UNIVERSITY OF CAPE COAST

# TIME SERIES ANALYSIS OF THE CONSUMER PRICE INDEX IN GHANA (1964 – 2009)

VICTORIA ASANTEWA ANIM-ANSAH

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BY

VICTORIA ASANTEWA ANIM-ANSAH

A Dissertation submitted to the Department of Mathematics & Statistics of the School of Physical Sciences, University of Cape Coast in partial fulfillment of the requirements for the award of Master of Science degree in Statistics.

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# DECLARATION

## Candidate's Declaration

I hereby declare that this dissertation is the result of my original work and that no part of it has been presented for another degree in this university or elsewhere.

Candidate's Signature: ………………………

Candidate's Name: Victoria Asantewa Anim-Ansah

Date:

## Supervisor's Declaration

I hereby declare that the preparation and presentation of the dissertation were supervised in accordance with the guidelines on supervision of dissertation laid down by the University of Cape Coast.

Supervisor's Signature: ………………………

Supervisor's Name: Professor. N.N.N.Nsowah-Nuamah

Date:

## ABSTRACT

The dissertation was on Time Series Analysis of the Consumer Price Index (CPI) in Ghana for the period 1964 to 2009. The main objective of the study was to determine the general trend pattern and to develop a model for forecasting the Consumer Price Index (CPI) for the old and new series. In order to achieve these objectives, CPI figures for the period were obtained from the prices section of Ghana Statistical Service.

The major statistical software used to analyze the data was the MINITAB and SPSS.The study revealed for the old series that the index has increase to 72488.38 percentage points from 1965 to 1997. Also the highest inflation rate of 121.35 percent was recorded in the year 1983 and the lowest inflation rate of -87.09 percent occurred in the year 1978. For the new series it revealed that the index has increase to 165.15 percentage points from 1998 to 2009 and the highest inflation rate of 33.59 percent was recorded in the year 2001 while the lowest inflation rate of 10.73 percent occurred in the year 2007. The yearly CPI shows an increasing trend for both the old and new series.The trend analysis for the old series shows that the average change of CPI from one year to the other is 43.89 percent and that for the new series was 139.882 percent.

Four main smoothing techniques were used for forecasting the yearly CPI figures and from the empirical evidence gathered the Holt's exponential smoothing is most significant for the old series and AR(1) of the ARIMA model was the most appropriate technique for the forecast of the new series.

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## DEDICATION

To my dear husband, Godwin Anim-Ansah and son, Spencer Ishmael Anim-Ansah.

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# CHAPTER ONE

# INTRODUCTION

## Background Information

Inflation in Ghana is the main measure to negotiate for wage/salary increase, for fixing interest rates, as convergent criteria in regional integration, for macroeconomic purposes, and forms the basis for the government's inflation target. The Consumer Price Index (CPI) which is used to measure inflation is the average change from month to month in the prices of goods and services purchased by households in a country. It also measures the cost of a basket of goods and services at a specified period relative to that of a base period. The basket includes consumption expenditure items such as food, clothing, shelter, fuels, transportation, medical care, school fees and other commodities purchased for day-to-day living.

There are factors like import prices of petroleum products and the seasons (weather) which have a major influence on the rate of inflation in addition to government fiscal and monetary polices. Due to the widespread use of CPI for all kinds of index linking, inaccurate CPI can have major financial ramifications throughout the economy. The implications for the government alone can be considerable, given that the CPI can affect interest payments and taxation receipts as well as the wages in the government service.

Therefore there is the need for the government to put in place good economic and fiscal polices that will help lower the rate of inflation since in a study by Catoa and Terrones (2003), Ghana was cited as one of the top 25 countries in the world with high inflation levels. In Ghana, the Ghana Statistical Service (GSS) is the sole agency that has been established to calculate the Consumer Price Index.

**The Ghana Statistical Service**

The Statistical system currently operating in Ghana has its formal beginnings in a law passed in 1951. The Statistics Ordinance (1951) law set up the office of the Government Statistician (OGS), as the main operating agency for the collection and reporting of official statistics. The Statistical Service was set up by the Statistical Service law, 1985 (P. N. D. C. L 135). This law makes the usual provision giving the Government Statistician power to obtain information from any person or persons having the custody or charge of any public records or documents on any of a wide range of specified activities and subjects. The Statistical Ordinance gave legal backing to the Service and assigned it the following duties:

- To collect, compile, analyse, abstract and publish statistical information relating to the commercial, industrial, agricultural, mining, social, economic and general activities and conditions of the inhabitants of Ghana;

- To conduct statistical surveys, including any census in Ghana;

- To organise a co-ordinated scheme of economic and social statistics relating to Ghana.

**Consumer Price Index (CPI) in Ghana**

The Consumer Price Index (CPI) measures the pure price change in consumer goods and services experienced over time by the total population by comparing the cost of a fixed basket of goods and services at one time with the cost of exactly the same basket in the base period. Consumer Price Indices (CPI) have been compiled for a long period in Ghana. The computation of CPI started in 1957 for only the capital city Accra and the whole country began in the 1970s.

The1977 index was based on a Household Budget Survey carried out during 1974-75, and it was used to replace the previous series which had been in use since March 1963. The present series is the first one to cover the urban and rural areas in all ten regions. From the year 1963 to the year 1997 the series generated by the service was termed as the old series and the series generated using the base year June 2002 that is starting from 1998 up to date is called the new series.

The spending pattern on which the index is based is revised regularly, using information from the various rounds of the Ghana Living Standard Surveys (GLSS). The CPI series with base September 1997 uses the results of the third round of GLSS. The fieldwork for this survey was carried out in 1992 and the index therefore reflects the household consumption pattern of the early 1990's. The base year June 2002 is based on the fourth round of GLSS for which the fieldwork was conducted during 1998/99. Currently, the data for the fifth round of the GLSS is ready and the results will be used in the next revision of the base year and also to update the weights as well as the list of the items in the basket.

The review and improvement exercise of the CPI in Ghana to generate the new series was started by the Ghana Statistical Service in the year 2002, with the support from the International Monetary Fund (IMF) and Department for International Development (DFID). The exercise included:

1) Changing the base of the CPI from September 1997 prices (with GLSS 3,1992 weights) to average 2002 prices with GLSS 4, 1998/9 weights;

2) Changing the classification from the Central Product Classification (CPC) to the Classification of Individual Consumption by Purpose (COICOP);

3) Introducing new computer software (PRIMA) to calculate the indices;

4) Increase the number of markets and review the rural/urban markets;

5) Improvements in data collection, processing and dissemination.

It is impossible to collect all the data to match this theoretical definition, so in practice a number of compromises and approximations have to be made. Generally, the index can only be calculated by means of sampling at a number of levels:

- The concept of a basket is used as a representation for all spending on all goods and services in the economy;

- Since not every Ghanaian household can be asked about its pattern of expenditure, the basket of goods has to be built up from information gained from a survey of a representative sample of households;

- Once proportions on particular categories are known, representative commodities or items have to be selected. For example, if it is known that the average household spends 3% on vegetables, it is impossible to go out and collect the price of each vegetable. Therefore, a small number are chosen to represent the price of all different types of vegetables;

- Once the set of items for which prices are to be collected is decided, it is also clearly not possible to collect their prices from every shop or market. Price collection has therefore to be organised in a selection of areas and a sample of outlets within those areas (e.g. shops and markets).

It is also important to define precisely what household expenditure is to be included in the range of the index. First, it must represent all consumer expenditure, services as well as goods. Prices therefore need to be collected from sources other than just markets and shops. Second, prices are collected inclusive of indirect taxes levied at point of sale, on the grounds that a consumer who wants the good or service has to pay the tax.

There is no common agreement between countries on exactly what expenditures are included and excluded, and to some extent this decision has to be taken on the basis of what uses are made of the index. However, bearing in mind that the purpose of the index is to measure changes in the prices being experienced by household consumers, and that the index is also intended as an economic measure of what is happening in the household consumption expenditure in the economy.

**Statement of the problem**

Managerial decisions are mostly based on past and present conditions to forecast future events (Hossein, 1994), therefore forecast is necessary and indispensable tool for an organization. Governments all over the world rely on Consumer Price Index (CPI) which is the main measure of inflation in Ghana to negotiate for wage/salary increase, for fixing interest rates, as convergent criteria in regional integration. Many economists have watched with keen interest the relationship between inflation and growth and also stakeholders such as the central bank, business sector, manufacturing sector, Ministry of Finance and Economic Planning (MOFEP) use it for planning and making informed decisions.

There is the need for the governments to come out with good economic and fiscal polices that will help reduce the inflation rates since it deals with the general price levels in the country, otherwise workers will agitate for higher wages and salaries and also businesses will collapse and it will affect the economy. It can also be used by the stakeholders to plan ahead and make decisions to reduce risk.

This study will use exponential smoothing to develop a forecast tool to help generate reliable inflation forecast for the two periods that is the old (1964-1997) and new series (1998-2009). The distinction between old and new series was necessary because when the base year is changed, the items in the CPI basket and the markets also changed. The structure of the economy has also change to warrant a new base year therefore the series generated would be different from the previous ones so it would be better to analysis them seperately.

**Objectives of the Study**

The main objective of this study is to statistically analysis the consumer price indexes and the inflation rates in Ghana, also come out with a model to make meaningful forecasts for inflation for the period of 1964 to 1997 and 1998 to 2009. The specific objectives are:

(i) To determine the trend pattern of the consumer price index for the period (1964 – 2009)

(ii) To determine whether the various components of time series have an influence on the consumer price index.

(iii) To explain and model the consumer price index for the two periods.

