in an era characterized by a trend towards the internationalization of financial institutions. One of the main implications of such a trend is the dominance of security-based financial systems i.e. Capital Markets over credit-based financial systems. That's why, it is believed that capital markets are getting, more and more involved in the development of any country's economy ( Barnes, 1986 ).

One of the approaches in understanding capital markets is through testing their efficiency [ Efficient Market Hypothesis ( EMH ) ]. As put by Fama ( 1970 ), an efficient market is one in which prices incorporate all the information available in the market. In fact, there are three forms of Market Efficiency ( Fabozzi, Modigliani, and Ferri, 1994 ):

**1.** Weak Form of Market Efficiency Hypothesis: The Weak Form of Market Efficiency Hypothesis claims that current market prices "fully" reflect public information including past prices, price changes, volume data and other market generated information such as specialist analysis. Hence, no one can earn excess returns solely through developing trading rules based on historical price movements or past market returns. In other words, past prices or returns are neither useful nor relevant in outperforming the market.

**2.** Semi-strong Form of Market Efficiency Hypothesis: This hypothesis assumes that market prices *adjust rapidly* to the release of *all new public information.* A direct implication of this hypothesis is that no investor can continuously earn excess returns given that all available information is simultaneously disclosed to every investor.

**3.** Strong Form of Market Efficiency Hypothesis: The Strong Form of Efficient Market Hypothesis asserts that security prices "fully" reflect all information (whether public information or any other form of information ). Hence, there is no way for any group of

investors to have " monopolistic" access to information relevant to price formation. This is the highest form of efficiency that may exist in a market. Moreover, the strong form of the efficiency hypothesis does not only require efficient markets ( i.e. markets in which prices *adjust rapidly to every new public information release* ), but also requires markets in which all information is *immediately* available to every investor *at the same time*. This form of efficient market hypothesis contends that, because all information is immediately available to everyone, no group of investors can have monopolistic access to important new information. Therefore, no one can consistently keep on earning excess returns ( *No One Can Beat the Market* ).

Many researchers have shown that, in developed countries, Efficient Market Hypothesis EMH holds mostly in the weak form ( Fama and Blume, 1966; Lawrance, 1986; Panas, 1990 ) and in the semi-strong form (Fama, Fisher, Jensen, and Roll, 1969).

This study aims at testing the weak form efficiency of the Turkish Gold Market. The reason behind choosing the Gold Market is that there are very few studies, if any, until this moment, that cover such a subject. Moreover, such a project will, hopefully, give some guides to both existing and potential investors in the Turkish Gold Market in the sense that it will try to highlight whether it is possible for arbitrageurs in the market to earn abnormal riskless profits.

Researchers, who have studied Precious Metal Exchange and in particular Gold Market Efficiency, agree more or less on the fact that Gold Markets are far from being efficient at least in the semi-strong and strong form. Akgiray, Booth, Hatem, and Chowdhury (1991 ) tested conditional dependence for the London Precious Metal prices and concluded that gold price distribution is peaked and thick tailed. In addition to that, they concluded that gold prices are dependent on time. Such a dependence is present not in first order

properties, rather in two higher order moments. Thus Akgiray, Booth, Hatem, and Chowdhury rejected the Gold Market Efficiency Hypothesis even in its weakest form for the London Precious Metal Market. In fact, they concluded in their study that both precious metal price series i.e. gold and silver are found to exhibit time dependence and pronounced generalized autoreggressive conditional heteroscedastic (GARCH ) effects.

Goss (1983 ), on the other hand, tested the Semi-strong Form Efficiency of the London Metal Exchange and concluded that this market is not efficient in the semi-strong form:

*"...while the individual tests are predominantly, but not unequivocally, in favor of the non rejection of the hypothesis that the coefficients of the prior forecast errors are zero, the joint test invariably leads to the rejection of the hypothesis that these coefficients are zero. The results therefore, support the view, for all four tested metals ( Tin, Zinc, Lead, and Copper ) that the market is not efficient in the semi-strong form sense"* ( Page 693 ).

Finally, Yin-Wong Cheung and Kon S. Lai ( 1993 ), tested the hypothesis of long memory for London gold market returns during the post- Bretton Woods period (weekly data starting July 1973 and ending December 1987 ). The study lead to the conclusion that long memory behavior for gold returns is rather unstable. Moreover, Yin-Wong Cheung and Kon S. Lai concluded that when only few observations corresponding to major political events in the Middle East, in late 1979[7], are omitted from the study period, little evidence of long memory can be found.

Turkish Gold Market is a thin market compared, for example, to the London Gold Market in terms of the volume, traded daily, in the gold market. This is mainly due to the fact that it is a rather young market. In fact, it is only after the radical economic reforms that were

[7]Recall the Gulf Crisis between Irak and Iran that started in the late 1979.

conducted in Turkey in the beginning of 80's, that the Turkish Gold Market was believed to have started operating.

Unfortunately, as it was mentioned above, though there were some studies conducted to test Efficient Market Hypothesis for the Turkish Stock Market (Alparslan, 1990; Muradoglu and Oktay, 1992 ), no study was carried out to accept or reject the Efficient Market Hypothesis as far as the Turkish Gold Market is concerned. This is an important motive behind this study.

# METHODOLOGY

**1.** Sample: This study is based on 1288 daily 24-carat bullion gold price observations covering the period starting from January, 1, 1992 and ending at March, 20, 1996. These observations are all taken from the daily newspaper Hurriyet.

The study period is divided into 4 mutually exclusive periods reflecting important decisions undertaken by the Turkish government, and concerning the operations in the Turkish gold market. These four periods are as follows:

●**Period I:** Period I runs from January 1, 1992 till October 3, 1993. This period comes just before the day on which the Istanbul Gold Exchange was opened, upon the decision of deputies in the Turkish Great National Assembly, on October 4 , 1993. This period accounts for 539 daily observations.

●**Period II:** Period II runs from October, 4 , 1993 till March 15, 1994. This period covers the day from which the law concerning the establishment of Istanbul gold exchange was put into effect till one day before the decided operational opening of Istanbul gold exchange on March 16, 1994. This period covers 139 daily observations.

●**Period III:** Due to the serious economic crisis faced by Turkey in the beginning of 1994, the operational opening of Istanbul gold exchange was postponed to July 26, 1995. Hence, this period encompasses the period running from the decided effective opening and the day on which Istanbul gold exchange started operating. This period covers 419 daily observations.

●**Period IV:** This period runs from the operational opening of the Istanbul gold exchange ( July 26$^{Th.}$, 1995 ) until March 20$^{Th.}$, 1996. This period accounts for 191

daily observations. It ends on March 20$^{Th.}$, 1996 due to technical reasons concerning the time constraints put on this analysis finalization. Yet, it may be extended further in the future. Hence, this study may be, hopefully, a guide towards a better analysis of the weak form efficiency hypothesis applied to the Turkish gold market.

For comparison purposes, one more period will be added namely **period T**. It is a consolidated period covering the whole study time horizon.

At this stage, four main points need to be clarified prior to proceeding with the analysis:

**1.** The reason why data collection starts from January 1, 1992 is to provide a certain symmetry around a crucial decision for the Turkish gold market: *the decided effective opening of Istanbul gold exchange on March, 16$^{Th.}$, 1994*. That's why, approximately half of the collected data cover the period prior to this above mentioned event ( 27 months ) and the other half covers the period after it ( 24 months ). Moreover, since there are other important events, during the study period, that influenced the Turkish gold market ( these events are discussed throughout period I-period IV in the above section ), it is desirable to categorize data into four periods.

**2.** The reason behind choosing TL/Gr. as the measurement for gold prices is that it is the only available and existing data through the whole 1992 - 1995 period. As far as the collection of data is concerned, only one Turkish daily journal was used: **Hurriyet**. The reason behind this was to assert scientificity for the conducted study through recourse to only one source of data. Moreover, different daily journals disclosed slightly different gold prices; therefore, the intended choice of one source is vital here.

**3.** The reason why a relatively large period of time is chosen in the scope of the study is that the larger is the sample size, the better will be the quality of the parameter estimates.

**4.** The nature of the statistical tests which will be used to confirm or reject the Efficient Market Hypothesis for the Turkish Gold Market in its weak form ( i.e. auto-correlation, run tests, independence tests etc. ) necessitates that gold prices should be tabulated into a ranking order, that reflects the continuity of prices. Therefore, days on which gold is not traded in the Turkish Gold Market are omitted ( usually on Sundays ). Moreover, daily 24-carat gold prices are assumed to reflect closing prices. This is another shortcoming of this study, since such data does not account for price volatility during a given trading day. For convenience, daily gold prices are measured as a weighted average of "bid" and "offer" prices within the same trading day.

**5.** In order to get rid of the inflationary component in nominal gold prices and to smoothen gold distribution, the logarithmic function will be applied. At this stage, a unit root test will be conducted, in order to clarify whether the logarithmic function of *gold prices* or the logarithmic function of *price returns* would be suitable to be taken as a basis for the Turkish gold market efficiency analysis. Gold return is defined as:

$$\textbf{Gold Return } R_t = ( P_t / P_{t-1} )$$

The unit root hypothesis will be depicted in the next section, while a brief understanding of the Augmented Dickey-Fuller unit root test will be introduced in the hypotheses test section.

**2.** Hypotheses:

As was adopted by most Efficient Market Hypothesis researchers ( ex: Lawrance, 1985; Panas, 1990; Butler and Malaikah, 1991 ), the weak form of Efficient Market Hypothesis can be tested by examining the independence, randomness and normality of gold price series. These tests along with the unit root test would be used for the analysis of the Weak Form Efficiency of the Turkish gold market.

● **Unit root hypothesis:**

$H_0$: Gold return distribution possess a unit root.

$H_1$: Gold return distribution is stationary.

● **Independence hypothesis:**

$H_0$: Gold returns are not correlated with each other.

$H_1$: Gold returns are autocorrelated.

● **Randomness hypothesis:**

$H_0$: Gold returns depict a random walk through time.

$H_1$: Gold returns do not depict a random walk through time.

● **Normality hypothesis:**

$H_0$: Gold returns follow a normal distribution through time.

$H_1$: Gold returns distribution is not normal.

**3.** Hypothesis tests:

● Augmented Dickey-Fuller test ( ADF ): The ADF test consists of running a regression of the first difference of the series against the series lagged once, lagged difference terms,

and optionally, a constant and time trend. With two lagged difference terms, the regression equation is:

$$\Delta y_t = \beta_1 y_{t-1} + \beta_2 \Delta y_{t-1} + \beta_3 \Delta y_{t-2} + \beta_4 + \beta_5 t$$

where $\Delta y_t$ is the logarithmic gold return difference between time t and t-1, $\Delta y_{t-1}$ is the logarithmic gold return difference between time t-1 and t-2, $y_{t-1}$ is the logarithmic gold return at time t-1.

There are three choices in running the ADF test regression. One concerns whether to include a constant term in the regression. Another has to do with whether to include a linear time trend or not. The third is how many lagged differences are to be included in the regression.

● Independence tests:

For the Weak Form Efficiency to hold true, gold prices in a time series should be dependent on each other. In fact, if they are somehow correlated with each other, then investors may take, while trading in gold, some positions as to earn riskless profits.

There are several statistical analysis, documented in statistics literature, to test the independence of any price series ( e.g. Serial Correlation Analysis, Kolmogorov-Smirnov test, Ljung-Box test...etc. ). During this study serial correlation analysis, along with Ljung-Box independence test will be applied to gold return distribution.

*Serial correlation analysis:* The serial correlation coefficient that will be obtained by conducting the correlation analysis, measures the strength of the relationship between the

value of a random variable ( in this case gold returns ) at time t and its value in the preceding periods. The population serial correlation coefficient at lag **k** ( $\rho_k$ ) is estimated using the sample serial correlation coefficient at lag **k** ( $r_k$ ) which is defined by :

$$r_k = \Sigma (y_t - y)(y_{t-k} - y) / \Sigma (y_t - y)^2 \qquad \text{for} \quad k = 1,2,3,.....$$

In this study, $y_t$ denotes the natural logarithm of gold returns $R_t$, **y** the mean of all logarithmic gold returns, $y_{t-k}$ the natural logarithm of $R_{t-k}$.

For complete serial independence, $\rho_k = 0$, and complete dependence $\rho_k = +/- 1$. Using the null hypothesis that $\rho_k = 0$, a hypothesis test may be performed to detect whether $r_k$ is significantly different from 0. For the purpose of this study, a two tailed hypothesis test is conducted at the significance level $\alpha = 0.05$. The critical value for a 95 % confidence interval is $1.96 / \sqrt{n}$, where n is the total number of observations in the sample.

A more general approach for testing for serial correlation is to compute the sample autocorrelation and partial autocorrelations of the residuals up to any specified number of lags. This computation can be made using the Ljung-Box Q statistic test. In fact, the Ljung-Box Q statistic tests for serial correlation by summarizing the autocorrelation coefficients. The test statistic is given by:

$$Q_{LB} = n ( n + 2 ) \Sigma ( r_k^2 ) / ( n - k )$$

where $r_k$ is the autocorrelation at lag k, and n is the total number of observations in the sample. Q can be used to test the hypothesis that all of the autocorrolations are zero; i.e. the series exhibits white noise. Under the null hypothesis, Q is distributed as $\chi 2$, with

degrees of freedom equal to the number of autocorrelations in the sum of the above formulae.

● Tests for randomness:

The Weak Form Efficiency hypothesis implies that gold prices follow a random walk through time so that investors won't gain much when analyzing past prices. However, too many or few price change series mean that the market is not efficient even in the weak form. In order to detect, the randomness of a distribution, run test is used. This test shows whether the changes in gold prices follow a systematic pattern. The test is non-parametric and does not require normality and constant variance of the data. A run can be defined as a sequence of price changes of the same sign. For example, a logarithmic return change series as follows:

**++++/----------/0/++/00/-------** consists of six runs.

The sample proportion of positive, negative, and zero runs of logarithmic return changes are used to estimate the corresponding population proportions; hence under the hypothesis of randomness, the total expected number of runs of all signs for a proportion can be computed as:

$$m = [\, N\,(N+1) - \Sigma\,(n_i)^2 \,] / N$$

where N is the total number of price changes, and n, are the total number of runs of logarithmic return changes of each sign, with i = 1, 2, 3 representing the total number of positive (+), negative ( - ) and zero ( 0 ) logarithmic return changes. The variance of *m* is given by:

$$(\delta_m)^2 = [\Sigma (n_i)^2 [\Sigma (n_i)^2 + N(N+1)] - 2N \Sigma (n_i)^3 - N^3] / N^2 (N-1)$$

For large N, the sampling distribution of m is approximately normal. The standardized z-score may be determined by:

$$Z = [(R+0.5) - m] / \delta_m$$

where R is the actual number of runs that exists in the gold return distribution. Two confidence intervals will be used in testing the randomness hypothesis: 95% and 99% confidence intervals.

● Tests for normality

The Weak Form Efficiency hypothesis implies that prices should follow a normal distribution. In fact, if, for example, the distribution is right skewed, it implies that prices show an increasing trend. This leads investors to buy the financial asset, hold it for some time, sell it, and make abnormal profits. From this perspective, tests of normality are very crucial for the Weak Form Efficiency hypothesis.

Tests of normality are used to investigate whether or not the empirical distribution of the successive log price changes conform to the normal distribution. Here, the coefficient of skewness ( $\beta_1$ ) and kurtosis ( $\beta_2$ ) will be applied.

If the sample of gold logarithmic return series is large, than according to the central limit theory, the function of the square root of the coefficient of skewness is normally distributed, with a mean of **0** and variance of **6/n** ( where n is the number of elements in

the sample ). Moreover, the coefficient of kurtosis is also normally distributed with mean **0** and variance **24/n**.

Furthermore, Kolmogorov - Smirnov test will be applied to check the normality of gold logarithmic return distribution in order to support the conclusions concerning the normality of gold return distributions derived from the tests of the coefficients of skewness ($\beta_1$), and kurtosis ($\beta_2$) respectively. The Kolmogorov - Smirnov test statistic is equal to the absolute value of maximum deviation between the observed cumulative proportion and the theoretical normal cumulative proportion. The confidence interval applied to test the normality hypothesis is a 95 % interval ( i.e.: $\alpha$ = **0.05** ). The critical value for a 95 % confidence interval is **1.36 / $\sqrt{n}$**, where n is the total number of observations in the sample.

Last but not least, another normality test will be used, in order to enhance and strengthen the conclusion about the normality of gold logarithmic returns. This test is the Jarque-Bera normality test.

The Jarque-Bera normality test: The Jarque-Bera statistic tests whether a series is normally distributed. The statistic is given by:

$$(n-k/6)\left[\beta_1^2 + 1/4\,(\beta_2 - 3)^2\right]$$

where n is the number of observations, k is zero for an ordinary series and the number of regressors when examining the normality of residuals resulting from the regression, $\beta_1$ is the skewness coefficient and $\beta_2$ is the kurtosis coefficient. Under the null hypothesis of normality, the Jarque-Bera statistic is distributed $\chi^2$ with 2 degrees of freedom.

# FINDINGS

## 1. Unit Root test:

### Table 1

Augmented Dickey-Fuller Unit Root Test for Logarithmic Function of Gold Prices

| Period | Coefficient | Standard Error | t-Statistic |
|---|---|---|---|
| 01/01/92-03/10/93 ( I ) | - 0.012783 | 0.007275 | - 1.757 |
| 04/10/93-15/03/94 ( II ) | - 0.093444 | 0.043127 | - 2.167 |
| 16/03/94-25/07/95 ( III ) | - 0.058259 | 0.023721 | - 2.4560 |
| 26/07/95-20/03/96 ( IV ) | - 0.064711 | 0.024470 | - 2.645 |
| 01/01/92-20/03/96 ( T ) | - 0.004996 | 0.002625 | - 1.904 |

(**): significant at 0.01.

Table 1 lists the corresponding Augmented Dickey-Fuller coefficients for the each of the periods included in the study. As can be tracked from the table, all the t-statistics obtained, are found not to be significant even at 0.01 level. Hence, the unit root hypothesis conducted on the logarithmic function of gold prices can not be rejected. This arises the question of whether gold prices would be smoothened or not using the logarithmic function of the gold returns.

## Table 2

Augmented Dickey-Fuller Unit Root Test for Logarithmic Function of Gold Returns

| Period | Coefficient | Standard Error | t-Statistic |
|---|---|---|---|
| 01/01/92-03/10/93 ( I ) | -1.121385 | 0.065319 | - 17.168** |
| 04/10/93-15/03/94 ( II ) | - 1.091673 | 0.125241 | - 8.717** |
| 16/03/94-25/07/95 ( III ) | - 1.158708 | 0.057363 | - 20.200** |
| 26/07/95-20/03/96 ( IV ) | - 0.858049 | 0.100503 | - 8.538** |
| 01/01/92-20/03/96 ( T ) | - 1.119651 | 0.036147 | - 30.975** |

(**): significant at 0.01.

Table 2 lists the corresponding Augmented Dickey-Fuller coefficients for the each of the periods included in the study. As can be tracked from the table, all the t-statistics obtained, are found to be significant at 0.01 level. This serves to reject the unit root test hypothesis, and leads to the statistical evidence that the logarithmic function of the Turkish return distribution are stationary. Hence, the main outcome from the above results is that the Turkish gold return distribution is smoothened by the logarithm function, in order to get rid of the trends and cycles that it contained. Therefore, during the remaining of the study, all efficiency tests will be conducted on the logarithm function of gold returns.

## 2. Logarithmic Gold Return Distributions' Statistics

### Table 3

Descriptive Statistics

| | 01/01/92-03/10/93 | 04/10/93-15/03/94 | 16/03/94-25/07/95 | 26/07/95-20/03/96 |
|---|---|---|---|---|
| Mean | 0.00163 | 0.00482 | 0.01636 | 0.00229 |
| Median | 0 | 0.00375 | 0.01636 | 0.00229 |
| Mode | 0 | 0 | 0.00561 | 0.00413 |
| Standard Deviation | 0.00863 | 0.01563 | 0.01491 | 0.00400 |
| Variance | $7.45\ 10^{-5}$ | 0.00024 | 0.00022 | $1.60\ 10^{-5}$ |
| Minimum | - 0.03905 | - 0.09378 | 0.00581 | - 0.00053 |
| Maximum | 0.04668 | 0.06076 | 0.02690 | 0.00565 |
| Range | 0.08573 | 0.15454 | 0.02109 | 0.00565 |

Table 3 depicts some statistics concerning the logarithmic distribution of gold returns for the four study periods. As can be noticed above, the means of the logarithmic return distributions showed some increase over time, yet for the last period, the mean of the logarithmic gold return distribution decreased significantly ( 0.00229 ). This implicitly infers that, during the fourth period, gold price variations, from day to day, are minimized. Actually, this implication can be tracked from the standard deviation and variation columns of table 1. In fact, the standard deviation of the logarithmic function of gold price distributions showed higher variations through time[8]. Yet, as far as the period starting from the operational opening of Istanbul Gold Exchange is concerned, the

[8] Refer to Period I,II,III, and IV's graphs in the appendix section.

volatility of the logarithmic function of gold returns, translated in the standard deviation, reached its minimum. This implies that gold prices, during the last period, did not show a significant deviation from each other. Hence, the volatility of the gold prices, reached its minimum during the last period.

### 3 Independence test:

## Table 4

Autocorrealtion Coefficient Statistics

| Period | 1 Day Lag | 2 days Lag | 3 Days Lag | 4 Days Lag | 5 Days Lag | 6 Days Lag | 7 Days Lag | 8 Days Lag | 9 Days Lag | 10 Days Lag |
|---|---|---|---|---|---|---|---|---|---|---|
| 01/01/92-03/10/93 ( I ) | - 0.133* | 0.028 | 0.0998* | 0.0822 | 0.0351 | - 0.022 | - 0.0669 | 0.0234 | - 0.0045 | - 0.0087 |
| 04/10/93-15/03/94 ( II ) | - 0.0339 | - 0.0412 | - 0.174* | - 0.203* | 0.1531 | 0.0024 | 0.1146 | - 0.0639 | - 0.1325 | 0.0051 |
| 16/03/94-25/07/95 ( III ) | 0.1811* | - 0.358* | - 0.250* | 0.0295 | 0.0526 | - 0.0010 | 0.0039 | 0.0236 | 0.0612 | 0.05451 |
| 26/07/95-20/03/96 ( IV ) | 0.0656 | 0.0893 | 0.0000 | 0.1293 | - 0.0725 | - 0.0191 | - 0.1159 | - 0.0896 | - 0.0153 | 0.03586 |
| 01/01/92-20/03/96 ( T ) | 0.1059* | - 0.238* | - 0.183* | 0.01316 | 0.0689* | 0.01004 | 0.01888 | 0.01814 | 0.03376 | 0.04128 |

( * ): statistically significant at 0.05.

Table 4 lists all the autocorrolation coefficients at various lags up to the lag of 10 days for different periods' logarithmic gold returns. As far as period I is concerned, 1 day and 3 day lags reveal an autocorrelation coefficient significantly different from 0. For 4 days

lag onwards, all autocorrelation coefficients seem to be in the acceptance region of the independence hypothesis.

On the other hand, during period II, only the gold returns which are two, or three days apart, depict a coefficient of autocorrelation different from 0. Again, for lags of 4 and more, all autocorrelation coefficients are in the acceptance region of the independence hypothesis.

Coming to period III, all autocorrelation coefficients of gold returns which are 1,2, and 3 days apart from each other, are significantly different than 0. Yet, for lags of 4 and more days, autocorrelation coefficients are consistently within the acceptance region of the independence hypothesis.

Finally, there is no significant evidence to reject the independence hypothesis of gold returns during period IV. In fact, the fourth period's autocorrelation coefficients appeared to be consistently in the acceptance region of the independence hypothesis.

As it is all the time better to see the whole image, period T, which is the consolidated form of periods I throughout IV, is incorporated in this study. The autocorrelation coefficient of gold returns, during the whole period, that are 1, 2, 3, and 5 days apart from each other seem to be significantly different than 0.

# Table 5

The Ljung-Box Statistics

| Period | 1 Day Lag | 2 days Lag | 3 Days Lag | 4 Days Lag | 5 Days Lag | 6 Days Lag | 7 Days Lag | 8 Days Lag | 9 Days Lag | 10 Days Lag |
|---|---|---|---|---|---|---|---|---|---|---|
| 01/01/92-03/10/93 (I) | 9.5958* | 10.020* | 15.430* | 19.107* | 19.780* | 20.066* | 22.514* | 22.816* | 22.827* | 22.870* |
| 04/10/93-15/03/94 (II) | 0.1623 | 0.4039 | 4.739 | 10.721* | 14.126* | 14.127* | 16.067* | 16.675* | 19.306* | 19.310* |
| 16/03/94-25/07/95 (III) | 13.816* | 67.943* | 94.493* | 94.864* | 96.044* | 96.044* | 96.051* | 96.291* | 97.901* | 99.180* |
| 26/07/95-20/03/96 (IV) | 0.6310 | 2.3791 | 2.3791 | 5.6582 | 6.6974 | 6.7703 | 9.4519 | 11.0624 | 11.1102 | 11.3709 |
| 01/01/92-20/03/96 (T) | 14.480* | 87.811* | 131.15* | 131.37* | 137.53* | 137.66* | 138.12* | 138.55* | 140.03* | 142.24* |

('*'): statistically significant at 0.05.

Table 5 lists the Ljung-Box statistics for various lags up to 10 days for different periods' logarithmic gold returns. As far as period I is concerned, all gold returns which are separated up to 10 days lag from each other reveal a value of Ljung-Box statistics leading to the rejection of the independence hypothesis.

On the other hand, during period II, gold returns, gold returns which are 1,2, and 3 days apart from each other, depict Ljung-Box statistics, all within the acceptance region of the independence hypothesis. As the lag increases from 4 days onwards, the Ljung-box statistics seemed to be towards the rejection of the independence hypothesis.

Coming to period III, all gold returns that are separated up to 10 days lag appeared to possess Ljung-Box statistics leading to the rejection of the independence hypothesis.

Finally, there is no significant evidence to reject the independence hypothesis of gold returns during period IV. In fact, the fourth period's Ljung-Box statistics appeared to be consistently in the acceptance region of the independence hypothesis.

For comparison purposes, the consolidated period ( T ), revealed the fact that all gold returns, which are up to 10 days separated from each other, possess Ljing-Box statistics towards the rejection of the independence hypothesis. To recapitulate, periods I, III and T, each show dependency of gold returns on each other, for all lags in the above table. This demonstrates that Turkish gold market is not efficient even in its weakest form. Yet, as far as period IV is concerned, the independence hypothesis can not be rejected and, hence, some sort of dependency seem to be gained with the effective opening of Istanbul Gold Exchange.

## 4 Randomness Test ( Run test ):

**Table 6**

Run test

| Period | Actual Runs | Expected Runs | Standard Error | Standard Variable ( Z ) |
|---|---|---|---|---|
| 01/01/92-03/10/93 ( I ) | 349 | 463.256 | 58.7166 | - 1.9374** |
| 04/10/93-15/03/94 ( II ) | 76 | 122.986 | 29.6203 | - 1.5694 |
| 16/03/94-25/07/95 ( III ) | 221 | 375.888 | 51.289 | - 3.0102'*'** |
| 26/07/95-20/03/96 ( IV ) | 84 | 175.453 | 34.4716 | - 2.6385'*'** |
| 01/01/92-20/03/96 ( T ) | 729 | 1,141.11 | 90.134 | - 4.5667'*'** |

('**'): significant at 0.01.

Table 6 depicts the results of the run tests for the 5 study periods in concern. The results will highlight whether gold returns in the Turkish market depict a random walk or not. One main observation from the table is that, throughout all periods, the actual number of runs is smaller than the expected number of runs, for each period, giving a hint to the negative sign that the calculated value of the test statistic takes.

As far as period I is concerned, the random walk hypothesis is rejected at 0.05 significance level. Yet, for period II, the standard variable (Z) is in the acceptance region of the random walk hypothesis both at 0.01 significance levels. Period III, on the other hand, depict a standard variable (-3.0102) which leads to the rejection of the random walk hypothesis both at 0.05 and 0.01 levels of significance. Such a result holds true for periods III, IV, and VI. Hence, the random hypothesis is rejected for all periods of study, except for period II. Therefore, on an aggregate basis, we can conclude that gold returns do not depict a random walk. Based solely on the random walk hypothesis, the Turkish gold market is not efficient in the weak form.

## 5. Tests for Normality:

**Table 7**

Coefficient of Skewness

| Period | $\beta_1$ | $\delta\beta 1$ | Standard Variable ( Z ) |
|---|---|---|---|
| 01/01/92-03/10/93 ( I ) | $0.6895^{R}$ | 0.1053 | 6.5479** |
| 04/10/93-15/03/94 ( II ) | $-0.9321^{L}$ | 0.2063 | - 4.518** |
| 16/03/94-25/07/95 ( III ) | $-0.0503^{L}$ | 0.1194 | - 0.042 |
| 06/07/95-20/03/96 ( IV ) | $0.193^{R}$ | 0.1793 | 1 .0947 |
| 01/01/92-20/03/96 ( T ) | $-0.1140^{L}$ | 0.07 | - 1.62857 |

(**): significant at 0.01. ($^{R}$): right skewed. ($^{L}$): left skewed.

As table 7 reveals, gold price distributions for period I and VI are right skewed, while those of periods II, and III are left skewed. Moreover, the consolidated period (T) depicts gold returns which posses a left skewed distribution.

As far as period I is concerned, the coefficient of skewness of the gold return distribution, turned out to be statistically different from 0 at 0.01 significance levels. The same result is true for period II. On the other hand, periods II and III reveal coefficients of skewness which are significantly within the acceptance range of the normality hypothesis. Last but not least, considering all the aggregated periods' gold return distribution, the normality hypothesis, based only on coefficient of skewness is not rejected.

## Table 8

Coefficient of kurtosis

| Period | $\beta_2$ | $\delta\beta 2$ | Standard Variable ( Z ) |
|---|---|---|---|
| 01/01/92-03/10/93 ( I ) | 5.2117 | 0.2102 | 24.794** |
| 04/10/93-15/03/94 ( II ) | 13.2376 | 0.4098 | 32.302** |
| 16/03/94-25/07/95 ( III ) | 39.0404 | 0.2382 | 163.89** |
| 06/07/95-20/03/96 ( IV ) | 1.5948 | 0.3509 | 4.544** |
| 01/01/92-20/03/96 ( T ) | 60.75 | 0.14 | 433.92** |

(**): significant at 0.01.

Table 8 depicts the coefficient of kurtosis for various periods of time constituting the study horizon. The major result out of table 8 is that the coefficient of kurtosis, for all periods, turned to be significantly different from 3 ( recall that the normal distributions has a coefficient of kurtosis of 3) at 0.01 significance levels. Therefore, based solely on kurtosis test, the normality hypothesis of logarithmic gold returns is rejected.

## Table 9

Kolmogorov-Smirnov Goodness of Fit Test

| Period | Most Extreme Positive Difference | Most Extreme Negative Difference | Most Extreme Absolute Difference | Kolmogorov-Smirnov Z-statistic |
|---|---|---|---|---|
| 01/01/92-03/10/93 ( I ) | 0.14902 | - 0.13118 | 0.14902 | 3.456* |
| 04/10/93-15/03/94 ( II ) | 0.12638 | - 0.13746 | 0.13746 | 1.615* |
| 16/03/94-25/07/95 ( III ) | 0.26760 | - 0.23758 | 0.26760 | 5.471* |
| 26/07/95-20/03/96 ( IV ) | 0.07392 | - 0.06977 | 0.07392 | 1.019* |
| 01/01/92-20/03/96 ( T ) | 0.18067 | - 0.18976 | 0.18976 | 6.808* |

(*): significant at 0.05.

Table 9 depicts the Kolmogorov-Smirnov Goodness of Fit test statistics for various periods of time constituting the study horizon. The calculated values of the Kolmogorov-Smirnov Z-statistic, are significantly larger than the critical values, for each of the

periods. Thus, the null hypothesis that the gold returns are normally distributed is rejected.

## Table 10

The Jarque-Bera Statistic

| Period | Jarque-Bera Statistic |
|---|---|
| 01/01/92-03/10/93 ( I ) | 686.78** |
| 04/10/93-15/03/94 ( II ) | 1,007.65** |
| 16/03/94-25/07/95 ( III ) | 26,548.26** |
| 26/07/95-20/03/96 ( IV ) | 20.54** |
| 01/01/92-20/03/96 ( VI ) | 198,060.2** |

(**): significant at 0.01.

Table 10 depicts the Jarque-bera Statistic for various periods of time constituting the study horizon. The major result out of table 10 is that the Jarque-Bera Statistic, for all periods, turned out to reject of the normality of the distribution of gold returns both at 0.05 and 0.01 significance levels. Therefore, based solely on the Jarque-Bera Statistic, the normality hypothesis of gold returns is rejected.

Therefore, based on the above normality tests, the hypothesis on the normality of gold returns is rejected. Thus, based solely on the results of the normality tests, the weak form efficiency of Turkish gold market seems to be far from holding true.

# CONCLUSIONS AND RECOMMENDATIONS

Many researchers, in the last years, an increasing interest in testing the market efficiency hypothesis. The importance of such studies emerges from the vital question of whether arbitrage profits still exist in certain markets or not, despite all the talk about globalization, deregulation and the role of market forces in minimizing if not eliminating such opportunities.

Capital markets are expected to be efficient because of three main underlying reasons:

**1.** In the market place, there are a large number of profit maximizing participants who are concerned with the analysis and valuation of securities, and such participants are independent of each other.

**2.** New information about securities come to the market in a random fashion.

**3.** Markets adjust prices rapidly to reflect the effect of new information.

This study is performed to fill the gap arising from the fact that market efficiency studies related to developing countries are very few, let alone the fact that studies testing the weak form efficiency hypothesis on the Turkish gold market are nonexistent. In order to test the above mentioned hypothesis, four mutually exclusive periods were defined reflecting some important decisions undertaken by the Turkish government, and concerning the operations in the Turkish gold market. Moreover, for comparison purposes a fifth period which is nothing but a consolidated form of all above mentioned four periods, was devised. Finally, several tests were conducted on the five periods ranging from independence tests to randomness and normality tests.

Results of these tests reveal, on one hand, that gold returns are rather dependent on each other. Through time, gold return distributions ( for the tested five periods ) are not normal. Instead, they show a skewness to the left ( except for periods I and IV ). Furthermore, gold return distributions do not depict a random walk. To sum it up, the Turkish gold market appears to be inefficient even in the weak form. This may be due to the fact that the Turkish gold market is still a thin market where a relatively small number of buyers and sellers interact to trade a small volume of gold. Therefore, such a study may be extended or redesigned to test for such an effect. Hence, it is possible that a redesigned version of this study, accounting for the volume effect, would yield different results.

The major result of this study, is that with the effective opening of Istanbul Gold Exchange ( IGE ), the market did show some tendency towards becoming a more efficient gold market. In fact, as far as the period starting from the effective opening of IGE is concerned[9], the independence hypothesis of gold returns is not rejected[10]. Moreover, gold return distribution in period IV can be considered as a normal one as far as skewness is concerned[11], though, based on all tests for normality applied in this study, gold returns in period IV indicated a non-normal distribution[12]. On the other hand, gold return distribution in period IV did not depict a random walk. This fact is stressed by the rejection of the random walk hypothesis for the fourth period [13]. Hence, in general, even, period IV seemed to strengthen the market inefficiency hypothesis. However, such an inefficiency must not be taken for granted. In fact, due to severe time constraints, this study allowed only for a period of 8 months to be accounted for in the fourth period. Moreover, since the Istanbul Gold Exchange is a newly established market, it is highly

[9]Period running from July 26, 1995 till March 20, 1996.
[10]See tables 4 and 5.
[11]See table 7.
[12]See tables 8, 9 and 10.
[13]See table 6.

probable that it may show some deficiencies . For, as any new financial market, anomalies exist in the sense that financial assets may be under or over priced. This mispricing may be due to the fact that institutional investors, trading in the new market as well as in global market, can get benefit of assets price differences and, hence, develop certain trading rules as to gain abnormal profits. Lastly, throughout history, it is, all the time, the case that the rules and regulations concerning market efficiencies do come to eliminate anomalies. Therefore, existing deficiencies in the Turkish gold market may, very well, be a positive signal to initiate stricter rules and regulations as far as trading in the Turkish Gold Market is concerned.

# REFERENCES:


**[ 1 ]** Akgiray V., Booth G., Hatem J., and Chowdhury M.( 1991 ) **"Conditional Dependence in Precious Metal Prices"**, The Financial Review, August, pp. 367-386.

**[ 2 ]** Alparslan S. M. ( 1989 ) **"Tests of Weak Form Efficiency in Istanbul Stock Exchange"**, Bilkent University MBA thesis, June, pp. 4-11.