(iv) Forecast the future consumer price index for the two periods.

The research will be based on the quantitative application of appropriate models and how it could be used to predict the consumer price index. The objectives stated above require that the pattern of the time series data is gathered and the identified pattern could then be extrapolated to predict future consumer price index figures.

**Research Questions**

The following research questions were asked:

(i) What pattern does the CPI in the country follow over the period under review?

(ii) What movement does the monthly and yearly collections exhibits?

(iii) What is going to be the expected Consumer Price Index for the subsequent years?

**Literature Review**

Laryea and Sumaila (2001) in their study noted that Tanzania inflation remained above 30 percent and fiscal discipline declined toward the middle of the 1990s with both budget and external current account deficits increasing sharply (IMF country report on Tanzania, 1999, page 5). Maintaining inflation rates within reasonable targets continues to be one of the principal goals of the ongoing economic reforms. The government through the monetary authorities has instituted tight monetary and fiscal policies which often target the demand causes of inflation. On the other hand, there are real factors such as food production which also influences inflation.

They also said there are two important measures of inflation computed by the Tanzania Bureau of Statistics (BOS). One measure is the year to year headline inflation which is defined as the percentage change in the National Consumer

Price Index (NCPI). The other measure of inflation is the underlying inflation rate which is defined as the rate of inflation excluding changes in food prices. The general rate of inflation in Tanzania shows a downward trend between the period 1992 –1998 and since then the rates have declined steadily, averaging 12.8% as at the end of 1998. The significant decline in inflation rates since 1994 reflects the impact of tight monetary and fiscal policies pursued by the central bank. They also established that in the short-run, output and monetary factors are the main determinants of inflation in Tanzania. They also pointed out that in the long-run, parallel exchange rate also influences inflation and in their conclusion, they emphasized that; inflationary situation in Tanzania is basically a monetary phenomenon.

A paper prepared by Acute et al. (2001), revealed that structural factors like weather conditions, and protective industrial and trading policies of the government are believed to influence the rate of inflation in Swaziland. It can be argued that government protects infant industries from intra currency area trade and regulates domestic marketing of agricultural products by quantitative import restrictions through import permits or licensing. These policies are believed to have created monopolistic and oligopolistic structures of firms, which usually set their prices well above border prices. The general feeling is that these policies may be highly inflationary as prices of some of the controlled items have risen quickly in Swaziland.

Weather conditions, crop failures or drought have a direct impact on the inflation rate in Swaziland given that food items carry the biggest weight in the computation of the CPI (24.5%). During good weather (rainy agricultural year), prices are in general expected to fall in the future and vice versa. For example, a rise in Swaziland's inflation rate during the year 2000 is believed to have been partially a result of the floods experienced during the first three months of 2000. Since these variables can not be easily quantified, and their impact is only significant in one-off periods, it was decided not to include these variables but to assign, where appropriate, structural dummies to account for their effects.

According to Appiah and Boahene (2009) in their paper noted that Inflation is one of Ghana's major macroeconomic problems since the late 1960s, though the magnitude of this problem continues to vary overtime. Immediately after independence, the rates of inflation were low and in the single digit bracket, averaging below 10% in the period (1957 – 1972). Although the rates were low, they were increasing gradually over-time and in most cases the rates were achieved during the late 1950s.The period (1957–1972) is classified as the first episode of inflationary situation in Ghana. The gradual but increasing inflation rate became serious during the period (1973- 1982), which is the second episode of inflation in Ghana.

This period was marked by several military interventions which led to huge balance of payment deficits and resulted in increases in money supply and the subsequent effects on the economy through high general price levels. By 1983, inflation had reached a "sky-rocketing" level of 123 % (Ghana Statistical Service's annual report: 1984 issue). By 1983, when inflation was out of control and the entire economy was near collapse, the then head of state adopted the

Economic Recovery Programme (ERP) which was proposed by the International Monetary Fund (IMF), with the aim of stabilizing the economy. This marked the beginning of the third episode of inflation in Ghana.  In the era of democracy which started in 1992, Ghana still has not been able to achieve the single digit target level of inflation that it had achieved in the 1950s and early 1960s.

According to the New York Times Wednesday, March 10, 2010 edition "The CPI is the most widely used measure of inflation and is sometimes viewed as an indicator of the effectiveness of government economic policy. It provides information about price changes in the Nation's economy to government, business, labor, and private citizens and is used by them as a guide to making economic decisions. In addition, the President, Congress, and the Federal Reserve Board use trends in the CPI to aid in formulating fiscal and monetary policies.

The CPI and its components are used to adjust other economic series for price changes and to translate these series into inflation-free dollars. Examples of series adjusted by the CPI include retail sales, hourly and weekly earnings, and components of the National Income and Product Accounts. An interesting example of this is the use of the CPI as a deflator of the value of the consumer's dollar to find its purchasing power. The purchasing power of the consumer's dollar measures the change in the value to the consumer of goods and services that a dollar will buy at different dates. In other words, as prices increase, the purchasing power of the consumer's dollar declines."

According to the Economic Survey (2001-2005) the prices of food items which account for about half of the total households purchases exerted a big influence on the CPI and the prices of both food and non-food increased consistently by an average of 17.3 percent over the period 2001 to 2005. Ghana experienced high inflationary pressures in the 1990s but subsided considerably after 2001 due to the stable exchange rate, tight fiscal and monetary policies of the government and favourable rainfall pattern and distribution succeeded in reducing the general price level during the period under review.

The Bureau of Labor Statistics in USA have two separate CPI indexes namely All Urban Consumers (CPI-U) and Urban Wage Earners and Clerical Workers (CPI-W). Both the CPI-U and the CPI-W reflect only the buying habits of urban consumers. The CPI-U is the more comprehensive of the two and represents the expenditure by all urban consumers, about 87 percent of the total U.S. population. The CPI-W represents a subset of the CPI-U population, that is, the expenditures by urban households that derive more than one-half of their income from clerical or hourly wage occupations. These households comprise about 32 percent of the total U.S. population. The CPI market basket represents all the consumer goods and services purchased by households. Price data are collected for over 180 categories in United States of America (USA), which Bureau of Labor Statistics has grouped into 8 major groups. Indexes for these categories are published at the U.S. city average level. The CPIs are based on prices of food, clothing, shelter, and fuels, transportation fares, charges for doctors' and dentists' services, drugs, and other goods and services that people buy for day-to-day living. Prices are collected in 87 urban areas across the country from about 50,000 housing units and approximately 23,000 retail establishments-department stores, supermarkets, hospitals, filling stations, and other types of stores and service establishments.

In calculating the index, price changes for the various items in each location are averaged together with weights, which represent their importance in the spending of the appropriate population group. For the CPI-U and CPI-W separate indexes are also published by size of city, by region of the country, for cross-classifications of regions and population-size classes, and for 27 local areas. For the CPI-U and the CPI-W the reference base is 1982 to1984. The reference base for the C-CPI-U is December 1999.

**Research Methodology**

The CPI covers the whole country, both the urban and rural areas and in all ten regions. Forty (40) markets, made up of 9 urban and 31 rural markets have been sampled throughout the country from where market prices are collected. There are 242 items (goods and services) in the CPI basket that represent the total expenditures of households (Appendix 9). Data collection for the calculation of the CPI is undertaken by staff of the Regional Offices of the Statistical Service. A single questionnaire is used for all the products in all the markets. No product in the basket is considered seasonal. Price collection is done twice every month, during the first and third week of the month.

The data for the research was collected from the Prices Section of the Ghana Statistical Service. The data involves monthly and yearly CPI's and inflation rates for the period of 36 years, from 1964 to 2009. The CPI and the inflation rates are separated into combined, food and non-food groups. Since 1963 the service has changed the base year three times that is in 1977, 1997 and 2002, currently it is in the process of rebasing the CPI. The data has been linked to have a continuous data.

Effective model fitting do not require any long series and the exponential smoothing use for the prediction does not require large sample size. (Wilson and Keating, 1994). So the selected data is reasonable for the time series analysis in respect of exponential smoothing.

Due to cost, objective of the study and time constraint secondary data was employed. Appendix 1 shows the monthly consumer price index figures from 1964 to 2009 and Appendix 2 also shows the annual consumer price index figures for the given period.

**Outline of Dissertation**

The study was organized and presented in five chapters. Chapter one covered the Background to the study and Statement of the problem. It also outlines the Objectives of the Study, Research questions, Reviewed literature, Research methodology. Chapter two reviews the Basic theory and methods that would be used in the study. Chapter three involves the Preliminary analysis of the data and Chapter four is on the Further analysis. Chapter five involves the Discussion, Summary of Findings, Conclusions and Recommendations.

# CHAPTER TWO

## REVIEW OF BASIC THEORY AND METHODS

### Time Series Analysis

A time series is "a chronological sequence of observations on a particular variable" (Keller and Warrack, 2003). The observations are usually taken at regular intervals (days, months, years), but the sampling could be irregular. Common examples of time series are the Consumer Price Index, Gross Domestic Product, unemployment rate, and airline passenger loads.

A time series analysis consists of two steps, that is building a model that represents a time series and using the model to predict (forecast) future values. If a time series has a regular pattern, then a value of the series should be a function of previous values. If Y is the target value that we are trying to model and predict, and $Y_t$ is the value of Y at time *t*, then the goal is to create a model of the form:

$$Y_t = f\left(Y_{t-1}, Y_{t-2}, Y_{t-3}, \ldots, Y_{t-n}\right) + e_t \tag{1}$$

where $Y_{t-1}$ is the value of Y for the previous observation, $Y_{t-2}$ is the value two observations ago, etc., and $e_t$ represents noise that does not follow a predictable pattern (this is called a random shock). Values of variables occurring prior to the current observation are called lag values. If a time series follows a repeating pattern, then the value of $Y_t$ is usually highly correlated with $Y_{t\text{-}cycle}$ where *cycle* is the number of observations in the regular cycle. For example, monthly observations with an annual cycle often can be modeled by $Y_t = f(Y_{t-12})$

The reasons why time series analysis is applicable to the research are:

(i) Identifying patterns in the correlated data;

(ii) Modeling the data; and

(iii) Forecasting by predicting short term trends from previous patterns.