**[ 3 ]** Balke S. N. (1991) **"Modeling Trends in Macroeconomic Time Series"**, Economic Review, May, pp.19-31.

**[ 4 ]** Butler K.C., Malaikah S.J. (1990) " **Efficiency and inefficiency in thinly traded stock markets: Kuwait and Saudia Arabia** ", Journal of Banking and Finance, pp.197-210.

**[ 5 ]** Barnes P. (1986) " **Thin trading and stock market efficiency: The case of Kuala Lumpur stock exchange"**, Journal of Business Finance and Accounting, March, pp.197-210.

**[ 6 ]**Cheung Y. W., and Lai K. S. ( 1993 ) **"Do Gold Market Returns Have Long Memory ?"**, The Financial Review, May, pp.181-202.

**[ 7 ]** Churchill G. A. Jr., **Marketing Research: Methodological Foundations**, The Dryden Press International Edition ( 5th Edition ), pp.777-784.

**[ 8 ]** Ekonomik Trend, Dosya, **"Altin'in Turkiye Gulugu-II"**, March, 12 1995, pp. 38-40.

**[ 9 ]** Ekonomik Trend, Haber, "**Altin bankaciligi surekli gelir sagliyor**", March, 12 1995, pp. 36-37.

**[ 10 ]** Ekonomik Trend, Haber, "**Yastik altindan seans salonuna...**", August, 30 1995, pp.20-22.

**[ 11 ]** Fabozzi F. J., Modigliani F., Ferri M. G., **Foundations of Financial Markets and Institutions**, Prentice Hall International Editions ( 10th Edition ), pp.314-315.

[ **12** ] Fama, E.F. (1970) " **Efficient capital markets: a review of theory and emperical work** " , Journal of Finance, pp.383-417.

**[ 13 ]** Fama, E.F and Blume, M. (1966) " **Filter rules and stock market trading** ", Journal of Business, pp.226-241.

**[ 14 ]** Fama, E.F., Fisher, L., Jensen, M., and Roll, R. ( 1969 ) " **The adjustment of stock prices to new information** " International Economic Review, pp.1-21.

**[ 15 ]** Finans Dunyasi, Dosya, "**Altin artik Borsasi'nda isildiyor...**", September 1995, pp.52-58.

**[ 16 ]** Goss B. A. ( 1983 ) "**The Semi-strong Form Efficiency of the London Metal Exchange**", Applied Economics, pp.681-698.

**[ 17 ]** Kirkpatrick G. E., **Introductory Statistics and Probability for Engineering Science, and Technology**, Prentice Hall International Series in Industrial and Systems Engineering ( 10th Edition ), pp.244-246.

**[ 18 ]** Lawrance M. ( 1986 ) " **Weak Form Efficiency in the Kuala-Lampur and Singapore Stock Markets**", Journal of Banking and Finance, pp.441-445.

**[ 19 ]** Mc Clave T. J., **Statistics for Business and Economics**, Maxwell Mac Millan (5th Edition ), pp.345-388.

**[ 20 ]** Mendenhall W., Reinmuth J. E., Beaver R., **Statistics for Management and Economics**, PWS-KENT Publishing Company (6th Edition), pp. 738-744.

**[ 21 ]** O'Challaghan G. ( 1993 ) " **The Structure and Operation of the World Gold Economy**", September, pp.01-34.

**[ 22 ]** Panas E. (1990 ) "**The behaviour of Athens stock prices**", Applied Economics, pp.1715-1727.

**[ 23 ]** Paramatik, Haber, "**Altin reformu tamamlanmayi bekliyor**", October, 15 1995, pp.08-11.

**[ 24 ]** Sener N., and Akman V., **Istanbul Borsasi ve Dunya Ornekleri**, pp. 64-97.

**[ 25 ]** Sengul M., G. and Oktay, T. (1993) " **Calender anomalies in the Turkish Stock Market** ", paper presented at the International Conference on Business and

Economic Development in Middle Eastern and Mediterranean Countries, Istanbul-Turkey, July 1993.

**[ 26 ]** The Central Bank of the Republic of Turkey ( 1995 ) **1994 Annual Report**, April, pp.96-97.

# APPENDIX

# APPENDIX A

## Table 1 Gold Characteristics

| Symbol | Au |
|---|---|
| Melting Point ( Co ) | 1.063 |
| Density ( gr / $cm^3$ ) | 19.3 |
| Atomic Weight | 197 |
| Atomic Number | 70 |
| Toughness | 25 |
| Durability | 119 |
| Elasticity | 42 |

**Source:** Sener Nedim - Akman Vedat. **Istanbul Borsasi Ve Dunya Ornekleri**. p. 10.

## Table 2: Conversion Factors for Gold

| Measure | Metric Ton | Kilograms | Grams | Troy Ounce | Tolas | Taels |
|---|---|---|---|---|---|---|
| Metric Ton | 1.000000 | 1,000,000 | 1,000,000 $10^3$ | 32,150.74 | 85,735.35 | 26,717.25 |
| Kilogram | 0.001000 | 1.000000 | 1,000.000 | 32.15074 | 85.73535 | 26.71725 |
| Gram | 0.000001 | 0.001000 | 1.000000 | 0.032151 | 0.085735 | 0.026717 |
| Troy Ounce | 0.000031 | 0.031103 | 31.10348 | 1.000000 | 2.666666 | 0.830906 |
| Tolas | 0.000012 | 0.011664 | 11.66380 | 0.375000 | 1.000000 | 0.311624 |
| Taels | 0.000037 | 0.037429 | 37.42900 | 1.203370 | 3.208988 | 1.000000 |

**Source**: O'Challaghan Gary. **The structure and Operation of The World Gold Economy**. September 1993. p.34.

**Table 3: Purity Standards for Gold**

| Carats | Parts per 1,000 |
|---|---|
| 24 | 1,000.000 |
| 22 | 916.667 |
| 18 | 750.000 |
| 14 | 583.333 |
| 9 | 375.000 |
| 1 | 41.667 |

**Source:** O'Challaghan Gary. **The structure and Operation of The World Gold Economy**. September 1993. p.34.

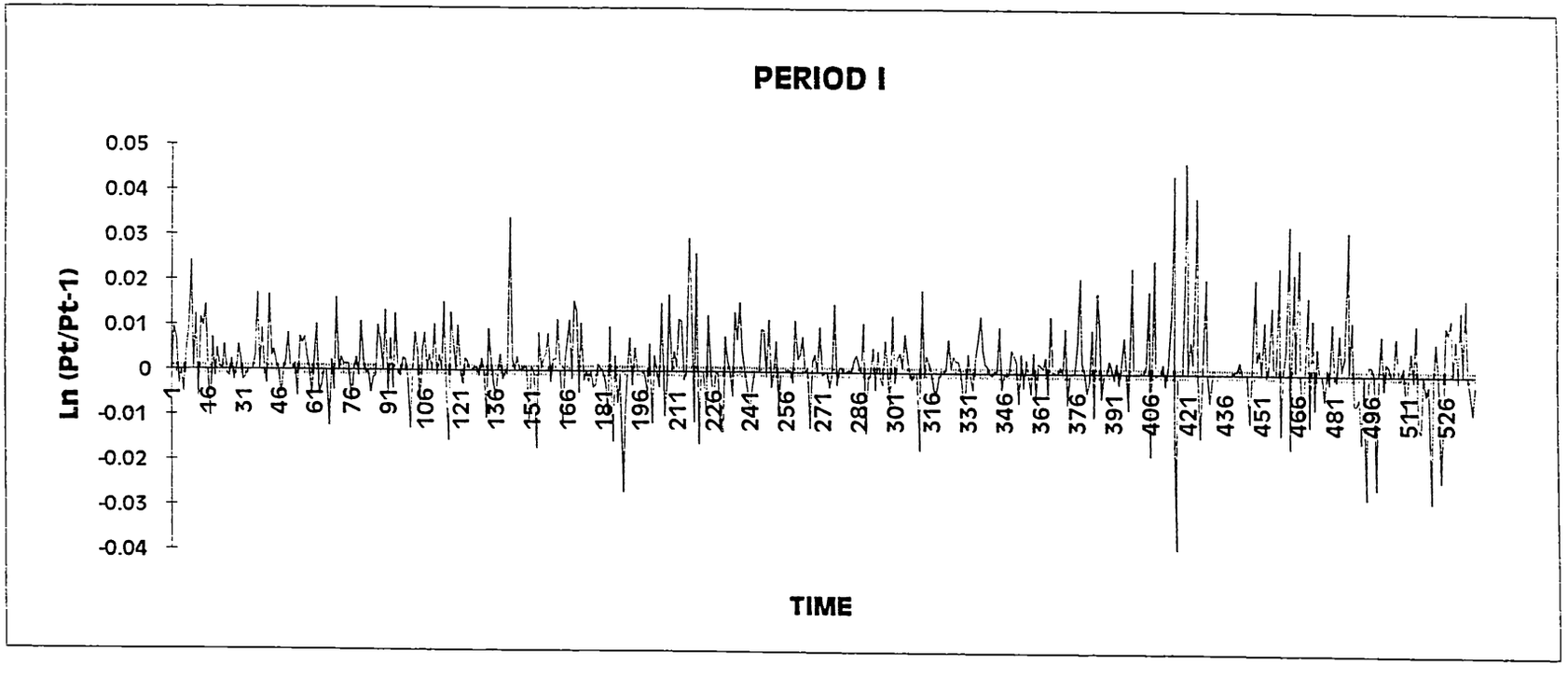
## Table 4: Refineries whose Gold can be traded in IGE

| COUNTRY | COMPANY |
|---|---|
| **Singapore** | Degussa ( private ) Limited |
| **South Africa** | Rand Refinery Limited |
| **Spain** | Industrias Reunidas |
| | Minero Metalulurgicas, SA ( Indumetal ) |
| | Sociedad Espanole de Metal Preciocos SA |
| **Sweden** | Boliden Mineral AB |
| **Switzerland** | Agor-Heraeus SA |
| | Cendres & Metaux Precieux SA |
| | Metalor |
| | Pamp SA |
| | Valcambi SA |
| **United Kingdom** | Engelhard Limited |
| | Johnson Matttey Plc |
| **USA** | ASARCO Incorporated |
| | Engelhard Corporation ( New Jersey Refinery ) |
| | Handy &Harman |
| | Homestake Mining Company |
| | Johnson Matthey Incorporated |
| | Metalor USA |

| | |
|---|---|
| | United States Assay Offices & Mints |
| **Russia** | State Refineries |
| **Zimbabwe** | Fidelity Printers & Refineries ( Private ) Limited |
| **Italy** | Metalli Preziosi SpA |
| **Japan** | Ishifuku Metal Industry Company Limited<br>Mitsubishi Meterials Corporation<br>Mitsui Mining and Smelting Co. Limited<br>Tanaka Kikinzoku Kogyo KK<br>Tokuriki Honten & Company Limited |
| **North Korea** | Central Bank, DPR of Korea |
| **Mexico** | Met - Mex Penoles, S.A. |
| **Netherlands** | H. Drijfhout & Zoon's Edelmetaalberidrijven BV<br>Shone Edelmetaal BV |
| **Brazil** | Banco Riame SA<br>Cassa de Moeda do Brazil<br>Degussa SA<br>Mineraco Morro Veho SA |
| **Canada** | Engelhard of Canada Limited<br>Johnson Matthey Limited |

| | |
|---|---|
| | Noranda Minerals Incorporated ( Diviasion CCR) |
| | Royal Canadian Mint |
| **France** | Engelhard S.A. |
| | Comptoir Lyon-Alemand |
| | Louyot-Paris |
| **Germany** | Degussa |
| | WC Heracus GmbH |
| | Norddeutsche Affinerie Aktiengesellschaft |

# APPENDIX B


PERIOD I
Ln (Pt/Pt-1)
0.05
0.04
0.03
0.02
0.01
0
-0.01
-0.02
-0.03
-0.04
1
16
31
46
61
76
91
106
121
136
151
166
181
196
211
226
241
256
271
286
301
316
331
346
361
376
391
406
421
436
451
466
481
496
511
526
TIME

PERIOD I

| | | | |
|---|---|---|---|
| 112 | 73325 | 0.998978202 | -0.001022321 |
| 113 | 73575 | 1.003409478 | 0.003403679 |
| 114 | 73575 | 1 | 0 |
| 115 | 74700 | 1.01529052 | 0.015174798 |
| 116 | 74300 | 0.994645248 | -0.00536914 |
| 117 | 73150 | 0.984522207 | -0.015598824 |
| 118 | 74100 | 1.012987013 | 0.012903405 |
| 119 | 74600 | 1.006747638 | 0.006724975 |
| 120 | 74600 | 1 | 0 |
| 121 | 75350 | 1.010053619 | 0.010003418 |
| 122 | 75350 | 1 | 0 |
| 123 | 75100 | 0.99668215 | -0.003323366 |
| 124 | 75300 | 1.002663116 | 0.002659576 |
| 125 | 75450 | 1.001992032 | 0.00199005 |
| 126 | 75450 | 1 | 0 |
| 127 | 75450 | 1 | 0 |
| 128 | 75500 | 1.000662691 | 0.000662471 |
| 129 | 75550 | 1.000662252 | 0.000662032 |
| 130 | 75450 | 0.998676373 | -0.001324504 |
| 131 | 75650 | 1.002650762 | 0.002647255 |
| 132 | 75650 | 1 | 0 |
| 133 | 74850 | 0.989424983 | -0.010631329 |
| 134 | 75550 | 1.009352037 | 0.009308578 |
| 135 | 75750 | 1.002647253 | 0.002643756 |
| 136 | 75550 | 0.997359736 | -0.002643756 |
| 137 | 75125 | 0.994374586 | -0.005641296 |
| 138 | 75125 | 1 | 0 |
| 139 | 75400 | 1.003660566 | 0.003653882 |
| 140 | 75250 | 0.99801061 | -0.001991371 |
| 141 | 75225 | 0.999667774 | -0.000332281 |
| 142 | 75250 | 1.000332336 | 0.000332281 |
| 143 | 77850 | 1.034551495 | 0.033967995 |
| 144 | 78050 | 1.002569043 | 0.002565749 |
| 145 | 78050 | 1 | 0 |
| 146 | 78300 | 1.003203075 | 0.003197956 |
| 147 | 78300 | 1 | 0 |
| 148 | 78325 | 1.000319285 | 0.000319234 |
| 149 | 78400 | 1.000957549 | 0.000957091 |
| 150 | 78450 | 1.000637755 | 0.000637552 |
| 151 | 77550 | 0.988527725 | -0.01153859 |
| 152 | 77625 | 1.000967118 | 0.000966651 |
| 153 | 77575 | 0.999355878 | -0.00064433 |
| 154 | 76250 | 0.982919755 | -0.017227795 |
| 155 | 76900 | 1.00852459 | 0.008488461 |
| 156 | 76950 | 1.000650195 | 0.000649984 |
| 157 | 77150 | 1.00259909 | 0.002595719 |
| 158 | 77450 | 1.003888529 | 0.003880988 |
| 159 | 78100 | 1.008392511 | 0.00835749 |
| 160 | 77900 | 0.997439181 | -0.002564104 |
| 161 | 78100 | 1.002567394 | 0.002564104 |
| 162 | 78300 | 1.002560819 | 0.002557546 |
| 163 | 79200 | 1.011494253 | 0.011428696 |
| 164 | 79200 | 1 | 0 |
| 165 | 78300 | 0.988636364 | -0.011428696 |
| 166 | 78500 | 1.002554278 | 0.002551022 |
| 167 | 79050 | 1.007006369 | 0.006981939 |

PERIOD I

| | | | |
|---|---|---|---|
| 168 | 79950 | 1.011385199 | 0.011320876 |
| 169 | 79800 | 0.998123827 | -0.001877935 |
| 170 | 81050 | 1.01566416 | 0.015542744 |
| 171 | 82150 | 1.013571869 | 0.013480596 |
| 172 | 81750 | 0.995130858 | -0.004881035 |
| 173 | 82625 | 1.010703364 | 0.010646488 |
| 174 | 82450 | 0.997881997 | -0.002120249 |
| 175 | 82450 | 1 | 0 |
| 176 | 82250 | 0.997574287 | -0.002428659 |
| 177 | 82250 | 1 | 0 |
| 178 | 81950 | 0.996352584 | -0.003654084 |
| 179 | 81700 | 0.996949359 | -0.003055303 |
| 180 | 81825 | 1.001529988 | 0.001528819 |
| 181 | 81875 | 1.00061106 | 0.000610874 |
| 182 | 81875 | 1 | 0 |
| 183 | 81650 | 0.997251908 | -0.002751875 |
| 184 | 80850 | 0.990202082 | -0.009846233 |
| 185 | 81650 | 1.009894867 | 0.009846233 |
| 186 | 80375 | 0.984384568 | -0.015738637 |
| 187 | 80650 | 1.003421462 | 0.003415622 |
| 188 | 80075 | 0.992870428 | -0.007155109 |
| 189 | 79975 | 0.998751171 | -0.00124961 |
| 190 | 77850 | 0.973429197 | -0.026930188 |
| 191 | 77125 | 0.990687219 | -0.009356416 |
| 192 | 77125 | 1 | 0 |
| 193 | 77700 | 1.007455429 | 0.007427775 |
| 194 | 77450 | 0.996782497 | -0.003222691 |
| 195 | 77850 | 1.005164622 | 0.005151331 |
| 196 | 77850 | 1 | 0 |
| 197 | 77850 | 1 | 0 |
| 198 | 77850 | 1 | 0 |
| 199 | 77775 | 0.999036609 | -0.000963855 |
| 200 | 77375 | 0.994856959 | -0.005156312 |
| 201 | 77850 | 1.006138934 | 0.006120167 |
| 202 | 76950 | 0.988439306 | -0.011628038 |
| 203 | 77225 | 1.003573749 | 0.003567379 |
| 204 | 77225 | 1 | 0 |
| 205 | 76950 | 0.996438977 | -0.003567379 |
| 206 | 78125 | 1.015269656 | 0.015154248 |
| 207 | 77350 | 0.99008 | -0.009969531 |
| 208 | 77175 | 0.997737557 | -0.002265007 |
| 209 | 78500 | 1.017168772 | 0.017023054 |
| 210 | 78500 | 1 | 0 |
| 211 | 78850 | 1.004458599 | 0.004448689 |
| 212 | 78950 | 1.001268231 | 0.001267427 |
| 213 | 79875 | 1.011716276 | 0.011648172 |
| 214 | 80775 | 1.011267606 | 0.011204599 |
| 215 | 80625 | 0.99814299 | -0.001858737 |
| 216 | 80625 | 1 | 0 |
| 217 | 83050 | 1.030077519 | 0.029634061 |
| 218 | 84475 | 1.017158338 | 0.017012797 |
| 219 | 83525 | 0.988754069 | -0.011309644 |
| 220 | 85750 | 1.026638731 | 0.026290098 |
| 221 | 84375 | 0.983965015 | -0.016164937 |
| 222 | 84375 | 1 | 0 |
| 223 | 84350 | 0.999703704 | -0.00029634 |