The goal of building a time series model is the same as the goal for other types of predictive models which is to create a model such that the error between the predicted value of the target variable and the actual value is as small as possible. The primary difference between time series models and other types of models is that lag values of the target variable are used as predictor variables, whereas traditional models use other variables as predictors, and the concept of a lag value does not apply because the observations do not represent a chronological sequence.

**Components of Time Series**

There are four components of time series, namely trend (T), seasonal (S), irregular or random (I) and cyclical variations (C).

**Trend**

The trend is the continuous long-term movement in a variable over extended period of time. There are no proven "automatic" techniques to identify trend components in the time series data; however, as long as the trend is monotonous (consistently increasing or decreasing) that part of data analysis is typically not very difficult. Trend analysis does not predict what the future will look like but becomes a powerful tool for strategic planning by creating plausible, detailed pictures of what the future might look like.

The easiest way of measuring a long term trend is by using regression to fit either a linear or exponential function to the data. If the long-term trend is believed to be approximately linear, then the model $y = \beta_0 + \beta_1 t + \varepsilon$ is used. However if the trend is non linear then the polynomial model used is $y = \beta_0 + \beta_1 t + \beta_2 t^2 + \varepsilon$

**Cyclical variation**

These are medium-term changes in results caused by circumstances which repeat in cycles. In business, cyclical variations are commonly associated with economic cycles, successful booms and slumps in the economy. A cyclical variation is wavelike in nature and such movements are fairly regular and oscillatory occuring over a relatively long time period. It contains four phases namely: expansion, recession, peak and depression. Reflections of changes in weather, style, taste, etc are some examples. It occurs in business and economic activity and is caused by complex combination of forces affecting the equilibrium of demand and supply.

**Seasonal Variation**

Seasonal variation is a component of a time series which is defined as the repetitive and predictable movement around the trend line in one year or less. Movements in the time series that tend to reoccur each year about the same time is said to have a seasonal variation. Skarp and Cher (2004) said "seasonality occurs within many aspects of our lives and the changing of the seasons is but just one simple example.

Seasonal variation is usually caused by the climatic changes of the different seasons, such as weather, observance of holidays and festivals, etc.

Organizations facing seasonal variations, like the motor vehicle industry, Ministry of Employment are often interested in knowing their performance relative to the normal seasonal variation.

The seasonality need to be identified and measured to help with planning for temporary increases or decreases. Seasonal variation is measured in terms of an index, called a seasonal index. It is an average that can be used to compare an actual observation relative to what it would be if there was no seasonal variation.

**Irregular or Random Variation**

These are disturbances due to 'everyday' unpredictable influences, such as weather conditions, illness, and transport breakdowns. They are also irregular movements caused by unusual occurrences such as earthquakes, wars, floods, strikes, etc. These movements do not reveal any discernible pattern (unlikely to reoccur in similar fashion). They may be considered as residual variation after trend, seasonal and cyclical variations have been account for.

**Stationarity of Time Series**

A stationary time series is one in which two consecutive values in the series depend only on the time interval between them and not on time itself. Analyzing the structure of a time series model one must make sure that the time series are stationary with respect to the variance and the mean. Time series is strictly sationary if the joint distribution of $X(t_1),\ldots, X(t_n)$ is the same as the joint distribution of $X(t_1+\tau),\cdots,X(t_n+\tau)$ for all $t_1,t_2,\cdots,t_n,\tau.$ If $n=1,$ it implies that the distribution of $X(t)$ must be the same for all *t*, so that

$$\mu(t)=\mu \quad \text{and} \quad \delta^2(t)=\delta^2$$

are both constants do not depend on the value of t. Also if $_n$ = 2 the joint distribution of $X(t_1)$ and $X(t_2)$ depends only on $(t_2 – t_1)$, which is called the *lag*. Thus the autocovariance function $\gamma$ $(t_1, t_2)$ also depends only on $(t_2 - t_1)$ and may be written as $\gamma(t)$, where

$$\gamma(t) = E\{[X(t) - \mu][X(t+\tau) - \mu]\}$$

$$= Cov[X(t), X(t+\tau)] \quad (2)$$

is called the *autocovariance coefficient at lag τ.*

There are two types of stationarity namely weak and strict stationarity (Enders, 2004). Weak stationarity assumes that only the mean and variance are invariant while strict stationarity requires that the series is normally distributed and that the variance remains homogenous. The visual plot of a time series is often enough to convince a forecaster that the data are stationary or non-stationary and the autocorrelation plot can also expose non-stationarity quite readily. The autocorrelations of stationary data drop to zero after the second or third time lag, while for a non-stationary series they are significantly different from zero for several time periods.

It is important to remove the non-stationarity before proceeding with the time series model building and this can be achieved routinely through the method of differencing.

**Time Series Models**

A time series model is simply a mathematical statement of the relationship among the four components. The four components combine into two types of models namely the additive model and the multiplicative model respectively.

$$Y_t = T_t + S_t + C_t + I_t \tag{3}$$

where $Y_t$ is the value of the time series for time period t and the right-hand side values are the trend($T_t$), the seasonal variation($S_t$), the cyclical variation($C_t$) and the random or irregular variation($I_t$) respectively for the same time period. The additive model suffers from the somewhat unrealistic assumption that the components are independent of each other and this is seldom in the real world.As a result, the multiplicative model is often preferred because it assumes that the components interact with each other and do not move independently. The multiplicative model is expressed as

$$Y_t = T_t \times S_t \times C_t \times I_t \tag{4}$$

**Box-Jenkins Time Series Models (ARIMA)**

The first step in developing a Box-Jenkins model is to determine if the series is stationary and if there is any significant seasonality that needs to be modeled. Stationarity can be assessed from a run sequence plot. The run sequence plot should show constant location and scale. It can also be detected from an autocorrelation plot. Specifically, non-stationarity is often indicated by an autocorrelation plot with very slow decay. Seasonality (or periodicity) can usually be assessed from an autocorrelation plot, a seasonal sub series plot, or a spectral plot. Box and Jenkins recommend the differencing approach to achieve stationarity. However, fitting a curve and subtracting the fitted values from the original data can also be used in the context of Box-Jenkins models.

Partial autocorrelation plots (Box and Jenkins, pp. 64–65, 1970) are a commonly used tool for model identification in Box-Jenkins models. Specifically, partial autocorrelations are useful in identifying the order of an autoregressive model (AR). The autoregressive process of order p denoted by AR(p) is defined as

$$X_t = \sum_{r=1}^{p} \alpha_r X_{t-r} + Z_t \qquad (5)$$

where $\alpha_1$, $\alpha_2$,....., $\alpha_p$ are fixed contants and $Z_t$ is a purely random process with mean 0 and variance $\delta^2$. The partial autocorrelation of an AR(p) process is zero at *lag* (p+1) and greater, if on the plot, there is only first two out of the band, then the process is identified as AR(2) where p is 2. At the model identification stage, our goal is to detect seasonality, if it exists, then we identify the order for the seasonal Auto Regressive (AR) and seasonal Moving Average (MA) terms. For Box-Jenkins models, we do not explicitly remove seasonality before fitting the model but instead we include the order of the seasonal terms in the model specification to the Auto Regressive Integrated Moving Average (ARIMA) estimation software. The Autoregressive Integrated Moving Average (ARIMA) model combines the methods of an AR and an MA on a differenced data. It is denoted by ARIMA (p, d, q) where p is order of autoregressive process, d is order of differencing and q is order of moving average process. In ARIMA each term represents steps taken in the model construction until only random noise remains. ARIMA can be used to model patterns that may not be visible in plotted data.

However, it may be helpful to apply a seasonal difference to the data and regenerate the autocorrelation and partial autocorrelation plots. This may help in the model identification of the non-seasonal component of the model. In some cases, the seasonal differencing may remove most or all of the seasonality effect.

Once stationarity and seasonality have been addressed, the next step is to identify the order of p and q of the autoregressive and moving average terms. The sample autocorrelation plot and the sample partial autocorrelation plot are compared to the theoretical behavior of these plots when the order is known. Specifically, for an AR (1) process, the sample autocorrelation function should have an exponentially decreasing appearance. However, higher-order AR processes are often a mixture of exponentially decreasing and damped sinusoidal components. This is usually determined by placing a 95% confidence interval on the sample partial autocorrelation plot (most software programs that generate sample autocorrelation plots will also plot this confidence interval). The Moving Average process of the order q denoted by MA(q) is defined as:

$$X_t = \beta_0 Z_t + \beta_1 Z_{t-1} + \beta_2 Z_{t-2} + .... + \beta_q Z_{t-q} \tag{6}$$

where $\beta_i$ are contants and $Z_t$ is a purely random process with mean 0 and variance $\delta^2$. The autocorrelation function of a MA (q) process becomes zero at *lag* (q+1) and greater, so we examine the sample autocorrelation function to see where it essentially becomes zero. We do this by placing the 95% confidence interval for the sample autocorrelation function on the sample autocorrelation plot.