| | | | |
|---|---|---|---|
| 224 | 83550 | 0.990515708 | -0.009529554 |
| 225 | 84600 | 1.012567325 | 0.012489012 |
| 226 | 84750 | 1.00177305 | 0.00177148 |
| 227 | 84100 | 0.992330383 | -0.007699179 |
| 228 | 84100 | 1 | 0 |
| 229 | 84050 | 0.99940547 | -0.000594707 |
| 230 | 82950 | 0.986912552 | -0.013173843 |
| 231 | 81850 | 0.986738999 | -0.013349713 |
| 232 | 82500 | 1.007941356 | 0.00790999 |
| 233 | 82700 | 1.002424242 | 0.002421309 |
| 234 | 82700 | 1 | 0 |
| 235 | 82250 | 0.994558646 | -0.005456212 |
| 236 | 83350 | 1.01337386 | 0.01328522 |
| 237 | 83950 | 1.00719856 | 0.007172774 |
| 238 | 85250 | 1.015485408 | 0.015366733 |
| 239 | 85650 | 1.004692082 | 0.004681109 |
| 240 | 85650 | 1 | 0 |
| 241 | 85350 | 0.996497373 | -0.003508776 |
| 242 | 84550 | 0.990626831 | -0.009417374 |
| 243 | 84250 | 0.996451804 | -0.003554506 |
| 244 | 84250 | 1 | 0 |
| 245 | 84250 | 1 | 0 |
| 246 | 84250 | 1 | 0 |
| 247 | 85050 | 1.009495549 | 0.00945075 |
| 248 | 85850 | 1.009406232 | 0.009362269 |
| 249 | 85750 | 0.998835178 | -0.001165501 |
| 250 | 86750 | 1.011661808 | 0.011594333 |
| 251 | 86450 | 0.996541787 | -0.003464207 |
| 252 | 86450 | 1 | 0 |
| 253 | 87050 | 1.006940428 | 0.006916454 |
| 254 | 86400 | 0.992533027 | -0.00749499 |
| 255 | 86400 | 1 | 0 |
| 256 | 86400 | 1 | 0 |
| 257 | 86400 | 1 | 0 |
| 258 | 86450 | 1.000578704 | 0.000578536 |
| 259 | 86450 | 1 | 0 |
| 260 | 86250 | 0.997686524 | -0.002316156 |
| 261 | 87250 | 1.011594203 | 0.011527505 |
| 262 | 87500 | 1.00286533 | 0.002861232 |
| 263 | 87850 | 1.004 | 0.003992021 |
| 264 | 88550 | 1.007968127 | 0.00793655 |
| 265 | 88550 | 1 | 0 |
| 266 | 88650 | 1.001129305 | 0.001128668 |
| 267 | 87550 | 0.987591653 | -0.012485974 |
| 268 | 87750 | 1.002284409 | 0.002281804 |
| 269 | 88100 | 1.003988604 | 0.003980671 |
| 270 | 88100 | 1 | 0 |
| 271 | 89000 | 1.010215664 | 0.010163837 |
| 272 | 88950 | 0.999438202 | -0.000561956 |
| 273 | 88950 | 1 | 0 |
| 274 | 88950 | 1 | 0 |
| 275 | 88650 | 0.996627319 | -0.003378382 |
| 276 | 88650 | 1 | 0 |
| 277 | 90000 | 1.015228426 | 0.015113638 |
| 278 | 89750 | 0.997222222 | -0.002781643 |
| 279 | 89850 | 1.001114206 | 0.001113586 |

PERIOD I

| DATE | PRICE | Pt/Pt-1 | Ln (Pt/Pt-1) |
|---|---|---|---|
| 1 | 57950 | | |
| 2 | 57950 | 1 | 0 |
| 3 | 58500 | 1.00949094 | 0.009446184 |
| 4 | 58900 | 1.006837607 | 0.006814336 |
| 5 | 58700 | 0.996604414 | -0.003401364 |
| 6 | 58700 | 1 | 0 |
| 7 | 58400 | 0.994889267 | -0.005123837 |
| 8 | 58650 | 1.004280822 | 0.004271685 |
| 9 | 59200 | 1.009377664 | 0.009333967 |
| 10 | 60650 | 1.024493243 | 0.024198094 |
| 11 | 60650 | 1 | 0 |
| 12 | 61400 | 1.012366035 | 0.0122902 |
| 13 | 61000 | 0.993485342 | -0.006535971 |
| 14 | 61700 | 1.01147541 | 0.011410067 |
| 15 | 62300 | 1.009724473 | 0.009677495 |
| 16 | 63200 | 1.014446228 | 0.014342875 |
| 17 | 63200 | 1 | 0 |
| 18 | 62550 | 0.98971519 | -0.010338064 |
| 19 | 63000 | 1.007194245 | 0.007168489 |
| 20 | 62900 | 0.998412698 | -0.001588563 |
| 21 | 63200 | 1.004769475 | 0.004758137 |
| 22 | 63250 | 1.000791139 | 0.000790826 |
| 23 | 63250 | 1 | 0 |
| 24 | 63600 | 1.005533597 | 0.005518343 |
| 25 | 63550 | 0.999213836 | -0.000786473 |
| 26 | 63450 | 0.998426436 | -0.001574803 |
| 27 | 63600 | 1.002364066 | 0.002361276 |
| 28 | 63450 | 0.997641509 | -0.002361276 |
| 29 | 63450 | 1 | 0 |
| 30 | 63800 | 1.005516154 | 0.005500996 |
| 31 | 63950 | 1.002351097 | 0.002348338 |
| 32 | 63800 | 0.997654418 | -0.002348338 |
| 33 | 63700 | 0.998432602 | -0.001568628 |
| 34 | 63700 | 1 | 0 |
| 35 | 63700 | 1 | 0 |
| 36 | 63700 | 1 | 0 |
| 37 | 63900 | 1.003139717 | 0.003134799 |
| 38 | 65000 | 1.017214397 | 0.017067909 |
| 39 | 65000 | 1 | 0 |
| 40 | 65600 | 1.009230769 | 0.009188426 |
| 41 | 65600 | 1 | 0 |
| 42 | 65400 | 0.99695122 | -0.003053437 |
| 43 | 66500 | 1.016819572 | 0.016679689 |
| 44 | 66700 | 1.003007519 | 0.003003005 |
| 45 | 67000 | 1.004497751 | 0.004487666 |
| 46 | 67100 | 1.001492537 | 0.001491425 |
| 47 | 67100 | 1 | 0 |
| 48 | 66700 | 0.994038748 | -0.005979091 |
| 49 | 66700 | 1 | 0 |
| 50 | 66850 | 1.002248876 | 0.002246351 |
| 51 | 67400 | 1.008227375 | 0.008193714 |
| 52 | 67400 | 1 | 0 |
| 53 | 67400 | 1 | 0 |
| 54 | 67500 | 1.00148368 | 0.00148258 |
| 55 | 67100 | 0.994074074 | -0.005943554 |

PERIOD I

| | | | |
|---|---|---|---|
| 56 | 67600 | 1.007451565 | 0.007423939 |
| 57 | 68000 | 1.00591716 | 0.005899722 |
| 58 | 68500 | 1.007352941 | 0.00732604 |
| 59 | 68700 | 1.002919708 | 0.002915454 |
| 60 | 68700 | 1 | 0 |
| 61 | 68300 | 0.994177584 | -0.005839433 |
| 62 | 68500 | 1.002928258 | 0.002923979 |
| 63 | 69200 | 1.010218978 | 0.010167117 |
| 64 | 68825 | 0.994580925 | -0.005433812 |
| 65 | 68600 | 0.996730839 | -0.003274516 |
| 66 | 68600 | 1 | 0 |
| 67 | 68600 | 1 | 0 |
| 68 | 67750 | 0.987609329 | -0.012468075 |
| 69 | 67900 | 1.002214022 | 0.002211575 |
| 70 | 67600 | 0.995581738 | -0.004428052 |
| 71 | 68700 | 1.016272189 | 0.016141216 |
| 72 | 68700 | 1 | 0 |
| 73 | 68900 | 1.002911208 | 0.002906979 |
| 74 | 69000 | 1.001451379 | 0.001450327 |
| 75 | 69100 | 1.001449275 | 0.001448226 |
| 76 | 69200 | 1.001447178 | 0.001446132 |
| 77 | 68700 | 0.992774566 | -0.007251663 |
| 78 | 68700 | 1 | 0 |
| 79 | 68900 | 1.002911208 | 0.002906979 |
| 80 | 68800 | 0.998548621 | -0.001452433 |
| 81 | 69550 | 1.010901163 | 0.010842173 |
| 82 | 69700 | 1.002156722 | 0.002154399 |
| 83 | 69650 | 0.99928264 | -0.000717618 |
| 84 | 69650 | 1 | 0 |
| 85 | 69300 | 0.994974874 | -0.005037794 |
| 86 | 69200 | 0.998556999 | -0.001444044 |
| 87 | 69100 | 0.998554913 | -0.001446132 |
| 88 | 69800 | 1.010130246 | 0.010079279 |
| 89 | 70250 | 1.006446991 | 0.006426298 |
| 90 | 70250 | 1 | 0 |
| 91 | 71200 | 1.013523132 | 0.01343251 |
| 92 | 70800 | 0.994382022 | -0.005633818 |
| 93 | 71300 | 1.007062147 | 0.007037327 |
| 94 | 71000 | 0.995792426 | -0.00421645 |
| 95 | 71900 | 1.012676056 | 0.012596388 |
| 96 | 71900 | 1 | 0 |
| 97 | 71800 | 0.998609179 | -0.001391789 |
| 98 | 72000 | 1.002785515 | 0.002781643 |
| 99 | 72175 | 1.002430556 | 0.002427607 |
| 100 | 72125 | 0.999307239 | -0.000693001 |
| 101 | 71200 | 0.987175043 | -0.012907906 |
| 102 | 71200 | 1 | 0 |
| 103 | 71800 | 1.008426966 | 0.008391658 |
| 104 | 72100 | 1.004178273 | 0.004169568 |
| 105 | 71475 | 0.991331484 | -0.008706306 |
| 106 | 71800 | 1.004547044 | 0.004536738 |
| 107 | 72400 | 1.008356546 | 0.008321823 |
| 108 | 72400 | 1 | 0 |
| 109 | 72650 | 1.003453039 | 0.003447091 |
| 110 | 72650 | 1 | 0 |
| 111 | 73400 | 1.010323469 | 0.010270546 |

| | | | |
|---|---|---|---|
| 280 | 89950 | 1.001112966 | 0.001112347 |
| 281 | 89950 | 1 | 0 |
| 282 | 89950 | 1 | 0 |
| 283 | 90000 | 1.000555864 | 0.00055571 |
| 284 | 90000 | 1 | 0 |
| 285 | 90250 | 1.002777778 | 0.002773927 |
| 286 | 90600 | 1.003878116 | 0.003870616 |
| 287 | 90750 | 1.001655629 | 0.00165426 |
| 288 | 90750 | 1 | 0 |
| 289 | 91750 | 1.011019284 | 0.010959014 |
| 290 | 90515 | 0.98653951 | -0.013551904 |
| 291 | 90350 | 0.998177098 | -0.001824566 |
| 292 | 90350 | 1 | 0 |
| 293 | 90850 | 1.005534034 | 0.005518778 |
| 294 | 90515 | 0.996312603 | -0.003694212 |
| 295 | 90950 | 1.004805833 | 0.004794322 |
| 296 | 90850 | 0.998900495 | -0.00110011 |
| 297 | 90600 | 0.997248211 | -0.002755582 |
| 298 | 91250 | 1.007174393 | 0.007148779 |
| 299 | 91350 | 1.00109589 | 0.00109529 |
| 300 | 90600 | 0.991789819 | -0.00824407 |
| 301 | 91750 | 1.012693157 | 0.012613274 |
| 302 | 91550 | 0.997820163 | -0.002182216 |
| 303 | 91850 | 1.003276898 | 0.003271541 |
| 304 | 92250 | 1.004354927 | 0.004345471 |
| 305 | 92350 | 1.001084011 | 0.001083424 |
| 306 | 93150 | 1.008662696 | 0.00862539 |
| 307 | 93500 | 1.003757381 | 0.003750339 |
| 308 | 93500 | 1 | 0 |
| 309 | 93350 | 0.998395722 | -0.001605566 |
| 310 | 93350 | 1 | 0 |
| 311 | 93350 | 1 | 0 |
| 312 | 91750 | 0.982860204 | -0.017288383 |
| 313 | 93450 | 1.01852861 | 0.018359047 |
| 314 | 93400 | 0.999464955 | -0.000535189 |
| 315 | 93750 | 1.003747323 | 0.00374032 |
| 316 | 93950 | 1.002133333 | 0.002131061 |
| 317 | 93950 | 1 | 0 |
| 318 | 93600 | 0.996274614 | -0.003732342 |
| 319 | 93200 | 0.995726496 | -0.004282662 |
| 320 | 93100 | 0.998927039 | -0.001073537 |
| 321 | 93100 | 1 | 0 |
| 322 | 93100 | 1 | 0 |
| 323 | 93200 | 1.001074114 | 0.001073537 |
| 324 | 93900 | 1.00751073 | 0.007482665 |
| 325 | 94000 | 1.001064963 | 0.001064396 |
| 326 | 94350 | 1.003723404 | 0.00371649 |
| 327 | 94600 | 1.002649709 | 0.002646204 |
| 328 | 94850 | 1.002642706 | 0.00263922 |
| 329 | 94850 | 1 | 0 |
| 330 | 94250 | 0.993674222 | -0.00634587 |
| 331 | 93900 | 0.996286472 | -0.00372044 |
| 332 | 94300 | 1.004259851 | 0.004250803 |
| 333 | 94250 | 0.999469777 | -0.000530363 |
| 334 | 93900 | 0.996286472 | -0.00372044 |
| 335 | 94250 | 1.00372737 | 0.00372044 |

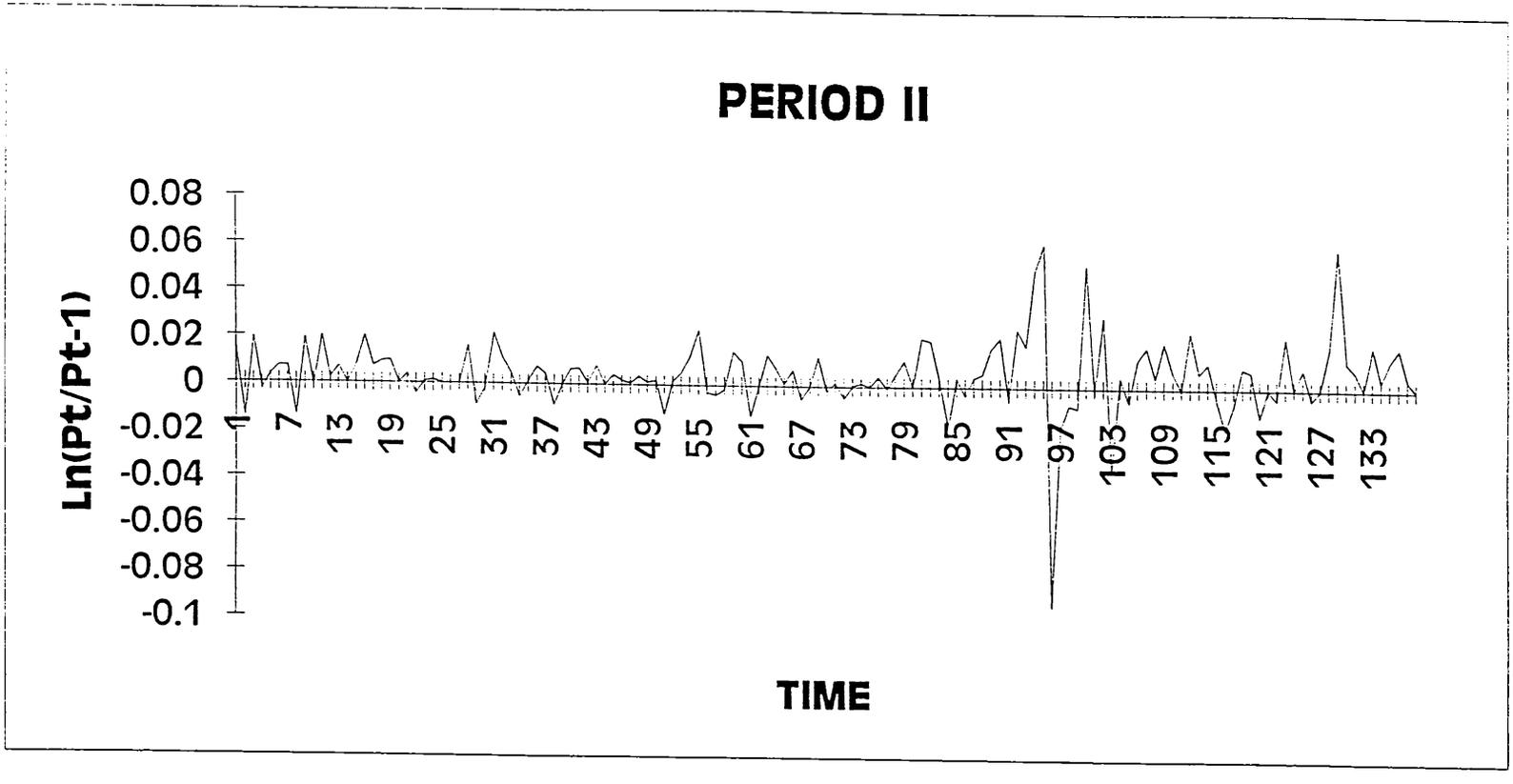
| | | | |
|---|---|---|---|
| 336 | 94900 | 1.006896552 | 0.006872879 |
| 337 | 96100 | 1.012644889 | 0.01256561 |
| 338 | 96600 | 1.005202914 | 0.005189425 |
| 339 | 96800 | 1.002070393 | 0.002068253 |
| 340 | 96950 | 1.001549587 | 0.001548387 |
| 341 | 96950 | 1 | 0 |
| 342 | 96900 | 0.99948427 | -0.000515863 |
| 343 | 96950 | 1.000515996 | 0.000515863 |
| 344 | 97000 | 1.00051573 | 0.000515597 |
| 345 | 98000 | 1.010309278 | 0.0102565 |
| 346 | 97650 | 0.996428571 | -0.003577821 |
| 347 | 97650 | 1 | 0 |
| 348 | 97600 | 0.999487967 | -0.000512164 |
| 349 | 97600 | 1 | 0 |
| 350 | 98100 | 1.005122951 | 0.005109873 |
| 351 | 98500 | 1.004077472 | 0.004069182 |
| 352 | 98750 | 1.002538071 | 0.002534856 |
| 353 | 98100 | 0.993417722 | -0.006604037 |
| 354 | 98525 | 1.004332314 | 0.004322957 |
| 355 | 98200 | 0.996701345 | -0.003304108 |
| 356 | 98500 | 1.00305499 | 0.003050333 |
| 357 | 98500 | 1 | 0 |
| 358 | 98050 | 0.995431472 | -0.004578996 |
| 359 | 98500 | 1.004589495 | 0.004578996 |
| 360 | 97950 | 0.994416244 | -0.005599404 |
| 361 | 98175 | 1.00229709 | 0.002294456 |
| 362 | 98350 | 1.001782531 | 0.001780944 |
| 363 | 98450 | 1.001016777 | 0.00101626 |
| 364 | 98800 | 1.003555104 | 0.0035488 |
| 365 | 98350 | 0.995445344 | -0.00456506 |
| 366 | 99600 | 1.01270971 | 0.01262962 |
| 367 | 99650 | 1.000502008 | 0.000501882 |
| 368 | 99650 | 1 | 0 |
| 369 | 99650 | 1 | 0 |
| 370 | 99800 | 1.001505268 | 0.001504137 |
| 371 | 99800 | 1 | 0 |
| 372 | 100800 | 1.01002004 | 0.009970172 |
| 373 | 100100 | 0.993055556 | -0.006968669 |
| 374 | 100100 | 1 | 0 |
| 375 | 100100 | 1 | 0 |
| 376 | 100100 | 1 | 0 |
| 377 | 100800 | 1.006993007 | 0.006968669 |
| 378 | 102950 | 1.021329365 | 0.021105078 |
| 379 | 103200 | 1.002428363 | 0.00242542 |
| 380 | 103200 | 1 | 0 |
| 381 | 102750 | 0.995639535 | -0.00437 |
| 382 | 102600 | 0.998540146 | -0.001460921 |
| 383 | 103600 | 1.009746589 | 0.009699397 |
| 384 | 102600 | 0.99034749 | -0.009699397 |
| 385 | 104500 | 1.018518519 | 0.018349139 |
| 386 | 105600 | 1.010526316 | 0.0104713 |
| 387 | 105000 | 0.994318182 | -0.005698021 |
| 388 | 105000 | 1 | 0 |
| 389 | 105000 | 1 | 0 |
| 390 | 105300 | 1.002857143 | 0.002853069 |
| 391 | 105450 | 1.001424501 | 0.001423488 |