Estimating the parameters for the Box-Jenkins models is a quite complicated non-linear estimation problem. The main approaches to fitting Box-Jenkins models are non-linear least squares and maximum likelihood estimation but the maximum likelihood estimation is generally the preferred technique.

Model diagnostics for Box-Jenkins models is similar to model validation for non-linear least squares fitting. The residuals should be white noise (or independent when their distributions are normal) drawings from a fixed distribution with a constant mean and variance. If the Box-Jenkins model is good for the data, the residuals should satisfy these assumptions. If these assumptions are not satisfied, we need to fit a more appropriate model. That is, we go back to the model identification step and try to develop a better model.

**Forecasting of the Time Series**

Forecasting involves making projections about future performance on the basis of historical and current data. When the result of an action is of consequence, but cannot be known in advance with precision, forecasting may reduce decision risk by supplying additional information about the possible outcome. Barrett and Kitska (1987) said "the forecast are not just show numbers; they are incorporated into the short-term and long-term business plans to which people willingly react."

Once data have been captured for the time series to be forecasted, the analyst's next step is to select a model for forecasting. Various statistical and graphic techniques may be useful to the analyst in the selection process. The best place to start with any time series forecasting analysis is to graph sequence plots of the time series to be forecasted. The purpose of the sequence plot is to give the analyst a visual impression of the nature of the time series. This visual impression would suggest to the analyst whether there are certain behavioral components such as trend and seasonality present within the time series. The presence or absence of such components can help the analyst in selecting the model with the potential to produce the best forecasts. After selecting a model, the next step is its specification. The process of specifying a forecasting model involves selecting the variables to be included, selecting the form of the equation of relationship, and estimating the values of the parameters in that equation. After the model is specified, its performance characteristics should be verified or validated by comparison of its forecasts with historical data for the process it was designed to forecast. Errors may be used for validating the model and it has an important effect on the conclusions whether the forecasting methods is most accurate.

Time-series forecasting assumes that a time series is a combination of a pattern and some random error. The goal is to separate the pattern from the error by understanding the pattern, its long-term increase or decrease, and its seasonality, the change caused by seasonal factors such as fluctuations in use and demand. Several methods of time series forecasting are available such as the Moving Averages method, Single Exponential Smoothing, Holt Exponential Smoothing and Winters Exponential Smoothing technique as applied to time series that exhibit seasonality

**Smoothing Techniques**

Smoothing data removes random variation or short term seasonal changes, but the trend may be somewhat obscured and difficult to observe. It is possible to eliminate many of these confounding factors by averaging of data over several time periods. This is accomplished by using certain smoothing techniques that remove random fluctuations in the series thereby providing a less obstructed view of the true behavior of the series. According to Diebold (2004), there are situations that the size of the available samples of data is sometimes very small then its associate degrees of freedom would be so limited that any estimated model is of dubious value. Smoothing is used for short term forecasting in practical situations.

Sincich (1991) states that exponential smoothed forecast are appropriate only when the trend and seasonal components of the series are relatively insignificant. The most common technique is moving average smoothing which replaces each element of the series by either the simple or weighted average of *n* surrounding elements, where *n* is the width of the smoothing "window" (Box & Jenkins, 1976; Velleman & Hoaglin, 1981). It will filter out the noise and convert the data into a smooth curve that is relatively unbiased by outliers. Medians can be used instead of means. The main advantage of median as compared to moving average smoothing is that its results are less biased by outliers (within the smoothing window). The main disadvantage of median smoothing is that in the absence of clear outliers it may produce more jagged curves than moving average and it does not allow for weighting.

**Moving Average Smoothing**

Another common approach for modeling univariate time series models is the moving average (MA) model. The MA model is of the form

$$X_t = \mu + A_t + \beta_1 A_{t-1} + \beta_2 A_{t-2} + ..... + \beta_q A_{t-q} \qquad (7)$$

where $X_t$ is the time series, $\mu$ is the mean of the series, $A_{t-i}$ are white noise, $\beta_i$ are constants and 1, ... , q are the parameters of the model. The value of q is called the order of the MA model. That is, a moving average model is conceptually a linear regression of the current value of the series against the white noise or random shocks of one or more prior values of the series. The distinction in this model is that these random shocks are even with the future values of the time series. Wilson and Keating (1994) said that the moving average smoothing technique of forecasting may be accurate to predict future values if the time series is a stationary one.

The moving average method calculates the average of the past observations and this average becomes the forecast for the next period. If we average the observations in pairs then we average observations one and two, two and three, three and four etc. so that the average steadily moves along the time period. We effectively replace each consecutive pair by a smoothed value located midway between the two points so that the smoothed series is out of phase with the original series. With a moving average based on just two observations we may still get a lot of fluctuations and not enough smoothing. If we average the observations three at a time, that is average observations one, two and three, then observations two, three and four etc., we will get a smoother curve. The more points we use to calculate the average, the smoother the curve we will get.

In general, $k$ is point moving average and is based on averaging $k$ adjacent time periods. How big should $k$ be? In order to decide on this we consider the fact that we lose some points at the beginning and end of the smoothed series. For example if $k = 3$, then the first three observations will give the first average and this average will be located at the middle of the interval, namely the second time period. Using the same reasoning, the last moving average will be located at the second to last time period. Thus, in effect, each point is replaced by the average of this point with the points before and after. This means that we have no smoothed points for the first and last time periods. If we average 5 points then we are short of two smoothed points at each end. We can, of course, use the original points at the ends or extend the smoothed curve at each end by eye. When *k* is an odd number, the smoothed series is on the middle of the number, however if *k* is an even number then an adjustment must be made because there is no middle observation at which the value is automatically centered. Since in moving averages the values at the end of the series are lost the graph has to be extended into the future before forecast could be made. So single exponential smoothing is more preferred.

**Single Exponential Smoothing**

Single exponential smoothing is a forecast tool in which the forecast is based on a weighted average of current and past values. It also provides an effective means of prediction. According to Wilson and Keating (1994), exponential smoothing contains self-correcting mechanism that adjusts forecasts in the opposite direction of past errors. The equation is:

$$F_{t-1} = \alpha B_t + (1-\alpha)F_t \qquad (8)$$

where $F_{t+1}$ is the forecast for the next time period

$B_t$ is the actual, observed value for the current time period

$F_t$ is the forecast previously made for the current time period

The α is a "smoothing constant" which is given a value between 0 and 1. According to Gardener (1985), a value of α smaller than 0.3 frequently yielded the best forecast and also that it is best to estimate an optimum α from the data rather than to guess and set artificial low value. Also he said to estimate the best α value, it is often chosen by a grid search of the parameter space. We take the value $F_{t+1}$ as the forecast for any future time period since the data do not trend up or down but fluctuate around some long run average. The major drawback of the single exponential smoothing forecasting method is that the secular trend seasonal components of a time series are not taken into account.

**Holt's Exponential Smoothing**

Holt (1957) introduced a method that was meant to be used for non-seasonal time series showing no trend but he later offered another procedure (1958) that does handle trends.

The Holt's two- parameter exponential smoothing method is an extension of simple exponential smoothing and it adds a trend factor to adjust the trend. Three equations and two smoothing constants are used in the model, given as follows:

$$F_{t+1} = \alpha X_t + \left(1 - \alpha\left(F_t + T_t\right)\right) \quad (9)$$

$$T_{t+1} = \gamma\left(F_{t+1} - F_t\right) + \left(1 - \gamma\right)T_t \quad (10)$$

$$H_{t+m} = F_{t+1} + mT_{t+1} \quad (11)$$

where:

$F_{t+1}$ = Smoothed value for the period t+1

α = Smoothing constant for the data (0< α<1)

$X_t$ = Actual value in the series for the period t

$F_t$ = Forecast (smoothed) value for time period t (which is also smoothed value for time period ($t-1$)

$T_{t+1}$ =Trend estimate

$\gamma$ =smoothing constant for the trend estimate ($0< \gamma<1$)

m =Number of periods ahead to be forecast

$H_{t+m}$ =Holt's forecast value for the period t+m

Equation (9) adjusts $F_{t+1}$ for the growth of the previous period, $T_t$ by adding $T_t$ to the smoothed value of the previous period, $F_t$. Equation (10) is for the calculation of trend estimate that is where the difference of the two smoothed values is calculated. The value $\gamma$ is arrived at by using the principle employed in simple exponential smoothing. The trend ($F_{t+1}$ - $F_t$ ) is weighted by $\gamma$ and $T_t$ is also weighted by (1- $\gamma$ ). The sum of the weighted values is the new smoothed trend value $T_{t+1}$. Equation (11) is also for the computation of the forecasts of the next m periods into the future that is by adding the product of $T_{t+1}$ and the number (m) of periods to forecast to the current value of the smoothed data, $F_{t+1}$. This method accurately accounts for any linear trend in the data.

**Winters' Exponential Smoothing**

Winters (1965) generalized the smoothing method to include seasonality; therefore it is used for data that exhibit both trend and seasonality. Wilson and Keating (1994) said if seasonality exist then the three-parameter exponential smoothing serve as a correction factor to Holt's model to adjust the seasonality. The Winters' model is as follows:

$$F_t = \alpha X_t \div S_{t-p} + (1-\alpha)(F_{t-1} + T_{t-1}) \quad (12)$$

$$S_t = \beta X_t \div F_t + (1-\beta)S_{t-p} \quad (13)$$

$$T_t = \gamma(F_t - F_{t-1}) + (1-\gamma)T_{t-1} \quad (14)$$

$$W_{t+m} = (F_t + mT_t)S_t \quad (15)$$

where:

$F_t$ = Smoothed value for the period t

α = Smoothing constant for the data (0< α<1)

$X_t$ = Actual value now (in period t)

$F_{t-1}$ = Average experience of series smoothed to period t-1

$T_{t+1}$ =Trend estimate

$S_t$ = Seasonality estimate

β = Smoothing constant for seasonality estimate

γ = Smoothing constant for trend estimate

m = Number of periods in the forecast lead period

p = Number of periods in the seasonal cycle

$W_{t+m}$ = Winters' forecast for m periods into the future

In Equation (12), $X_t$ is divided by $S_{t-p}$ to adjust for seasonality and it is used to deseasonalize the data or remove any seasonal effects left in the data. Equation (13) and Equation (14) smoothed the seasonality estimate and trend estimate respectively. Finally Equation (15) is used to compute the forecast for m periods into the future. Winter's Exponential Smoothing is best used when both a linear trend and seasonality appear in the data.