| | | | |
|---|---|---|---|
| 392 | 105300 | 0.998577525 | -0.001423488 |
| 393 | 105550 | 1.002374169 | 0.002371355 |
| 394 | 105300 | 0.997631454 | -0.002371355 |
| 395 | 105550 | 1.002374169 | 0.002371355 |
| 396 | 106400 | 1.008053055 | 0.008020803 |
| 397 | 106400 | 1 | 0 |
| 398 | 105550 | 0.992011278 | -0.008020803 |
| 399 | 108050 | 1.023685457 | 0.023409309 |
| 400 | 108050 | 1 | 0 |
| 401 | 108050 | 1 | 0 |
| 402 | 108050 | 1 | 0 |
| 403 | 108050 | 1 | 0 |
| 404 | 108050 | 1 | 0 |
| 405 | 108250 | 1.001850995 | 0.001849284 |
| 406 | 110250 | 1.018475751 | 0.018307147 |
| 407 | 108250 | 0.98185941 | -0.018307147 |
| 408 | 111000 | 1.025404157 | 0.025086834 |
| 409 | 110950 | 0.99954955 | -0.000450552 |
| 410 | 110950 | 1 | 0 |
| 411 | 110950 | 1 | 0 |
| 412 | 111200 | 1.002253267 | 0.002250732 |
| 413 | 110900 | 0.997302158 | -0.002701487 |
| 414 | 111100 | 1.001803427 | 0.001801802 |
| 415 | 112450 | 1.012151215 | 0.012077982 |
| 416 | 117500 | 1.044908848 | 0.043929655 |
| 417 | 113000 | 0.961702128 | -0.039050515 |
| 418 | 113000 | 1 | 0 |
| 419 | 113000 | 1 | 0 |
| 420 | 113000 | 1 | 0 |
| 421 | 118400 | 1.047787611 | 0.046680904 |
| 422 | 118400 | 1 | 0 |
| 423 | 119250 | 1.007179054 | 0.007153407 |
| 424 | 119500 | 1.002096436 | 0.002094242 |
| 425 | 124250 | 1.039748954 | 0.038979294 |
| 426 | 124250 | 1 | 0 |
| 427 | 122500 | 0.985915493 | -0.014184635 |
| 428 | 122500 | 1 | 0 |
| 429 | 125100 | 1.02122449 | 0.021002387 |
| 430 | 125100 | 1 | 0 |
| 431 | 124300 | 0.993605116 | -0.006415419 |
| 432 | 124300 | 1 | 0 |
| 433 | 124300 | 1 | 0 |
| 434 | 124300 | 1 | 0 |
| 435 | 124300 | 1 | 0 |
| 436 | 124300 | 1 | 0 |
| 437 | 124300 | 1 | 0 |
| 438 | 124300 | 1 | 0 |
| 439 | 124300 | 1 | 0 |
| 440 | 124300 | 1 | 0 |
| 441 | 124400 | 1.000804505 | 0.000804182 |
| 442 | 124500 | 1.000803859 | 0.000803536 |
| 443 | 124850 | 1.002811245 | 0.002807301 |
| 444 | 124850 | 1 | 0 |
| 445 | 124850 | 1 | 0 |
| 446 | 124850 | 1 | 0 |
| 447 | 123500 | 0.989187024 | -0.010871861 |

| | | | |
|---|---|---|---|
| 448 | 123550 | 1.000404858 | 0.000404776 |
| 449 | 126175 | 1.021246459 | 0.0210239 |
| 450 | 126550 | 1.002972063 | 0.002967655 |
| 451 | 127250 | 1.005531411 | 0.005516168 |
| 452 | 127250 | 1 | 0 |
| 453 | 128750 | 1.011787819 | 0.011718884 |
| 454 | 128700 | 0.99961165 | -0.000388425 |
| 455 | 128950 | 1.001942502 | 0.001940618 |
| 456 | 130900 | 1.01512214 | 0.015008941 |
| 457 | 130900 | 1 | 0 |
| 458 | 130900 | 1 | 0 |
| 459 | 134050 | 1.024064171 | 0.023779192 |
| 460 | 132250 | 0.986572175 | -0.013518794 |
| 461 | 132300 | 1.000378072 | 0.000378 |
| 462 | 133000 | 1.005291005 | 0.005277057 |
| 463 | 137450 | 1.033458647 | 0.032911086 |
| 464 | 135200 | 0.983630411 | -0.016505051 |
| 465 | 138250 | 1.022559172 | 0.022308477 |
| 466 | 138350 | 1.000723327 | 0.000723066 |
| 467 | 142250 | 1.028189375 | 0.027799367 |
| 468 | 142250 | 1 | 0 |
| 469 | 140950 | 0.99086116 | -0.009180855 |
| 470 | 140950 | 1 | 0 |
| 471 | 143400 | 1.01738205 | 0.017232711 |
| 472 | 141750 | 0.988493724 | -0.011572986 |
| 473 | 143500 | 1.012345679 | 0.012270093 |
| 474 | 142400 | 0.992334495 | -0.007695036 |
| 475 | 143250 | 1.005969101 | 0.005951357 |
| 476 | 143250 | 1 | 0 |
| 477 | 143250 | 1 | 0 |
| 478 | 142400 | 0.994066318 | -0.005951357 |
| 479 | 142600 | 1.001404494 | 0.001403509 |
| 480 | 142300 | 0.997896213 | -0.002106003 |
| 481 | 143950 | 1.011595221 | 0.011528512 |
| 482 | 143950 | 1 | 0 |
| 483 | 143750 | 0.998610629 | -0.001390337 |
| 484 | 145050 | 1.009043478 | 0.009002831 |
| 485 | 145200 | 1.001034126 | 0.001033592 |
| 486 | 145750 | 1.003787879 | 0.003780723 |
| 487 | 150450 | 1.032246998 | 0.031737978 |
| 488 | 150450 | 1 | 0 |
| 489 | 152250 | 1.011964108 | 0.011893104 |
| 490 | 151250 | 0.993431856 | -0.00658981 |
| 491 | 150250 | 0.99338843 | -0.006633523 |
| 492 | 149500 | 0.995008319 | -0.005004181 |
| 493 | 147250 | 0.984949833 | -0.01516457 |
| 494 | 147250 | 1 | 0 |
| 495 | 143250 | 0.972835314 | -0.027540467 |
| 496 | 143550 | 1.002094241 | 0.002092051 |
| 497 | 143850 | 1.002089864 | 0.002087683 |
| 498 | 143850 | 1 | 0 |
| 499 | 140250 | 0.974973931 | -0.025344546 |
| 500 | 140250 | 1 | 0 |
| 501 | 141500 | 1.008912656 | 0.008873173 |
| 502 | 141050 | 0.996819788 | -0.00318528 |
| 503 | 141450 | 1.002835874 | 0.00283186 |

| | | | |
|---|---|---|---|
| 504 | 141750 | 1.002120891 | 0.002118645 |
| 505 | 141750 | 1 | 0 |
| 506 | 141750 | 1 | 0 |
| 507 | 142950 | 1.008465608 | 0.008429976 |
| 508 | 142850 | 0.999300455 | -0.00069979 |
| 509 | 142750 | 0.999299965 | -0.00070028 |
| 510 | 143050 | 1.002101576 | 0.002099371 |
| 511 | 141900 | 0.991960853 | -0.008071635 |
| 512 | 141900 | 1 | 0 |
| 513 | 142650 | 1.005285412 | 0.005271493 |
| 514 | 142450 | 0.998597967 | -0.001403017 |
| 515 | 144075 | 1.011407511 | 0.011342936 |
| 516 | 142450 | 0.988721152 | -0.011342936 |
| 517 | 140650 | 0.987363987 | -0.012716526 |
| 518 | 140650 | 1 | 0 |
| 519 | 140050 | 0.995734092 | -0.004275033 |
| 520 | 139750 | 0.997857908 | -0.00214439 |
| 521 | 135850 | 0.972093023 | -0.028303776 |
| 522 | 135750 | 0.999263894 | -0.000736377 |
| 523 | 136750 | 1.007366483 | 0.007339482 |
| 524 | 136750 | 1 | 0 |
| 525 | 133550 | 0.976599634 | -0.023678502 |
| 526 | 132150 | 0.989517035 | -0.010538299 |
| 527 | 133600 | 1.01097238 | 0.01091262 |
| 528 | 134850 | 1.009356287 | 0.009312788 |
| 529 | 136550 | 1.0126066 | 0.012527798 |
| 530 | 136550 | 1 | 0 |
| 531 | 137650 | 1.008055657 | 0.008023384 |
| 532 | 137450 | 0.99854704 | -0.001454017 |
| 533 | 139450 | 1.014550746 | 0.014445899 |
| 534 | 139450 | 1 | 0 |
| 535 | 141850 | 1.01721047 | 0.017064047 |
| 536 | 141850 | 1 | 0 |
| 537 | 141250 | 0.99577018 | -0.004238791 |
| 538 | 140050 | 0.991504425 | -0.008531868 |
| 539 | 139750 | 0.997857908 | -0.00214439 |
| | | | |

# APPENDIX C


PERIOD II
Ln(Pt/Pt-1)
0.08
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
-0.08
-0.1
1
7
13
19
25
31
37
43
49
55
61
67
73
79
85
91
97
103
109
115
121
127
133
TIME

PERIOD II

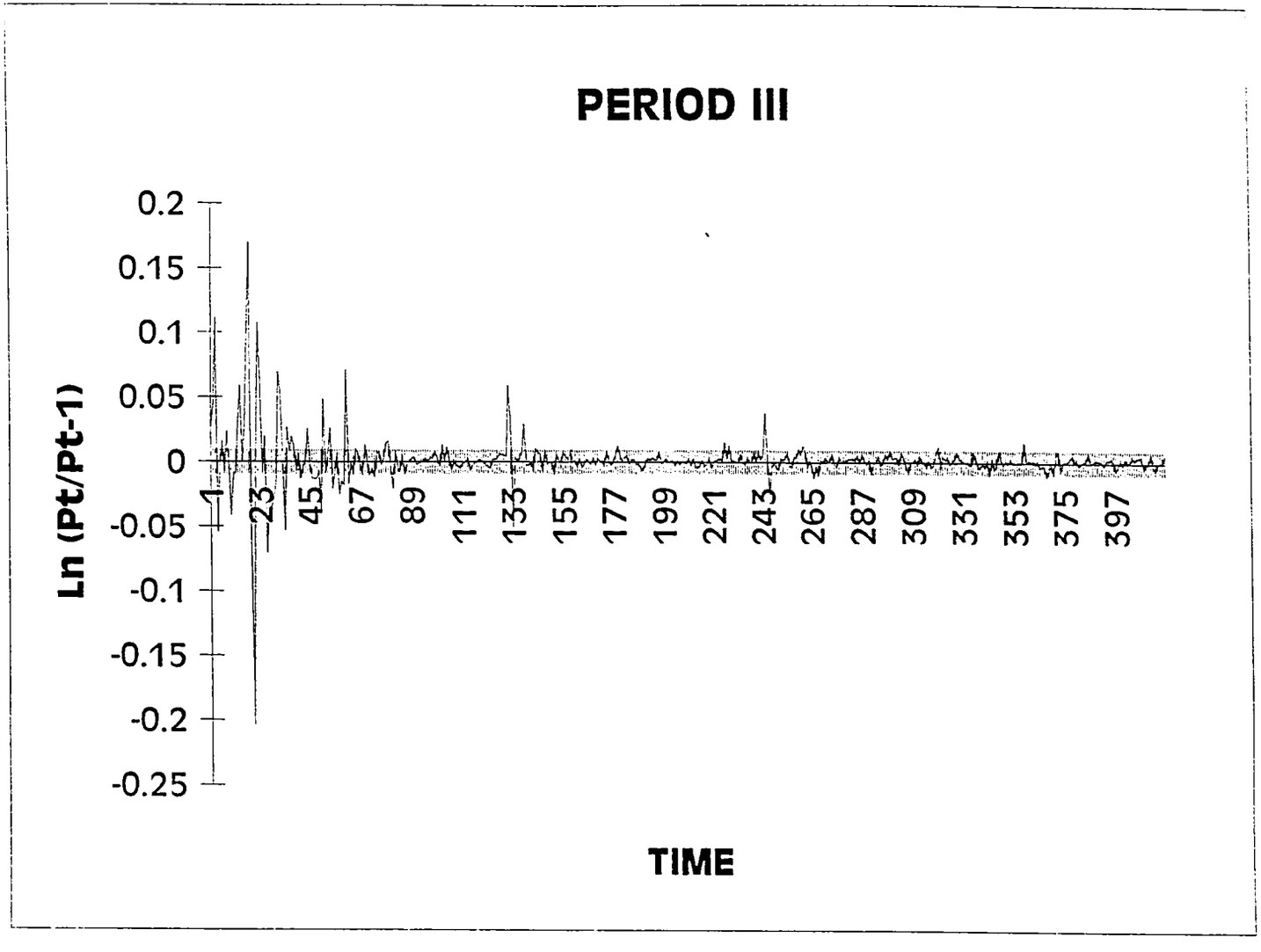
| TIME | PRICE | Pt/Pt-1 | Ln (Pt/Pt-1) |
|---|---|---|---|
| 1 | 139250 | | |
| 2 | 141250 | 1.014362657 | 0.014260491 |
| 3 | 139250 | 0.985840708 | -0.014260491 |
| 4 | 141950 | 1.019389587 | 0.019204004 |
| 5 | 141550 | 0.997182106 | -0.002821871 |
| 6 | 142050 | 1.003532321 | 0.003526097 |
| 7 | 143050 | 1.007039775 | 0.007015111 |
| 8 | 144050 | 1.006990563 | 0.006966242 |
| 9 | 142050 | 0.986115932 | -0.013981353 |
| 10 | 144750 | 1.019007392 | 0.018829008 |
| 11 | 144550 | 0.998618307 | -0.001382648 |
| 12 | 147450 | 1.020062262 | 0.019863667 |
| 13 | 147750 | 1.002034588 | 0.002032521 |
| 14 | 148750 | 1.00676819 | 0.006745388 |
| 15 | 148750 | 1 | 0 |
| 16 | 149850 | 1.007394958 | 0.007367749 |
| 17 | 152850 | 1.02002002 | 0.019822255 |
| 18 | 153950 | 1.007196598 | 0.007170826 |
| 19 | 155350 | 1.009093862 | 0.009052761 |
| 20 | 156850 | 1.009655616 | 0.009609299 |
| 21 | 156850 | 1 | 0 |
| 22 | 157450 | 1.003825311 | 0.003818013 |
| 23 | 156750 | 0.995554144 | -0.004455768 |
| 24 | 156850 | 1.000637959 | 0.000637755 |
| 25 | 157050 | 1.001275104 | 0.001274291 |
| 26 | 157050 | 1 | 0 |
| 27 | 157050 | 1 | 0 |
| 28 | 157050 | 1 | 0 |
| 29 | 159550 | 1.015918497 | 0.015793127 |
| 30 | 158150 | 0.991225321 | -0.008813403 |
| 31 | 157850 | 0.998103067 | -0.001898735 |
| 32 | 161250 | 1.021539436 | 0.021310741 |
| 33 | 163000 | 1.010852713 | 0.010794245 |
| 34 | 163750 | 1.004601227 | 0.004590674 |
| 35 | 162850 | 0.994503817 | -0.005511343 |
| 36 | 163050 | 1.001228124 | 0.001227371 |
| 37 | 164250 | 1.007359706 | 0.007332755 |
| 38 | 164950 | 1.004261796 | 0.00425274 |
| 39 | 163500 | 0.991209457 | -0.008829407 |
| 40 | 163500 | 1 | 0 |
| 41 | 164550 | 1.006422018 | 0.006401485 |
| 42 | 165650 | 1.006684898 | 0.006662653 |
| 43 | 165750 | 1.000603682 | 0.0006035 |
| 44 | 167050 | 1.007843137 | 0.00781254 |
| 45 | 167050 | 1 | 0 |
| 46 | 167750 | 1.004190362 | 0.004181607 |
| 47 | 168050 | 1.001788376 | 0.001786778 |
| 48 | 168150 | 1.000595061 | 0.000594884 |
| 49 | 168750 | 1.003568243 | 0.003561892 |
| 50 | 168950 | 1.001185185 | 0.001184483 |
| 51 | 169250 | 1.001775673 | 0.001774099 |
| 52 | 167150 | 0.987592319 | -0.012485299 |
| 53 | 167400 | 1.001495663 | 0.001494545 |
| 54 | 168250 | 1.005077658 | 0.00506481 |
| 55 | 170250 | 1.011887073 | 0.011816977 |
| 56 | 174250 | 1.02349486 | 0.023223105 |
| 57 | 173750 | 0.99713056 | -0.002873565 |
| 58 | 173050 | 0.995971223 | -0.004036914 |
| 59 | 172750 | 0.998266397 | -0.001735107 |

| | | | |
|---|---|---|---|
| 60 | 175250 | 1.01447178 | 0.014368063 |
| 61 | 177050 | 1.010271041 | 0.010218653 |
| 62 | 174750 | 0.987009319 | -0.013075797 |
| 63 | 174750 | 1 | 0 |
| 64 | 177050 | 1.01316166 | 0.013075797 |
| 65 | 178375 | 1.007483762 | 0.007455897 |
| 66 | 178550 | 1.000981079 | 0.000980598 |
| 67 | 179750 | 1.006720806 | 0.006698323 |
| 68 | 178750 | 0.994436718 | -0.005578815 |
| 69 | 178750 | 1 | 0 |
| 70 | 180950 | 1.012307692 | 0.012232568 |
| 71 | 180550 | 0.997789445 | -0.002213002 |
| 72 | 180850 | 1.00166159 | 0.001660211 |
| 73 | 179950 | 0.9950235 | -0.004988924 |
| 74 | 180000 | 1.000277855 | 0.000277816 |
| 75 | 180250 | 1.001388889 | 0.001387925 |
| 76 | 180250 | 1 | 0 |
| 77 | 181000 | 1.004160888 | 0.004152255 |
| 78 | 180850 | 0.999171271 | -0.000829073 |
| 79 | 181750 | 1.0049765 | 0.004964158 |
| 80 | 183750 | 1.011004127 | 0.010944022 |
| 81 | 183750 | 1 | 0 |
| 82 | 187550 | 1.020680272 | 0.020469338 |
| 83 | 191250 | 1.019728073 | 0.019535996 |
| 84 | 191950 | 1.003660131 | 0.003653449 |
| 85 | 188750 | 0.983328992 | -0.016811533 |
| 86 | 189450 | 1.003708609 | 0.003701749 |
| 87 | 188750 | 0.996305094 | -0.003701749 |
| 88 | 189500 | 1.00397351 | 0.003965636 |
| 89 | 190550 | 1.005540897 | 0.005525603 |
| 90 | 193650 | 1.016268696 | 0.016137779 |
| 91 | 197750 | 1.021172218 | 0.020951201 |
| 92 | 196600 | 0.994184576 | -0.005832399 |
| 93 | 201500 | 1.024923703 | 0.024618174 |
| 94 | 205050 | 1.017617866 | 0.01746447 |
| 95 | 215500 | 1.05096318 | 0.049707058 |
| 96 | 229000 | 1.062645012 | 0.060761094 |
| 97 | 208500 | 0.910480349 | -0.093782962 |
| 98 | 205000 | 0.983213429 | -0.016929062 |
| 99 | 203500 | 0.992682927 | -0.007343974 |
| 100 | 201800 | 0.991646192 | -0.008388897 |
| 101 | 212600 | 1.053518335 | 0.052135358 |
| 102 | 212000 | 0.997177799 | -0.002826191 |
| 103 | 218500 | 1.030660377 | 0.03019974 |
| 104 | 211000 | 0.965675057 | -0.034927881 |
| 105 | 212000 | 1.004739336 | 0.004728141 |
| 106 | 210750 | 0.994103774 | -0.005913678 |
| 107 | 213250 | 1.011862396 | 0.011792589 |
| 108 | 217000 | 1.017584994 | 0.017432167 |
| 109 | 218000 | 1.004608295 | 0.004597709 |
| 110 | 222250 | 1.019495413 | 0.019307812 |
| 111 | 223750 | 1.006749156 | 0.006726483 |
| 112 | 223600 | 0.999329609 | -0.000670616 |
| 113 | 229000 | 1.024150268 | 0.023863262 |
| 114 | 230500 | 1.006550218 | 0.006528859 |
| 115 | 233000 | 1.010845987 | 0.010787591 |
| 116 | 232000 | 0.995708155 | -0.004301082 |
| 117 | 228000 | 0.982758621 | -0.017391743 |
| 118 | 226500 | 0.993421053 | -0.006600684 |
| 119 | 228500 | 1.008830022 | 0.008791265 |

PERIOD II

| | | | |
|---|---|---|---|
| 120 | 230200 | 1.007439825 | 0.007412286 |
| 121 | 227500 | 0.988271069 | -0.011798258 |
| 122 | 227500 | 1 | 0 |
| 123 | 226500 | 0.995604396 | -0.004405293 |
| 124 | 231500 | 1.022075055 | 0.021834929 |
| 125 | 231500 | 1 | 0 |
| 126 | 233500 | 1.008639309 | 0.008602204 |
| 127 | 232500 | 0.995717345 | -0.004291852 |
| 128 | 232500 | 1 | 0 |
| 129 | 236500 | 1.017204301 | 0.017057983 |
| 130 | 251000 | 1.061310782 | 0.059504731 |
| 131 | 254000 | 1.011952191 | 0.011881328 |
| 132 | 256000 | 1.007874016 | 0.007843177 |
| 133 | 256000 | 1 | 0 |
| 134 | 260750 | 1.018554688 | 0.018384649 |
| 135 | 261750 | 1.003835091 | 0.003827756 |
| 136 | 265000 | 1.012416428 | 0.012339976 |
| 137 | 269750 | 1.017924528 | 0.017765778 |
| 138 | 271000 | 1.00463392 | 0.004623217 |
| 139 | 271000 | 1 | 0 |

# APPENDIX D


PERIOD III
Ln (Pt/Pt-1)
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
-0.25
1
23
45
67
89
111
133
155
177
199
221
243
265
287
309
331
353
375
397
TIME

PERIOD III

| TIME | PRICE | Pt/Pt-1 | LN ( Pt/Pt-1) |
|---|---|---|---|
| 1 | 275000 | | |
| 2 | 282500 | 1.027272727 | 0.026907453 |
| 3 | 295250 | 1.045132743 | 0.044143904 |
| 4 | 330000 | 1.117696867 | 0.111270199 |
| 5 | 312500 | 0.946969697 | -0.054488185 |
| 6 | 311500 | 0.9968 | -0.003205131 |
| 7 | 316500 | 1.016051364 | 0.015923903 |
| 8 | 313500 | 0.990521327 | -0.009523882 |
| 9 | 321000 | 1.023923445 | 0.023641763 |
| 10 | 321000 | 1 | 0 |
| 11 | 308000 | 0.959501558 | -0.04134134 |
| 12 | 305000 | 0.99025974 | -0.009788006 |
| 13 | 302500 | 0.991803279 | -0.008230499 |
| 14 | 312000 | 1.031404959 | 0.03092191 |
| 15 | 331000 | 1.060897436 | 0.059115188 |
| 16 | 331000 | 1 | 0 |
| 17 | 340000 | 1.027190332 | 0.026827242 |
| 18 | 375500 | 1.104411765 | 0.099312854 |
| 19 | 445000 | 1.185086551 | 0.169815811 |
| 20 | 417500 | 0.938202247 | -0.063789738 |
| 21 | 340500 | 0.815568862 | -0.203869419 |
| 22 | 340500 | 1 | 0 |
| 23 | 379500 | 1.114537445 | 0.108439471 |
| 24 | 405000 | 1.067193676 | 0.06503247 |
| 25 | 401500 | 0.991358025 | -0.008679534 |
| 26 | 409500 | 1.01992528 | 0.01972937 |
| 27 | 381500 | 0.931623932 | -0.070826053 |
| 28 | 367500 | 0.963302752 | -0.037387532 |
| 29 | 355000 | 0.965986395 | -0.034605529 |
| 30 | 345000 | 0.971830986 | -0.028573372 |
| 31 | 340500 | 0.986956522 | -0.013129291 |
| 32 | 365000 | 1.07195301 | 0.069482228 |
| 33 | 385000 | 1.054794521 | 0.053345981 |
| 34 | 385000 | 1 | 0 |
| 35 | 365000 | 0.948051948 | -0.053345981 |
| 36 | 375000 | 1.02739726 | 0.027028672 |
| 37 | 378000 | 1.008 | 0.00796817 |
| 38 | 385500 | 1.01984127 | 0.019646997 |
| 39 | 390000 | 1.011673152 | 0.011605546 |
| 40 | 387500 | 0.993589744 | -0.00643089 |
| 41 | 390000 | 1.006451613 | 0.00643089 |
| 42 | 385000 | 0.987179487 | -0.012903405 |
| 43 | 383500 | 0.996103896 | -0.003903713 |
| 44 | 383500 | 1 | 0 |
| 45 | 393500 | 1.026075619 | 0.025741447 |
| 46 | 392500 | 0.997458704 | -0.002544531 |
| 47 | 387500 | 0.987261146 | -0.012820688 |
| 48 | 382500 | 0.987096774 | -0.012987196 |
| 49 | 377500 | 0.986928105 | -0.013158085 |
| 50 | 374500 | 0.99205298 | -0.007978766 |
| 51 | 361000 | 0.963951936 | -0.036713845 |
| 52 | 379000 | 1.049861496 | 0.048658247 |
| 53 | 375500 | 0.990765172 | -0.009277734 |
| 54 | 377500 | 1.005326232 | 0.005312097 |
| 55 | 387500 | 1.026490066 | 0.02614528 |

PERIOD III

| | | | |
|---|---|---|---|
| 56 | 379500 | 0.979354839 | -0.020861252 |
| 57 | 376500 | 0.992094862 | -0.00793655 |
| 58 | 379000 | 1.006640106 | 0.006618158 |
| 59 | 369500 | 0.974934037 | -0.025385465 |
| 60 | 364000 | 0.98511502 | -0.014996873 |
| 61 | 357500 | 0.982142857 | -0.018018506 |
| 62 | 384000 | 1.074125874 | 0.07150719 |
| 63 | 377500 | 0.983072917 | -0.017071984 |
| 64 | 377500 | 1 | 0 |
| 65 | 373500 | 0.989403974 | -0.010652564 |
| 66 | 377500 | 1.010709505 | 0.010652564 |
| 67 | 380000 | 1.006622517 | 0.006600684 |
| 68 | 379500 | 0.998684211 | -0.001316656 |
| 69 | 375500 | 0.989459816 | -0.010596126 |
| 70 | 380500 | 1.013315579 | 0.013227706 |
| 71 | 380000 | 0.99868594 | -0.001314925 |
| 72 | 376000 | 0.989473684 | -0.010582109 |
| 73 | 374000 | 0.994680851 | -0.005333346 |
| 74 | 369500 | 0.987967914 | -0.012105057 |
| 75 | 372000 | 1.0067659 | 0.006743114 |
| 76 | 375000 | 1.008064516 | 0.008032172 |
| 77 | 374000 | 0.997333333 | -0.002670229 |
| 78 | 375000 | 1.002673797 | 0.002670229 |
| 79 | 380500 | 1.014666667 | 0.014560151 |
| 80 | 386500 | 1.015768725 | 0.015645691 |
| 81 | 385000 | 0.996119017 | -0.003888534 |
| 82 | 377000 | 0.979220779 | -0.020998147 |
| 83 | 380500 | 1.00928382 | 0.00924099 |
| 84 | 378500 | 0.994743758 | -0.005270104 |
| 85 | 375500 | 0.992073976 | -0.007957602 |
| 86 | 377500 | 1.005326232 | 0.005312097 |
| 87 | 373500 | 0.989403974 | -0.010652564 |
| 88 | 373500 | 1 | 0 |
| 89 | 373500 | 1 | 0 |
| 90 | 374500 | 1.002677376 | 0.002673798 |
| 91 | 376000 | 1.00400534 | 0.00399734 |
| 92 | 375350 | 0.998271277 | -0.001730219 |
| 93 | 375000 | 0.999067537 | -0.000932898 |
| 94 | 375000 | 1 | 0 |
| 95 | 375000 | 1 | 0 |
| 96 | 376000 | 1.002666667 | 0.002663117 |
| 97 | 376000 | 1 | 0 |
| 98 | 377250 | 1.003324468 | 0.003318954 |
| 99 | 378375 | 1.002982107 | 0.00297767 |
| 100 | 381500 | 1.008259002 | 0.008225083 |
| 101 | 382200 | 1.001834862 | 0.001833181 |
| 102 | 381000 | 0.996860283 | -0.003144657 |
| 103 | 386000 | 1.01312336 | 0.013037994 |
| 104 | 386000 | 1 | 0 |
| 105 | 390500 | 1.011658031 | 0.0115906 |
| 106 | 391000 | 1.00128041 | 0.001279591 |
| 107 | 388500 | 0.993606138 | -0.00641439 |
| 108 | 388500 | 1 | 0 |
| 109 | 387750 | 0.998069498 | -0.001932368 |
| 110 | 386325 | 0.996324952 | -0.003681818 |
| 111 | 384500 | 0.995275998 | -0.004735195 |

PERIOD III

| | | | |
|---|---|---|---|
| 112 | 384250 | 0.999349805 | -0.000650407 |
| 113 | 384000 | 0.999349382 | -0.00065083 |
| 114 | 385000 | 1.002604167 | 0.002600782 |
| 115 | 382500 | 0.993506494 | -0.006514681 |
| 116 | 381000 | 0.996078431 | -0.003929278 |
| 117 | 381000 | 1 | 0 |
| 118 | 380800 | 0.999475066 | -0.000525072 |
| 119 | 381500 | 1.001838235 | 0.001836548 |
| 120 | 381900 | 1.001048493 | 0.001047944 |
| 121 | 382000 | 1.000261849 | 0.000261814 |
| 122 | 381000 | 0.997382199 | -0.002621233 |
| 123 | 379750 | 0.99671916 | -0.003286234 |
| 124 | 377850 | 0.994996708 | -0.00501585 |
| 125 | 378500 | 1.001720259 | 0.001718781 |
| 126 | 379250 | 1.001981506 | 0.001979545 |
| 127 | 380200 | 1.002504944 | 0.002501812 |
| 128 | 382600 | 1.006312467 | 0.006292627 |
| 129 | 385000 | 1.00627287 | 0.006253277 |
| 130 | 387000 | 1.005194805 | 0.005181359 |
| 131 | 388700 | 1.004392765 | 0.004383145 |
| 132 | 412500 | 1.06122974 | 0.059428368 |
| 133 | 426000 | 1.032727273 | 0.03220314 |
| 134 | 405000 | 0.950704225 | -0.050552279 |
| 135 | 406500 | 1.003703704 | 0.003696862 |
| 136 | 406500 | 1 | 0 |
| 137 | 408000 | 1.003690037 | 0.003683245 |
| 138 | 411250 | 1.007965686 | 0.007934128 |
| 139 | 423500 | 1.029787234 | 0.029352212 |
| 140 | 422500 | 0.997638725 | -0.002364067 |
| 141 | 421500 | 0.997633136 | -0.002369669 |
| 142 | 421500 | 1 | 0 |
| 143 | 418500 | 0.992882562 | -0.007142888 |
| 144 | 423000 | 1.010752688 | 0.010695289 |
| 145 | 426000 | 1.007092199 | 0.007067167 |
| 146 | 428625 | 1.006161972 | 0.006143065 |
| 147 | 425000 | 0.991542724 | -0.008493242 |
| 148 | 428625 | 1.008529412 | 0.008493242 |
| 149 | 428000 | 0.998541849 | -0.001459215 |
| 150 | 428000 | 1 | 0 |
| 151 | 427750 | 0.999415888 | -0.000584283 |
| 152 | 423500 | 0.99006429 | -0.009985399 |
| 153 | 426250 | 1.006493506 | 0.006472515 |
| 154 | 426500 | 1.00058651 | 0.000586338 |
| 155 | 426500 | 1 | 0 |
| 156 | 429500 | 1.007033998 | 0.007009374 |
| 157 | 431500 | 1.004656577 | 0.004645769 |
| 158 | 432300 | 1.001853998 | 0.001852281 |
| 159 | 435500 | 1.007402267 | 0.007375005 |
| 160 | 435500 | 1 | 0 |
| 161 | 436000 | 1.001148106 | 0.001147447 |
| 162 | 434250 | 0.995986239 | -0.004021838 |
| 163 | 435500 | 1.002878526 | 0.002874391 |
| 164 | 433750 | 0.99598163 | -0.004026465 |
| 165 | 433000 | 0.998270893 | -0.001730603 |
| 166 | 434000 | 1.002309469 | 0.002306806 |
| 167 | 434000 | 1 | 0 |