**Accuracy measures**

The accuracies check is often employed to determine whether or not the current forecasting models fit the data. To evaluate accuracy of these techniques the following could be used:

Mean Absolute Deviation (MAD): The mean absolute deviation measures the mean absolute deviation. It is calculated by

$$\sum_{i=1} \frac{|X_i - X_t|}{n}$$

Where $X_i$ is the actual value for the $i^{th}$ observation in the series and $X_t$ is the forecasted value for this observation.

Mean Absolute Percentage Error (MAPE): The better measure of relative overall fit is the mean absolute percentage error. This measure is usually more meaningful and interpretable than the Mean Squared Error (MSE). It is calculated by

$$\frac{100}{n} \sum_{i=1} \frac{|X_i - X_t|}{X_i}$$

Where $X_i$ is the actual value for the $i^{th}$ observation in the series and $X_t$ is the forecasted value for this observation.

Sum of Squared Error (SSE) or Mean Squared Error (MSE): These values are computed as the sum (or average) of the squared error values. This is the most commonly used lack-of-fit indicator in statistical fitting procedures. It is given by

$$\sum_{i=1} \frac{(X_i - X_t)^2}{n}$$

Where $X_i$ is the actual value for the $i^{th}$ observation in the series and $X_t$ is the forecasted value for this observation.

Root Mean Squared Error (RMSE) is used to evaluate the relative accuracy of the various forecasting methods. The RMSE is easy to interpret and is the most commonly used measure. It is given by $\sqrt{MSE}$ , the square root of the mean square error

# CHAPTER THREE

## PRELIMINARY ANALYSIS

The analysis involves the Consumer Price Index (CPI) for the period, 1964 to 2009 from the Price Section, Ghana Statistical Service (GSS). The chapter looks at the graphical and tabular exploration of yearly and monthly CPI from 1964 to 1997 which constitute the (old series) and from 1998 to 2009, constituting the (new series).

### Analysis of CPI for the period 1964 to 1997 (Old Series)

Table 1 presents the annual percentage changes of the CPI. We observed that the index recorded 119.69 in 1965 and escalated to 86,882.24 in 1997 an increase of 72,488.38 percent. The index recorded an increase of 26.42 percent in 1965 over 1964. The index fell over the years until 1975 which recorded 29.68 percent and also recorded an increase of 56.84 percent in 1976 over 1975.

In 1977, the index recorded an increase of 116.25 percent over 1976 and it increases to 122.82 percent in 1983. The index again fell until 1995 which recorded 59.46 percent and it also recorded negative values in 1967(-8.37 percent) and 1978 (-87.48 percent).

From Table 1, the highest inflation rate of 121.35 percent over the twelve month period was recorded in the year 1983 followed by 116.88 percent in the year 1981 and 113.24 in 1977. Whilst the lowest inflation rate of -87.09 percent occurred in year 1978, -8.27 percent in the year 1967 and 3.75 in 1970.

**Table 1: Yearly analysis of the Consumer Price Index (CPI) for the old series**

| | Consumer Price Index | | | Inflation over 12 months | | |
|---|---|---|---|---|---|---|
| Year | Combined | Food | Non-Food | Combined | Food | Non-Food |
| Weights | 100.00 | 51.90 | 48.10 | % | % | % |
| 1964 | 119.69 | 125.72 | 113.19 | 12.32 | 14.82 | 9.58 |
| 1965 | 151.31 | 172.67 | 128.26 | 26.26 | 37.12 | 13.24 |
| 1966 | 171.38 | 198.98 | 141.59 | 13.94 | 16.13 | 10.81 |
| 1967 | 157.03 | 169.62 | 143.44 | -8.27 | -14.58 | 1.37 |
| 1968 | 169.63 | 184.26 | 153.85 | 8.11 | 9.13 | 7.28 |
| 1969 | 181.80 | 200.03 | 162.13 | 7.30 | 8.82 | 5.40 |
| 1970 | 188.51 | 210.04 | 165.27 | 3.75 | 5.15 | 1.96 |
| 1971 | 205.98 | 236.11 | 173.48 | 9.22 | 12.28 | 4.96 |
| 1972 | 226.72 | 259.35 | 191.51 | 10.21 | 10.08 | 10.41 |
| 1973 | 266.43 | 313.35 | 215.81 | 17.57 | 21.18 | 12.78 |
| 1974 | 315.33 | 354.33 | 273.24 | 18.56 | 13.73 | 26.36 |
| 1975 | 408.91 | 473.59 | 339.11 | 29.36 | 34.80 | 25.01 |
| 1976 | 639.29 | 805.59 | 459.85 | 55.65 | 68.72 | 35.80 |
| 1977 | 1382.48 | 2033.86 | 679.65 | 113.24 | 148.33 | 46.67 |
| 1978 | 173.09 | 159.41 | 186.34 | -87.09 | -91.62 | -72.85 |
| 1979 | 267.33 | 257.74 | 276.61 | 60.33 | 63.86 | 58.74 |
| 1980 | 401.18 | 392.79 | 409.29 | 51.71 | 53.18 | 50.93 |
| 1981 | 868.72 | 828.46 | 907.71 | 116.88 | 111.80 | 121.62 |
| 1982 | 1062.46 | 1126.38 | 1000.55 | 24.56 | 36.94 | 13.92 |
| 1983 | 2367.39 | 2671.29 | 2039.48 | 121.35 | 136.04 | 102.95 |
| 1984 | 3304.18 | 3058.53 | 3569.23 | 48.75 | 23.23 | 89.94 |
| 1985 | 3647.17 | 2801.08 | 4560.10 | 10.72 | -5.82 | 28.24 |
| 1986 | 4543.08 | 3268.75 | 5918.07 | 24.44 | 17.37 | 30.27 |
| 1987 | 6351.90 | 4527.12 | 8320.85 | 39.81 | 38.41 | 40.70 |
| 1988 | 8343.84 | 6071.05 | 10796.19 | 31.48 | 34.24 | 29.85 |
| 1989 | 10449.32 | 7593.83 | 13530.40 | 25.24 | 25.12 | 25.32 |
| 1990 | 14341.49 | 10642.02 | 18333.23 | 37.18 | 40.06 | 35.43 |
| 1991 | 16927.44 | 11596.77 | 22679.25 | 18.45 | 9.62 | 24.07 |
| 1992 | 18629.81 | 12800.44 | 24275.59 | 10.03 | 10.38 | 7.04 |
| 1993 | 23279.70 | 15994.56 | 30335.40 | 24.90 | 24.93 | 24.89 |
| 1994 | 29069.43 | 20126.33 | 37714.46 | 24.72 | 25.62 | 24.22 |
| 1995 | 46354.65 | 32660.92 | 59617.10 | 58.55 | 61.30 | 57.22 |
| 1996 | 67937.77 | 44344.94 | 90787.59 | 48.62 | 38.63 | 53.95 |
| 1997 | 86882.24 | 53630.81 | 119086.40 | 28.05 | 20.98 | 31.43 |

Source: Ghana Statistical Service

### Graphical Analysis of Yearly Consumer Price Index

Figure 1 shows the pattern of yearly Consumer Price Index between 1964 and 1997. It may be observed that there was an upward trend from 1964 to 1997.

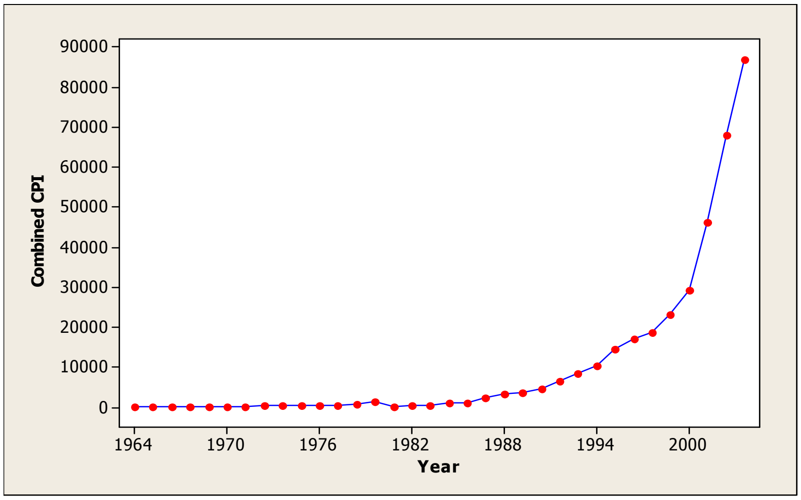


Figure 1: A plot of yearly combined CPI

### Graphical Analysis of Combined Monthly Consumer Price Index

Figure 2 shows the pattern of monthly Consumer Price Index from 1964 to 1997

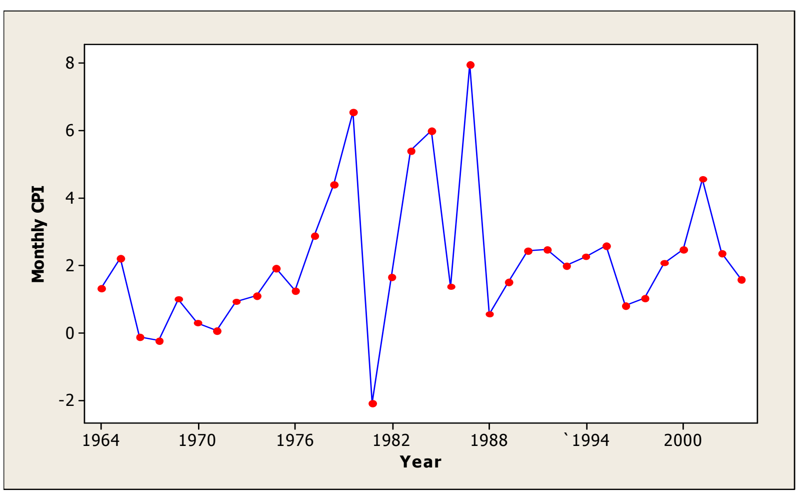


Figure 2: A plot of monthly combined CPI.