PERIOD III

| | | | |
|---|---|---|---|
| 168 | 433250 | 0.998271889 | -0.001729606 |
| 169 | 434500 | 1.00288517 | 0.002881016 |
| 170 | 433250 | 0.99712313 | -0.002881016 |
| 171 | 434500 | 1.00288517 | 0.002881016 |
| 172 | 434750 | 1.000575374 | 0.000575209 |
| 173 | 435000 | 1.000575043 | 0.000574878 |
| 174 | 433650 | 0.996896552 | -0.003108274 |
| 175 | 437250 | 1.008301626 | 0.008267357 |
| 176 | 437500 | 1.000571755 | 0.000571592 |
| 177 | 436500 | 0.997714286 | -0.002288331 |
| 178 | 436500 | 1 | 0 |
| 179 | 439000 | 1.005727377 | 0.005711038 |
| 180 | 444500 | 1.012528474 | 0.012450642 |
| 181 | 446500 | 1.004499438 | 0.004489345 |
| 182 | 446500 | 1 | 0 |
| 183 | 448000 | 1.003359462 | 0.003353832 |
| 184 | 450250 | 1.005022321 | 0.005009752 |
| 185 | 449500 | 0.998334259 | -0.00166713 |
| 186 | 450000 | 1.001112347 | 0.001111729 |
| 187 | 451000 | 1.002222222 | 0.002219757 |
| 188 | 450125 | 0.998059867 | -0.001942018 |
| 189 | 449500 | 0.998611497 | -0.001389468 |
| 190 | 447200 | 0.994883204 | -0.005129932 |
| 191 | 444125 | 0.993123882 | -0.006899867 |
| 192 | 444000 | 0.999718548 | -0.000281492 |
| 193 | 445250 | 1.002815315 | 0.00281136 |
| 194 | 445750 | 1.001122965 | 0.001122335 |
| 195 | 447250 | 1.003365115 | 0.003359466 |
| 196 | 448000 | 1.001676914 | 0.00167551 |
| 197 | 448750 | 1.001674107 | 0.001672707 |
| 198 | 452250 | 1.007799443 | 0.007769184 |
| 199 | 451750 | 0.998894417 | -0.001106195 |
| 200 | 451750 | 1 | 0 |
| 201 | 453000 | 1.002767017 | 0.002763196 |
| 202 | 453000 | 1 | 0 |
| 203 | 453250 | 1.000551876 | 0.000551724 |
| 204 | 453750 | 1.001103144 | 0.001102536 |
| 205 | 452250 | 0.996694215 | -0.003311261 |
| 206 | 452750 | 1.001105583 | 0.001104972 |
| 207 | 451750 | 0.997791276 | -0.002211167 |
| 208 | 452000 | 1.000553403 | 0.00055325 |
| 209 | 452000 | 1 | 0 |
| 210 | 451500 | 0.998893805 | -0.001106807 |
| 211 | 453000 | 1.003322259 | 0.003316753 |
| 212 | 451500 | 0.996688742 | -0.003316753 |
| 213 | 452750 | 1.002768549 | 0.002764724 |
| 214 | 451100 | 0.996355605 | -0.003651052 |
| 215 | 449100 | 0.995566393 | -0.004443464 |
| 216 | 448000 | 0.997550657 | -0.002452348 |
| 217 | 448750 | 1.001674107 | 0.001672707 |
| 218 | 447250 | 0.996657382 | -0.003348217 |
| 219 | 446500 | 0.998323086 | -0.001678322 |
| 220 | 447825 | 1.002967525 | 0.002963131 |
| 221 | 445500 | 0.99480824 | -0.005205284 |
| 222 | 445500 | 1 | 0 |
| 223 | 446000 | 1.001122334 | 0.001121705 |

PERIOD III

| | | | |
|---|---|---|---|
| 224 | 446750 | 1.001681614 | 0.001680202 |
| 225 | 448000 | 1.002797985 | 0.002794078 |
| 226 | 448500 | 1.001116071 | 0.001115449 |
| 227 | 455500 | 1.015607581 | 0.015487035 |
| 228 | 456500 | 1.00219539 | 0.002192983 |
| 229 | 462500 | 1.013143483 | 0.013057857 |
| 230 | 463000 | 1.001081081 | 0.001080497 |
| 231 | 463500 | 1.001079914 | 0.001079331 |
| 232 | 463625 | 1.000269687 | 0.000269651 |
| 233 | 463375 | 0.999460771 | -0.000539374 |
| 234 | 466250 | 1.006204478 | 0.006185309 |
| 235 | 466500 | 1.000536193 | 0.000536049 |
| 236 | 465500 | 0.997856377 | -0.002145924 |
| 237 | 467000 | 1.003222342 | 0.003217161 |
| 238 | 467000 | 1 | 0 |
| 239 | 467000 | 1 | 0 |
| 240 | 470500 | 1.007494647 | 0.007466701 |
| 241 | 470500 | 1 | 0 |
| 242 | 474000 | 1.007438895 | 0.007411363 |
| 243 | 475000 | 1.002109705 | 0.002107482 |
| 244 | 478000 | 1.006315789 | 0.006295928 |
| 245 | 496500 | 1.038702929 | 0.037972751 |
| 246 | 499000 | 1.005035247 | 0.005022612 |
| 247 | 486500 | 0.9749499 | -0.025369194 |
| 248 | 484500 | 0.995889003 | -0.00411947 |
| 249 | 484500 | 1 | 0 |
| 250 | 482500 | 0.995872033 | -0.004136511 |
| 251 | 479875 | 0.994559585 | -0.005455267 |
| 252 | 481000 | 1.002344361 | 0.002341617 |
| 253 | 481750 | 1.001559252 | 0.001558037 |
| 254 | 483500 | 1.00363259 | 0.003626008 |
| 255 | 487000 | 1.007238883 | 0.007212808 |
| 256 | 485750 | 0.997433265 | -0.002570035 |
| 257 | 484000 | 0.996397324 | -0.003609182 |
| 258 | 486000 | 1.004132231 | 0.004123717 |
| 259 | 487825 | 1.003755144 | 0.003748111 |
| 260 | 493000 | 1.010608312 | 0.010552439 |
| 261 | 495750 | 1.005578093 | 0.005562593 |
| 262 | 502125 | 1.012859304 | 0.012777325 |
| 263 | 506000 | 1.007717202 | 0.007687577 |
| 264 | 504000 | 0.996047431 | -0.003960401 |
| 265 | 504750 | 1.001488095 | 0.001486989 |
| 266 | 503000 | 0.996532937 | -0.003473087 |
| 267 | 496875 | 0.987823062 | -0.012251685 |
| 268 | 495250 | 0.99672956 | -0.0032758 |
| 269 | 490000 | 0.989399293 | -0.010657294 |
| 270 | 490750 | 1.001530612 | 0.001529442 |
| 271 | 490500 | 0.999490576 | -0.000509554 |
| 272 | 492250 | 1.003567788 | 0.003561439 |
| 273 | 492750 | 1.001015744 | 0.001015229 |
| 274 | 493000 | 1.000507357 | 0.000507228 |
| 275 | 496000 | 1.006085193 | 0.006066753 |
| 276 | 495750 | 0.999495968 | -0.000504159 |
| 277 | 493750 | 0.995965709 | -0.004042451 |
| 278 | 495750 | 1.004050633 | 0.004042451 |
| 279 | 495750 | 1 | 0 |

PERIOD III

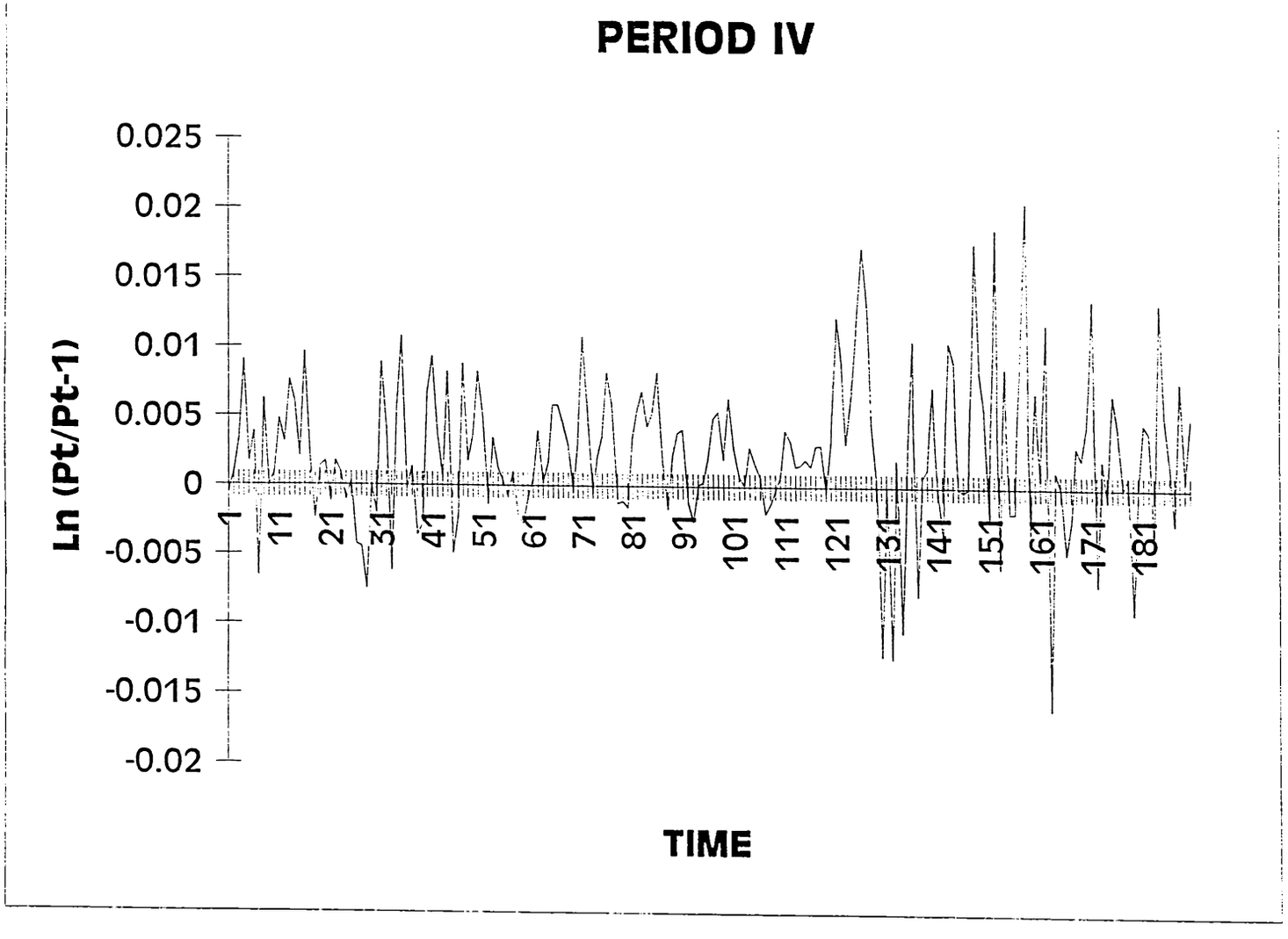
| | | | |
|---|---|---|---|
| 280 | 496250 | 1.001008573 | 0.001008065 |
| 281 | 496400 | 1.000302267 | 0.000302221 |
| 282 | 497750 | 1.002719581 | 0.00271589 |
| 283 | 499050 | 1.002611753 | 0.002608348 |
| 284 | 500500 | 1.00290552 | 0.002901308 |
| 285 | 501250 | 1.001498501 | 0.00149738 |
| 286 | 504000 | 1.005486284 | 0.005471289 |
| 287 | 503500 | 0.999007937 | -0.000992556 |
| 288 | 506750 | 1.006454816 | 0.006434073 |
| 289 | 507500 | 1.00148002 | 0.001478926 |
| 290 | 506750 | 0.998522167 | -0.001478926 |
| 291 | 507750 | 1.00197336 | 0.001971415 |
| 292 | 503250 | 0.991137371 | -0.008902136 |
| 293 | 502750 | 0.999006458 | -0.000994036 |
| 294 | 502750 | 1 | 0 |
| 295 | 505250 | 1.00497265 | 0.004960328 |
| 296 | 504000 | 0.997525977 | -0.002477088 |
| 297 | 504000 | 1 | 0 |
| 298 | 507250 | 1.006448413 | 0.006427711 |
| 299 | 508250 | 1.001971414 | 0.001969474 |
| 300 | 512850 | 1.009050664 | 0.009009952 |
| 301 | 514250 | 1.002729843 | 0.002726124 |
| 302 | 516250 | 1.003889159 | 0.003881616 |
| 303 | 518250 | 1.003874092 | 0.003866607 |
| 304 | 517250 | 0.998070429 | -0.001931435 |
| 305 | 520750 | 1.006766554 | 0.006743764 |
| 306 | 522750 | 1.003840614 | 0.003833258 |
| 307 | 521250 | 0.99713056 | -0.002873565 |
| 308 | 517000 | 0.991846523 | -0.008186899 |
| 309 | 517250 | 1.000483559 | 0.000483442 |
| 310 | 517250 | 1 | 0 |
| 311 | 518650 | 1.002706622 | 0.002702965 |
| 312 | 517750 | 0.998264726 | -0.001736782 |
| 313 | 520250 | 1.004828585 | 0.004816965 |
| 314 | 520250 | 1 | 0 |
| 315 | 520250 | 1 | 0 |
| 316 | 518250 | 0.996155694 | -0.003851714 |
| 317 | 519250 | 1.001929571 | 0.001927711 |
| 318 | 517250 | 0.996148291 | -0.003859146 |
| 319 | 516250 | 0.998066699 | -0.001935172 |
| 320 | 518750 | 1.004842615 | 0.004830927 |
| 321 | 525000 | 1.012048193 | 0.011976191 |
| 322 | 523000 | 0.996190476 | -0.003816799 |
| 323 | 525625 | 1.00501912 | 0.005006567 |
| 324 | 526325 | 1.001331748 | 0.001330862 |
| 325 | 528750 | 1.004607419 | 0.004596838 |
| 326 | 527750 | 0.998108747 | -0.001893044 |
| 327 | 528250 | 1.000947418 | 0.00094697 |
| 328 | 529750 | 1.002839565 | 0.002835541 |
| 329 | 534000 | 1.008022652 | 0.007990642 |
| 330 | 535750 | 1.003277154 | 0.003271795 |
| 331 | 536750 | 1.001866542 | 0.001864802 |
| 332 | 537000 | 1.000465766 | 0.000465658 |
| 333 | 537250 | 1.000465549 | 0.000465441 |
| 334 | 536750 | 0.999069335 | -0.000931099 |
| 335 | 535750 | 0.998136935 | -0.001864802 |

PERIOD III

| | | | |
|---|---|---|---|
| 336 | 539750 | 1.007466169 | 0.007438435 |
| 337 | 542000 | 1.004168597 | 0.004159932 |
| 338 | 540000 | 0.996309963 | -0.003696862 |
| 339 | 538000 | 0.996296296 | -0.003710579 |
| 340 | 538000 | 1 | 0 |
| 341 | 535750 | 0.995817844 | -0.004190926 |
| 342 | 536750 | 1.001866542 | 0.001864802 |
| 343 | 531250 | 0.989753144 | -0.010299717 |
| 344 | 532750 | 1.002823529 | 0.002819551 |
| 345 | 530000 | 0.994838104 | -0.005175264 |
| 346 | 528750 | 0.997641509 | -0.002361276 |
| 347 | 533750 | 1.009456265 | 0.009411834 |
| 348 | 535000 | 1.00234192 | 0.002339182 |
| 349 | 534000 | 0.998130841 | -0.001870908 |
| 350 | 534750 | 1.001404494 | 0.001403509 |
| 351 | 534500 | 0.999532492 | -0.000467617 |
| 352 | 535750 | 1.002338634 | 0.002335904 |
| 353 | 535500 | 0.999533364 | -0.000466744 |
| 354 | 535500 | 1 | 0 |
| 355 | 535500 | 1 | 0 |
| 356 | 535500 | 1 | 0 |
| 357 | 535500 | 1 | 0 |
| 358 | 544000 | 1.015873016 | 0.015748357 |
| 359 | 544000 | 1 | 0 |
| 360 | 545000 | 1.001838235 | 0.001836548 |
| 361 | 545250 | 1.000458716 | 0.00045861 |
| 362 | 546000 | 1.001375516 | 0.001374571 |
| 363 | 545500 | 0.999084249 | -0.00091617 |
| 364 | 546000 | 1.00091659 | 0.00091617 |
| 365 | 544000 | 0.996336996 | -0.003669729 |
| 366 | 542750 | 0.997702206 | -0.002300438 |
| 367 | 541250 | 0.997236297 | -0.002767529 |
| 368 | 535250 | 0.98891455 | -0.011147352 |
| 369 | 533000 | 0.995796357 | -0.004212503 |
| 370 | 532250 | 0.998592871 | -0.00140812 |
| 371 | 527500 | 0.991075622 | -0.008964438 |
| 372 | 530500 | 1.005687204 | 0.005671093 |
| 373 | 535500 | 1.009425071 | 0.009380932 |
| 374 | 532000 | 0.993464052 | -0.006557401 |
| 375 | 532000 | 1 | 0 |
| 376 | 532500 | 1.00093985 | 0.000939408 |
| 377 | 532750 | 1.000469484 | 0.000469373 |
| 378 | 534250 | 1.00281558 | 0.002811623 |
| 379 | 537250 | 1.005615349 | 0.005599641 |
| 380 | 537250 | 1 | 0 |
| 381 | 538750 | 1.002791996 | 0.002788106 |
| 382 | 537750 | 0.998143852 | -0.001857873 |
| 383 | 537750 | 1 | 0 |
| 384 | 538000 | 1.0004649 | 0.000464792 |
| 385 | 539000 | 1.001858736 | 0.001857011 |
| 386 | 543000 | 1.00742115 | 0.007393749 |
| 387 | 543125 | 1.000230203 | 0.000230176 |
| 388 | 543375 | 1.000460299 | 0.000460193 |
| 389 | 544250 | 1.001610306 | 0.001609011 |
| 390 | 545500 | 1.002296739 | 0.002294105 |
| 391 | 546000 | 1.00091659 | 0.00091617 |

| | | | |
|---|---|---|---|
| 392 | 546750 | 1.001373626 | 0.001372684 |
| 393 | 545600 | 0.997896662 | -0.002105553 |
| 394 | 547000 | 1.002565982 | 0.002562696 |
| 395 | 548250 | 1.002285192 | 0.002282585 |
| 396 | 550250 | 1.003647971 | 0.003641333 |
| 397 | 550250 | 1 | 0 |
| 398 | 546750 | 0.993639255 | -0.006381061 |
| 399 | 546000 | 0.998628258 | -0.001372684 |
| 400 | 547250 | 1.002289377 | 0.002286761 |
| 401 | 546250 | 0.998172682 | -0.00182899 |
| 402 | 548250 | 1.003661327 | 0.003654641 |
| 403 | 548750 | 1.000911993 | 0.000911577 |
| 404 | 549250 | 1.000911162 | 0.000910747 |
| 405 | 551750 | 1.004551661 | 0.004541334 |
| 406 | 553025 | 1.002310829 | 0.002308163 |
| 407 | 555300 | 1.004113738 | 0.0041053 |
| 408 | 557750 | 1.00441203 | 0.004402325 |
| 409 | 560500 | 1.004930524 | 0.004918409 |
| 410 | 558000 | 0.995539697 | -0.00447028 |
| 411 | 557750 | 0.999551971 | -0.000448129 |
| 412 | 557250 | 0.999103541 | -0.000896861 |
| 413 | 561250 | 1.007178107 | 0.007152467 |
| 414 | 560000 | 0.997772829 | -0.002229655 |
| 415 | 556750 | 0.994196429 | -0.005820478 |
| 416 | 556750 | 1 | 0 |
| 417 | 557000 | 1.000449035 | 0.000448934 |
| 418 | 557250 | 1.000448833 | 0.000448732 |
| 419 | 560500 | 1.005832212 | 0.00581527 |