We observed that there was a rise in 1965 and then fall in 1966 and 1967. It rose slightly in 1968 and oscillates until 1977, when it rises sharply and falls steeply in 1981. The graph rose again in1983 and then oscillates and finally fall.

Generally, there is a lot of oscillations in the period under review. The graph shows a cyclical pattern due to some unforeseen circumstances like the government increasing the prices of petroleum products which further increased the prices of goods and services and therefore increased the CPI in that period. Also, unfavourable climatic change experienced during 1983 caused a rise in the prices of food items and subsequently increasing the CPI for that period.

**Analysis of CPI for the period 1998 to 2009 (New Series)**

From Table 2 the yearly analysis of the CPI for the new series, the index recorded 114.62 in 1998 and increased to 303.93 in 2009 an increase of 165.15 percent. The index recorded an increase of 12.45 percent in 1999 over the level in 1998 and 25.15 percent in 2000 over that of the level in 1999. It also increased to 32.91 percent in 2001 from the level in 2000. In February 2003, the governments' intensions to regulate the petroleum sector resulted in about 90 percent upward adjustment in the prices of petroleum products. This resulted in an increase in the price of certain goods and services especially, products in the transport and communication sub-sector and this caused a spiral increases in the prices of most food items. The index in 2003 went up to 26.68 percent over the level in 2002. This was mainly due to the large increase in the non-food index (29.74%) as against the food index (24.04%).

In 2005, specifically in February petroleum prices was increased by about 50% and the ex-pump price of petrol went up by 52.6 percent thus affecting the prices of goods and services so the Consumer Price Index rose by 15.11 percent over the level in 2004. In 2006 the index decreased to 10.91percent and recorded a negative value of -51.22 percent in 2007. The index again went to 16.52 percent in 2008 over the level in 2007 (for details refer to Appendix1). From Table 2, apart from 1998 and 1999 in which the food component was a little higher than the non-food component, the rest of the years recorded a higher value in the non-food component than the food component. From the table below the highest inflation rate of 33.59 percent over the twelve month period was recorded in the year 2001 followed by 24.94 percent in the year 2000 and the lowest inflation rate of 10.73 percent occurred in year 2007 and 10.95 percent in the year 2006.

**Table 2: Yearly analysis of the Consumer Price Index (CPI) for the new series**

| | Consumer Price Index | | | Inflation over 12 months | | |
|---|---|---|---|---|---|---|
| Year | Combined | Food | Non-Food | Combined | Food | Non-Food |
| Weights | 100.00 | 51.90 | 48.10 | % | % | % |
| 1998 | 114.62 | 119.76 | 110.00 | 16.61 | 21.65 | 12.00 |
| 1999 | 128.89 | 130.22 | 127.60 | 12.51 | 8.97 | 15.95 |
| 2000 | 161.31 | 145.62 | 175.51 | 24.94 | 11.87 | 37.02 |
| 2001 | 214.39 | 179.42 | 246.13 | 33.59 | 23.39 | 41.57 |
| 2002 | 246.15 | 213.18 | 275.89 | 14.91 | 18.77 | 12.33 |
| 2003 | 311.81 | 264.43 | 357.93 | 26.68 | 24.09 | 29.71 |
| 2004 | 351.19 | 308.37 | 393.92 | 12.75 | 16.65 | 10.34 |
| 2005 | 404.27 | 356.29 | 451.33 | 15.09 | 15.55 | 14.55 |
| 2006 | 448.39 | 388.66 | 509.44 | 10.95 | 9.19 | 12.86 |
| 2007 | 218.73 | 206.45 | 228.73 | 10.73 | 9.46 | 11.68 |
| 2008 | 254.87 | 237.76 | 268.81 | 16.46 | 15.10 | 17.47 |
| 2009 | 303.93 | 275.05 | 327.47 | 19.29 | 15.78 | 21.83 |

Source: Ghana Statistical Service

## Graphical Analysis of Yearly and Combined Monthly Consumer Price Index

Figure 3 shows the pattern of yearly (CPI) between 1998 and 2009. There was an upward trend from 1998 to 2006, then fell in 2007 and rose again.

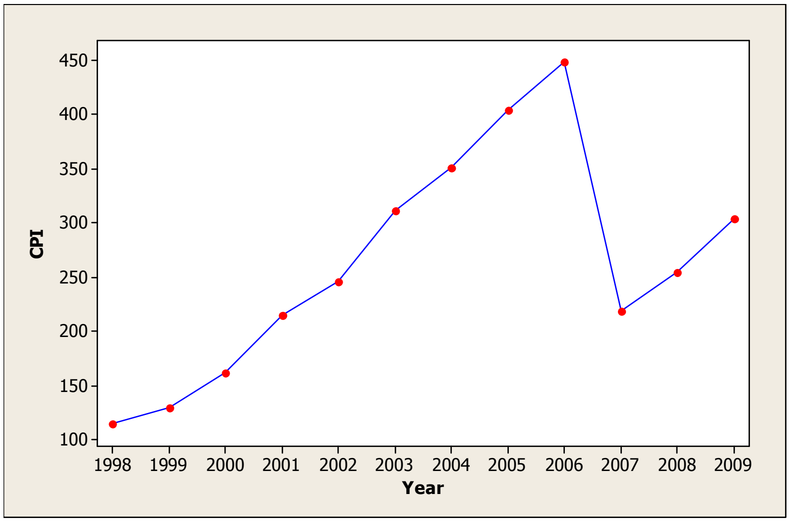


Figure 3: A plot of yearly combined CPI

Figure 4 shows the pattern of monthly (CPI) from 1998 to 2009

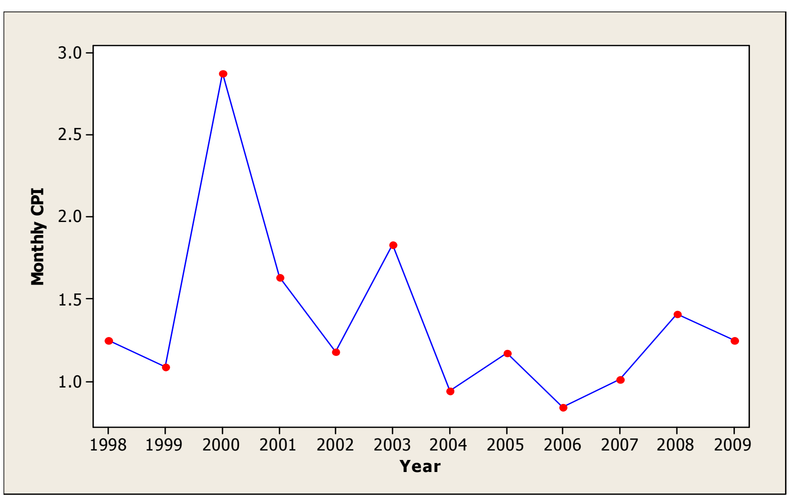


Figure 4: A plot of monthly combined CPI

We observed that there was a sharp rise from 1999 to 2000, then fall in 2001 and 2002. In 2003 it rises and then falls again in 2004 and 2006. In 2007 and 2008 it rises and then falls in 2009.

**Trend Analysis of the Consumer Price Index (CPI)**

**Trend Analysis of the (CPI) for the period 1964 to 1997**

The trend analysis used in this section was to forecast the yearly CPI figures for the next four- year period. Figure 5 is the trend analysis of the yearly CPI

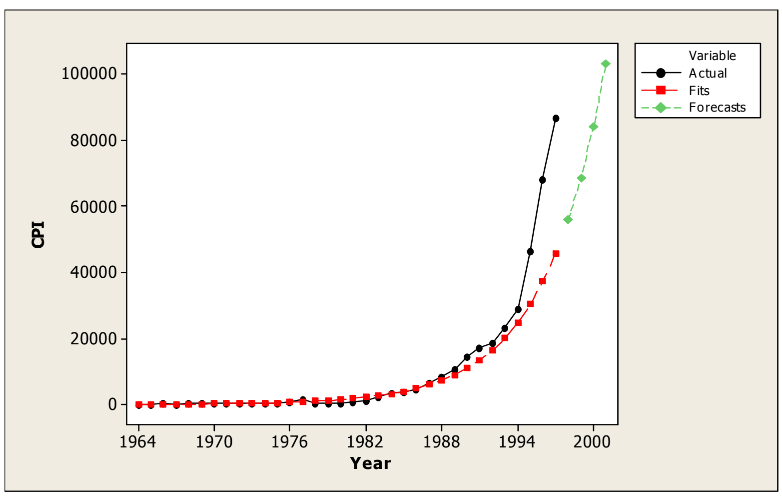


Figure 5: Trend Analysis of the Consumer Price Index of the Old Series

The fitted trend model for predicting the expected yearly CPI is

$$Y_t = 43.8907 * (1.22659 * * t)$$

The above equation shows that the average change of CPI from one year to the other is 43.89 percent and it has an upward trend. The trend model appears to fit well to the actual data. The forecast from the trend analysis for the next four years is shown in Table 3.