# APPENDIX E


PERIOD IV
Ln (Pt/Pt-1)
0.025
0.02
0.015
0.01
0.005
0
-0.005
-0.01
-0.015
-0.02
1
11
21
31
41
51
61
71
81
91
101
111
121
131
141
151
161
171
181
TIME

PERIOD IV

| TIME | PRICE | Pt/Pt-1 | LN ( Pt/Pt-1 ) |
|---|---|---|---|
| 1 | 560950 | | |
| 2 | 560650 | 0.999465193 | -0.00053495 |
| 3 | 561150 | 1.000891822 | 0.000891425 |
| 4 | 563000 | 1.003296801 | 0.003291379 |
| 5 | 568100 | 1.009058615 | 0.009017831 |
| 6 | 569050 | 1.001672241 | 0.001670844 |
| 7 | 571250 | 1.003866093 | 0.003858638 |
| 8 | 567500 | 0.993435449 | -0.006586193 |
| 9 | 571050 | 1.006255507 | 0.006236022 |
| 10 | 571000 | 0.999912442 | -8.75618E-05 |
| 11 | 571500 | 1.000875657 | 0.000875274 |
| 12 | 574225 | 1.004768154 | 0.004756822 |
| 13 | 576000 | 1.003091123 | 0.003086355 |
| 14 | 580375 | 1.007595486 | 0.007566786 |
| 15 | 583850 | 1.005987508 | 0.005969654 |
| 16 | 585050 | 1.002055322 | 0.002053213 |
| 17 | 590700 | 1.009657294 | 0.009610961 |
| 18 | 591975 | 1.002158456 | 0.00215613 |
| 19 | 590525 | 0.997550572 | -0.002452433 |
| 20 | 591325 | 1.001354727 | 0.00135381 |
| 21 | 592325 | 1.001691117 | 0.001689689 |
| 22 | 591600 | 0.99877601 | -0.00122474 |
| 23 | 592625 | 1.00173259 | 0.00173109 |
| 24 | 593150 | 1.000885889 | 0.000885497 |
| 25 | 592500 | 0.998904156 | -0.001096445 |
| 26 | 592675 | 1.000295359 | 0.000295315 |
| 27 | 590150 | 0.995739655 | -0.004269446 |
| 28 | 587525 | 0.995551978 | -0.004457944 |
| 29 | 583125 | 0.992510957 | -0.007517227 |
| 30 | 583150 | 1.000042872 | 4.28715E-05 |
| 31 | 581950 | 0.99794221 | -0.00205991 |
| 32 | 587150 | 1.008935476 | 0.00889579 |
| 33 | 589600 | 1.004172699 | 0.004164017 |
| 34 | 585950 | 0.993809362 | -0.006209879 |
| 35 | 589200 | 1.005546548 | 0.005531223 |
| 36 | 595575 | 1.010819756 | 0.010761641 |
| 37 | 595425 | 0.999748143 | -0.000251889 |
| 38 | 596225 | 1.001343578 | 0.001342676 |
| 39 | 594050 | 0.996352048 | -0.003654622 |
| 40 | 592400 | 0.997222456 | -0.002781409 |
| 41 | 596350 | 1.006667792 | 0.006645661 |
| 42 | 601925 | 1.009348537 | 0.00930511 |
| 43 | 604125 | 1.00365494 | 0.003648277 |
| 44 | 604450 | 1.000537968 | 0.000537823 |
| 45 | 609450 | 1.008271983 | 0.008237957 |
| 46 | 606450 | 0.995077529 | -0.004934626 |
| 47 | 605125 | 0.997815154 | -0.002187236 |
| 48 | 610475 | 1.008841149 | 0.008802294 |
| 49 | 611550 | 1.001760924 | 0.001759375 |
| 50 | 613800 | 1.003679176 | 0.003672424 |
| 51 | 618875 | 1.008268166 | 0.008234171 |
| 52 | 621925 | 1.004928297 | 0.004916193 |
| 53 | 621075 | 0.998633276 | -0.001367659 |
| 54 | 623225 | 1.00346174 | 0.003455762 |
| 55 | 624000 | 1.001243532 | 0.001242759 |

PERIOD IV

| | | | |
|---|---|---|---|
| 56 | 624200 | 1.000320513 | 0.000320461 |
| 57 | 623700 | 0.999198975 | -0.000801346 |
| 58 | 624325 | 1.001002084 | 0.001001583 |
| 59 | 622925 | 0.997757578 | -0.00224494 |
| 60 | 621200 | 0.997230806 | -0.002773035 |
| 61 | 620675 | 0.999154862 | -0.000845496 |
| 62 | 621000 | 1.000523623 | 0.000523486 |
| 63 | 623475 | 1.003985507 | 0.003977586 |
| 64 | 623600 | 1.000200489 | 0.000200469 |
| 65 | 624650 | 1.001683772 | 0.001682356 |
| 66 | 628300 | 1.005843272 | 0.005826267 |
| 67 | 632000 | 1.005888907 | 0.005871635 |
| 68 | 634875 | 1.004549051 | 0.004538735 |
| 69 | 636800 | 1.003032093 | 0.003027505 |
| 70 | 636525 | 0.999568153 | -0.00043194 |
| 71 | 638500 | 1.003102785 | 0.003097981 |
| 72 | 645400 | 1.010806578 | 0.010748604 |
| 73 | 649175 | 1.005849086 | 0.005832046 |
| 74 | 648800 | 0.999422344 | -0.000577823 |
| 75 | 650175 | 1.002119297 | 0.002117055 |
| 76 | 652500 | 1.00357596 | 0.003569582 |
| 77 | 657875 | 1.008237548 | 0.008203804 |
| 78 | 661725 | 1.005852176 | 0.005835118 |
| 79 | 660875 | 0.998715478 | -0.001285347 |
| 80 | 660150 | 0.99890297 | -0.001097633 |
| 81 | 659100 | 0.998409452 | -0.001591814 |
| 82 | 661325 | 1.003375816 | 0.00337013 |
| 83 | 664950 | 1.00548142 | 0.005466452 |
| 84 | 669500 | 1.00684262 | 0.006819315 |
| 85 | 672400 | 1.004331591 | 0.004322236 |
| 86 | 675975 | 1.005316776 | 0.005302692 |
| 87 | 681575 | 1.00828433 | 0.008250203 |
| 88 | 682775 | 1.001760628 | 0.00175908 |
| 89 | 681625 | 0.998315697 | -0.001685723 |
| 90 | 683150 | 1.002237301 | 0.002234802 |
| 91 | 685800 | 1.00387909 | 0.003871585 |
| 92 | 688625 | 1.004119277 | 0.004110816 |
| 93 | 687825 | 0.998838265 | -0.001162411 |
| 94 | 686050 | 0.997419402 | -0.002583934 |
| 95 | 686100 | 1.000072881 | 7.28783E-05 |
| 96 | 686325 | 1.000327941 | 0.000327887 |
| 97 | 687750 | 1.002076276 | 0.002074123 |
| 98 | 691125 | 1.004907306 | 0.004895305 |
| 99 | 694875 | 1.005425936 | 0.005411269 |
| 100 | 696225 | 1.001942795 | 0.001940911 |
| 101 | 700675 | 1.006391612 | 0.006371272 |
| 102 | 702600 | 1.002747351 | 0.002743584 |
| 103 | 703100 | 1.000711642 | 0.000711389 |
| 104 | 703150 | 1.000071114 | 7.11111E-05 |
| 105 | 705150 | 1.002844343 | 0.002840306 |
| 106 | 706325 | 1.001666312 | 0.001664925 |
| 107 | 706825 | 1.000707889 | 0.000707639 |
| 108 | 705425 | 0.998019312 | -0.001982652 |
| 109 | 704550 | 0.998759613 | -0.001241157 |
| 110 | 704350 | 0.999716131 | -0.000283909 |
| 111 | 704875 | 1.000745368 | 0.00074509 |

PERIOD IV

| | | | |
|---|---|---|---|
| 112 | 707750 | 1.004078737 | 0.004070442 |
| 113 | 710125 | 1.003355705 | 0.003350087 |
| 114 | 711175 | 1.001478613 | 0.001477521 |
| 115 | 712300 | 1.001581889 | 0.001580639 |
| 116 | 713725 | 1.002000562 | 0.001998563 |
| 117 | 714775 | 1.001471155 | 0.001470074 |
| 118 | 716900 | 1.002972964 | 0.002968553 |
| 119 | 719075 | 1.003033896 | 0.003029303 |
| 120 | 718800 | 0.999617564 | -0.000382509 |
| 121 | 721100 | 1.003199777 | 0.003194669 |
| 122 | 729975 | 1.012307586 | 0.012232463 |
| 123 | 736625 | 1.009109901 | 0.009068656 |
| 124 | 738925 | 1.003122349 | 0.003117484 |
| 125 | 743725 | 1.006495923 | 0.006474916 |
| 126 | 752975 | 1.012437393 | 0.012360684 |
| 127 | 766050 | 1.017364454 | 0.017215415 |
| 128 | 775950 | 1.012923438 | 0.012840643 |
| 129 | 779500 | 1.004575037 | 0.004564603 |
| 130 | 780000 | 1.000641437 | 0.000641231 |
| 131 | 770500 | 0.987820513 | -0.012254265 |
| 132 | 770500 | 1 | 0 |
| 133 | 761000 | 0.987670344 | -0.012406297 |
| 134 | 762500 | 1.001971091 | 0.001969151 |
| 135 | 754500 | 0.989508197 | -0.01054723 |
| 136 | 754500 | 1 | 0 |
| 137 | 762500 | 1.010603048 | 0.01054723 |
| 138 | 756500 | 0.992131148 | -0.007899975 |
| 139 | 757000 | 1.000660939 | 0.00066072 |
| 140 | 758000 | 1.001321004 | 0.001320132 |
| 141 | 763500 | 1.007255937 | 0.007229739 |
| 142 | 763500 | 1 | 0 |
| 143 | 760500 | 0.996070727 | -0.003937013 |
| 144 | 768500 | 1.010519395 | 0.010464451 |
| 145 | 775500 | 1.009108653 | 0.00906742 |
| 146 | 775500 | 1 | 0 |
| 147 | 775250 | 0.999677627 | -0.000322425 |
| 148 | 775250 | 1 | 0 |
| 149 | 789000 | 1.017736214 | 0.017580763 |
| 150 | 795500 | 1.008238276 | 0.008204527 |
| 151 | 800000 | 1.00565682 | 0.00564088 |
| 152 | 798250 | 0.9978125 | -0.002189896 |
| 153 | 813250 | 1.018791106 | 0.018616734 |
| 154 | 808500 | 0.994159238 | -0.005857886 |
| 155 | 815500 | 1.008658009 | 0.008620743 |
| 156 | 814000 | 0.998160638 | -0.001841056 |
| 157 | 812500 | 0.998157248 | -0.001844452 |
| 158 | 820500 | 1.009846154 | 0.009797996 |
| 159 | 837500 | 1.020719074 | 0.020507353 |
| 160 | 834750 | 0.996716418 | -0.003288985 |
| 161 | 840500 | 1.00688829 | 0.006864674 |
| 162 | 841000 | 1.000594884 | 0.000594707 |
| 163 | 851000 | 1.011890606 | 0.011820469 |
| 164 | 837500 | 0.98413631 | -0.015990865 |
| 165 | 838500 | 1.00119403 | 0.001193318 |
| 166 | 838500 | 1 | 0 |
| 167 | 834500 | 0.995229577 | -0.004781838 |

PERIOD IV

| | | | |
|---|---|---|---|
| 168 | 832500 | 0.997603355 | -0.002399521 |
| 169 | 835000 | 1.003003003 | 0.002998503 |
| 170 | 836750 | 1.002095808 | 0.002093615 |
| 171 | 840500 | 1.004481625 | 0.004471613 |
| 172 | 852000 | 1.013682332 | 0.013589574 |
| 173 | 846000 | 0.992957746 | -0.007067167 |
| 174 | 847750 | 1.002068558 | 0.002066421 |
| 175 | 847000 | 0.999115305 | -0.000885086 |
| 176 | 852750 | 1.006788666 | 0.006765727 |
| 177 | 856500 | 1.004397537 | 0.004387896 |
| 178 | 856500 | 1 | 0 |
| 179 | 857225 | 1.000846468 | 0.00084611 |
| 180 | 849500 | 0.990988364 | -0.009052487 |
| 181 | 849500 | 1 | 0 |
| 182 | 853500 | 1.004708652 | 0.004697601 |
| 183 | 857000 | 1.004100762 | 0.004092376 |
| 184 | 853500 | 0.995915986 | -0.004092376 |
| 185 | 865000 | 1.013473931 | 0.013383965 |
| 186 | 869500 | 1.005202312 | 0.005188827 |
| 187 | 871000 | 1.001725129 | 0.001723643 |
| 188 | 868750 | 0.997416762 | -0.00258658 |
| 189 | 875500 | 1.007769784 | 0.007739755 |
| 190 | 876000 | 1.000571102 | 0.000570939 |
| 191 | 880500 | 1.005136986 | 0.005123837 |

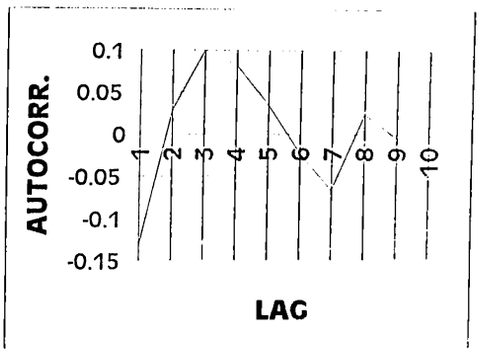
# APPENDIX F

# INDEPENDENCE TESTS

## PERIOD 1

**Critical Value** **0.086**

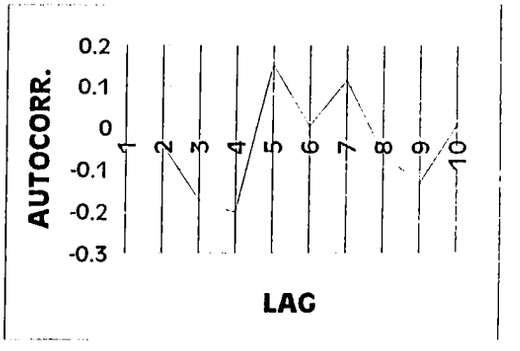
| Lag | r | QLB |
|---|---|---|
| 1 | -0.13318 | 9.5958 |
| 2 | 0.028 | 10.0207 |
| 3 | 0.09981 | 15.4304 |
| 4 | 0.082213 | 19.1076 |
| 5 | 0.035165 | 19.7803 |
| 6 | -0.02282 | 20.0660 |
| 7 | -0.0669 | 22.5146 |
| 8 | 0.02346 | 22.8163 |
| 9 | -0.00453 | 22.8276 |
| 10 | -0.00878 | 22.8700 |




## PERIOD 2

**Critical Value** **0.17025**

| Lag | r | QLB |
|---|---|---|
| 1 | -0.033927 | 0.1623 |
| 2 | -0.041236 | 0.4039 |
| 3 | -0.174045 | 4.7390 |
| 4 | -0.2037 | 10.7215 |
| 5 | 0.153108 | 14.1267 |
| 6 | 0.002416 | 14.1276 |
| 7 | 0.114676 | 16.0671 |
| 8 | -0.063976 | 16.6753 |
| 9 | -0.132539 | 19.3062 |
| 10 | 0.0051 | 19.3102 |

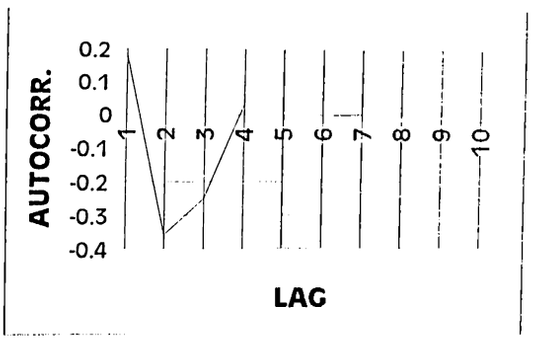


INDEPENDENCE TESTS

# PERIOD 3

**Critical Value** **0.0978231**

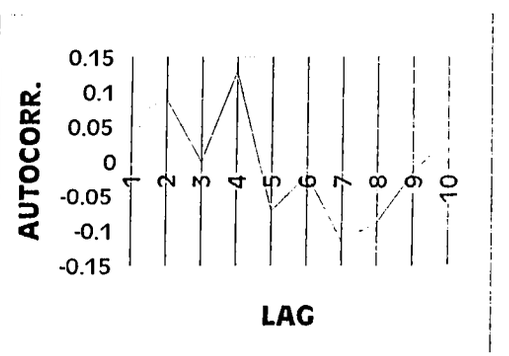
| Lag | r | QLB |
|---|---|---|
| 1 | 0.181157 | 13.8166 |
| 2 | -0.35813 | 67.9435 |
| 3 | -0.25052 | 94.4934 |
| 4 | 0.029579 | 94.8644 |
| 5 | 0.052686 | 96.0444 |
| 6 | -0.00108 | 96.0448 |
| 7 | 0.003926 | 96.0514 |
| 8 | 0.023695 | 96.2919 |
| 9 | 0.061228 | 97.9010 |
| 10 | 0.054519 | 99.1800 |




# PERIOD 4

**Critical Value** **0.1450952**

| Lag | r | QLB |
|---|---|---|
| 1 | 0.0656151 | 0.8310 |
| 2 | 0.0893197 | 2.3791 |
| 3 | 0.00005176 | 2.3791 |
| 4 | 0.129303 | 5.6582 |
| 5 | -0.0725965 | 6.6974 |
| 6 | -0.0191636 | 6.7703 |
| 7 | -0.1159835 | 9.4519 |
| 8 | -0.0896384 | 11.0624 |
| 9 | -0.0153956 | 11.1102 |
| 10 | 0.0358691 | 11.3709 |



INDEPENDENCE TESTS

# PERIOD T

**Critical Value** **0.0557278**

| Lag | r | QLB |
|---|---|---|
| 1 | 0.10594844 | 14.4804 |
| 2 | -0.23833 | 87.8111 |
| 3 | -0.183155 | 131.1526 |
| 4 | 0.013164 | 131.3766 |
| 5 | 0.0689892 | 137.5356 |
| 6 | 0.010042 | 137.6662 |
| 7 | 0.0188821 | 138.1282 |
| 8 | 0.0181413 | 138.5551 |
| 9 | 0.0337661 | 140.0351 |
| 10 | 0.0412878 | 142.2497 |