**Table 3: Forecast Figures for the CPI**

| Period | Forecast |
|---|---|
| 1998 | 55827 |
| 1999 | 68477 |
| 2000 | 83993 |
| 2001 | 103026 |

**Trend Analysis of the (CPI) for the period 1998 to 2009**

Figure 6 is the trend analysis of the yearly CPI

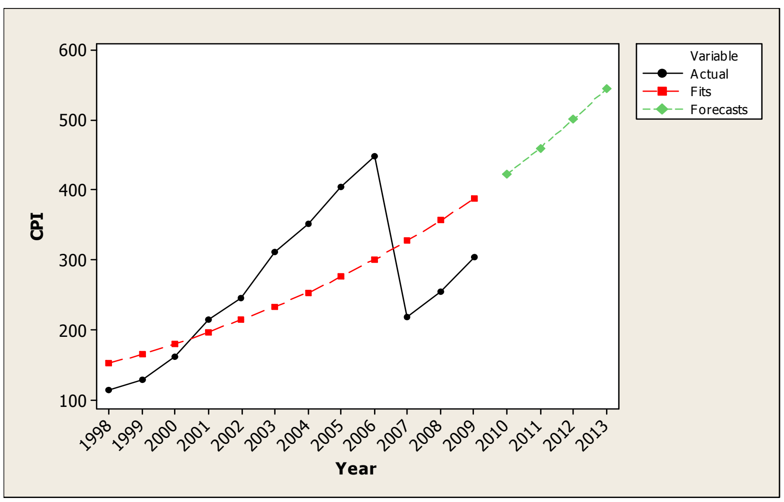


Figure 6: Trend Analysis of the Consumer Price Index of the New Series

The fitted trend model for predicting the expected yearly CPI is

$$Y_t = 139.882 * (1.08865 * * t)$$

The trend model does not fit well to the actual data. To better fit this data, we consider decomposition on the stored residuals and add the trend analysis.

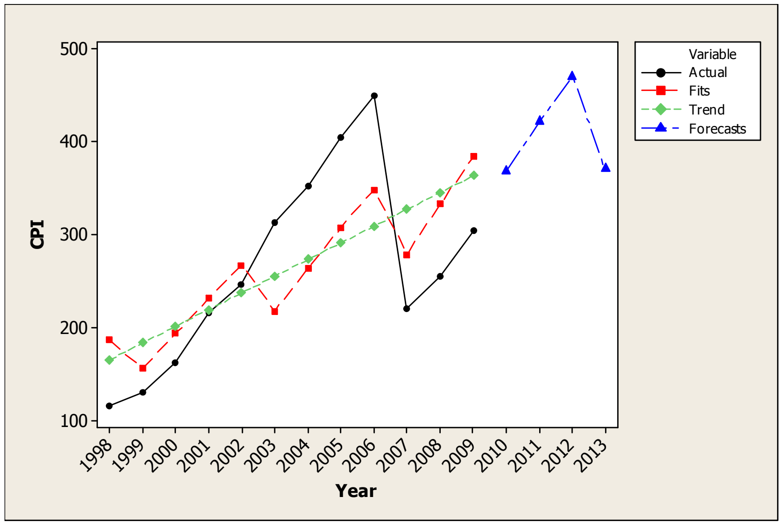


Figure 7: Time Series Decomposition plot for CPI

Decomposition is used to separate the time series into seasonal components and since the CPI possess some seasonality it is better to fit by decomposition using MINITAB software. From the time series plot it shows that the combined fits from the trend analysis and decomposition are close to the actual CPI values. So we use it to forecast the CPI for the new series and it is shown in Table 4.

**Table 4: Forecast Figures from the Decomposition**

| Period | Forecast |
|---|---|
| 2010 | 367.059 |
| 2011 | 420.975 |
| 2012 | 469.756 |
| 2013 | 370.288 |

We also consider the curve estimation analysis on the CPI data for both the old and new series. For the curve fit we need many points to plot, therefore the CPI data was put into quarterly data.

**Curve estimation analysis for the CPI for the period 1964 to 1997**

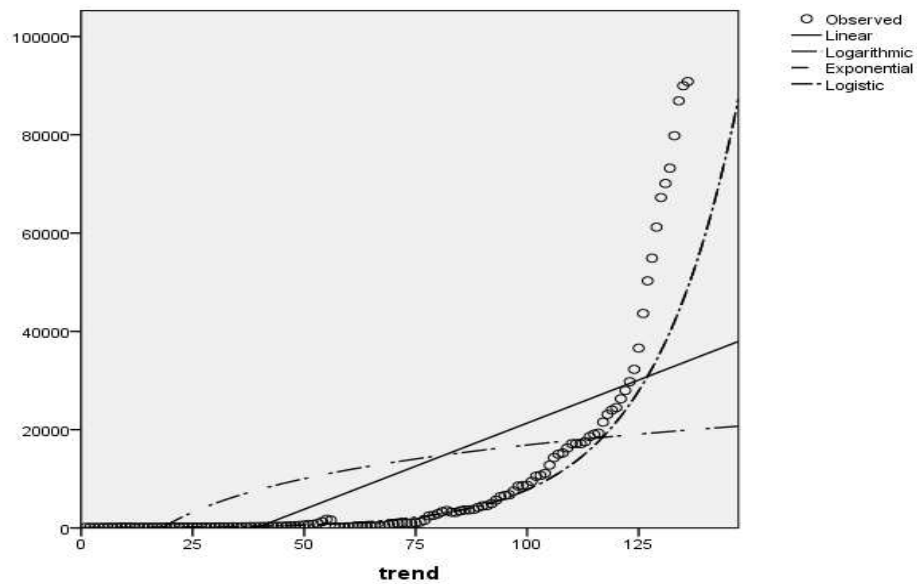


Figure 8: Quarterly curve fit for the CPI (old series)

From Figure 8, it appears that the exponential model best follows the shape of the data. From the model summary, the linear, logarithmic and exponential models are all significant since they are less than 0.05 (Appendix 7), which means that the variation explained by the model is not due to chance. It shows that the R Square of 92% of the variation was explained by the exponential model and the positive value for the exponential term suggests that the CPI increases with time (Appendix7).

**Curve estimation analysis for the CPI for the period 1998 to 2009**

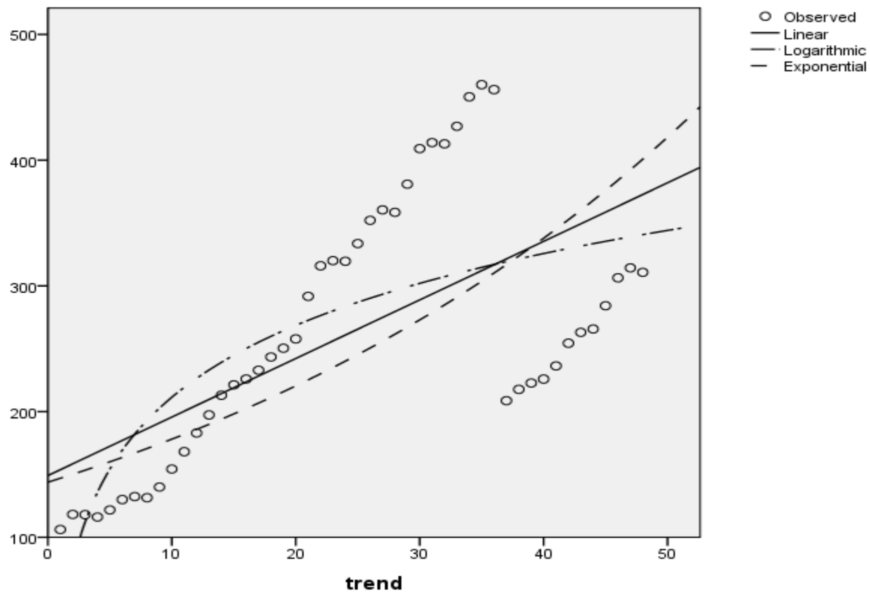


Figure 9: Quarterly curve fit for the CPI (new series)

From the plot, it appears that both the exponential and the logarithmic model follows the shape of the data. From the model summary, the linear, logarithmic and exponential models are all significant since they are less than 0.05, which means that the variation explained by the model is not due to chance. It shows that 50% of the variation was explained by the exponential and the logarithmic models and the positive values for the constant terms suggest that the CPI increases with time (Appendix7).

The preliminary analysis has shown that for the old series the index recorded an increase of 72488.38 percent from 1965 to 1997 and the yearly CPI had an upward trend. It also revealed that the average change of the CPI from one year to the other is 43.89 percent. The curve fit shows that 92 percent of the variation was explained and the positive value for the exponential term suggests that the CPI increases with time.

For the new series (1998-2009), the index recorded an increase of 165.15 percent and the yearly CPI had an upward trend from 1998 to 2006 then fell in 2007 and rose again. The average change of the CPI from one year to the other is 139.88 percent. The curve fit shows that 50 percent of the variation was explained and the positive value for the exponential term suggests that the CPI increases with time.

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# CHAPTER FOUR

# FURTHER ANALYSIS

There are four basic smoothing techniques which are empirical to estimate and test based on some accuracy measures. The most precised way of evaluating the accuracy of the forecasts based on particular values is to plot the observed values and the forecasts. In this chapter a model will be provided for each of the two periods.

**Analysis of CPI for the period 1964 to 1997 (old series)**

**Moving Average (MA) Smoothing of the Consumer Price Index (CPI)**

In order to identify the long-term trend of the series we need to average or smooth out the seasonal fluctuations so we calculate 3-point moving average. According to Wilson and Keating (1994) the choice of the interval for the moving average depends upon the length of the underlying cycle or pattern in the original data. The moving average is shown in Appendix 3

The computations are done using the equation

$$M_1 = \frac{y_1 + y_2 + y_3}{3}$$

for the first moving average and the second moving is given by

$$M_2 = \frac{y_2 + y_3 + y_4}{3}$$

and so on. The ratio

$$R_t = \frac{Y_t}{M_t}$$

is then calculated to find the seasonal index for each period. Sincich (1991) shows a formula for the forecast of a particular quarter as:

$$F_t = M_t \times (\text{Seasonal index of the quarter}) = M_t \times S_t \qquad (16)$$

where $F_t$ is the forecast for $Y_t$

Figure 10 shows the plot of both the CPI and the three (3) moving average.

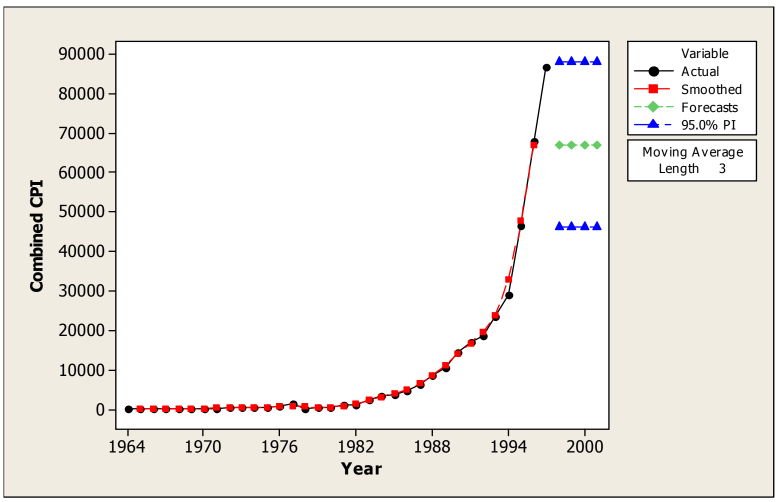


Figure 10: A plot of the CPI and moving average smoothing

In Figure 10, we can observe that the moving average $M_t$ curve is smoother than the actual CPI $Y_t$ curve. We have to calculate the seasonal index for each of the years before any forecast could be made and the last column of Appendix 3 gives the average of each year ratios thus giving the seasonal index for the year.

**Single exponential smoothing of the CPI**

The smoothing constant α value was 1.87 generated by the MINITAB. The optimal α value generated provides forecast of CPI values as well as 95% confidence limits for each forecast. Also α value produced measures of accuracy for determining the extent of strength of the smoothing methods. Below is Figure 11 showing the single exponential smoothing and the consumer price index.

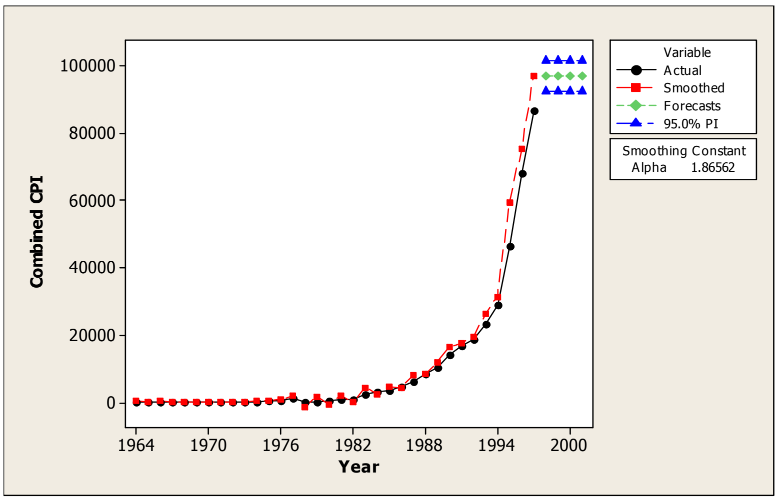


Figure 11: A plot of single exponential smoothing with forecasts

The forecast and the confidence limits for the years in 1998 and 2001 have been shown in Table 5. From Equation (8), the calculations of the forecast values for the year1998 that is t = 35 is given by:

$F_t = 1.86562A_t - 0.86562Y_t$

$F_{35} = 1.86562(86882.2) - 0.86562\ (75386.9) = 96832.76$

The forecast CPI for the 1998 is 96832.76 and other future CPI will all be the same as 96832.76 shown in the Table 5.

**Table 5: Single exponential smoothing forecast figures**

| Period | Forecast | Lower | Upper |
|---|---|---|---|
| 1998 | 96832.8 | 92243.2 | 101422 |
| 1999 | 96832.8 | 92243.2 | 101422 |
| 2000 | 96832.8 | 92243.2 | 101422 |
| 2001 | 96832.8 | 92243.2 | 101422 |

The forecast CPI for each year is 96832.8 percent and the limits lies within 92243.2 and 101422 with 95% confidence level.

**Holt's Exponential Smoothing of the Consumer Price Index**

Holt's exponential smoothing is used to adjust the model for any trend in the data. From the MINITAB software the two smoothing constants $\alpha$ and $\gamma$ is given as 1.04183 and 1.20991 respectively. A computation could be made for the period 4 (1967), so t+1 = 4 for consumer price index value.

From Equations 9, 10 and 11 we have the smoothed value for the year 1967 as:

$$F_{t+1} = 1.04183\, X_t + (1- 1.04183)(F_t + T_t)$$

$$F_4 = 1.04183\, X_3 + (-0.04183)(F_3 + T_3)$$

The values of $X_{3,}$ $F_3$ and $F_4$ can be found in Appendix5,

but $T_3 = 171.4- 151.3= 20.1$

$$F_4 = 1.04183\,(157.0) + (-0.04183)(171.4+20.1)$$

$$F_4 = 155.556865$$

$$T_{t+1} = 1.20991(F_{t+1} - F_t) + (1- 1.20991)\, T_t$$

$T_4$ = 1.20991 (155.556865 –170.9) +- 0.20991 (20.1)

$T_4$ = -22.78300

The forecast for the 1967 is calculated as

$H_{t+m} = F_{t+1} + m\ T_{t+1}$

$H_4 = F_4 + 1\ T_4$

$H_4$ = 155.556865 + 1(-22.78300)

$H_4$ = 132.773865

The actual forecast CPI value for the 1967 is 132.773865. The subsequent year values are also derived in the same way.

The run sequence plot of the Holt's exponential smoothing is shown below.

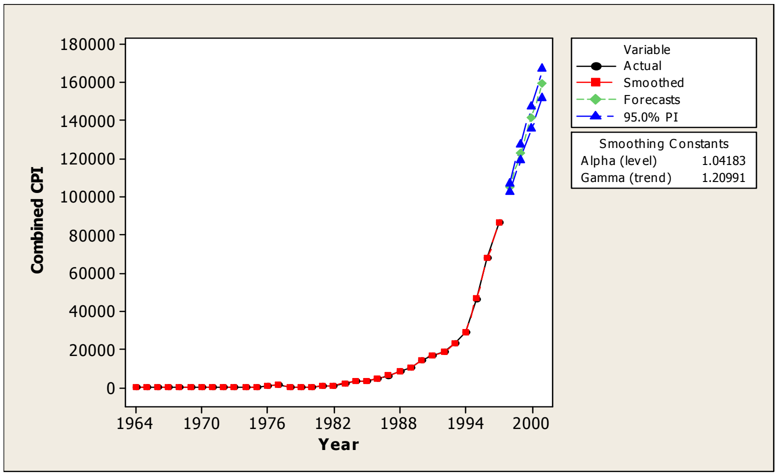


Figure 12: A run plot of Holt's exponential smoothing and the CPI with forecasts

The smoothed techniques allows for an extension of the graph to cover the forecast figures from the 1998 to 2001. The forecast has been provided within 95% confidence limits shown in Table 6.

**Table 6: Forecast figures from Holt's Exponential Smoothing**

| Period | Forecast | Lower | Upper |
|---|---|---|---|
| 1998 | 105066 | 102745 | 107387 |
| 1999 | 123351 | 119265 | 127436 |
| 2000 | 141635 | 135733 | 147537 |
| 2001 | 159919 | 152185 | 167654 |

From the Table 6, the forecast for each year could be calculated. For instance the forecast for 1999 is (123351 ± 4085) percent and the forecast for 2001 is (159919 ± 7735) percent respectively.

**Winters' Exponential Smoothing of the Consumer Price Index**

If there exist some sort of seasonality in the data then Winters' three-parameter model which is an extension of Holt's model is useful. It helps to adjust for the seasonality present in the original data. From the yearly plot in Figure 13 we observed that there are some seasonal patterns so the Winters' smoothing techniques would be appropriate. For instance the computations could be made for the 1973 with smoothing constants $\alpha = 0.2$, $\beta = 0.2$ and $\gamma = 0.2$ from the MINITAB software.

From Equations 12, 13 and 14 we have:

$$F_t = \alpha X_t \div S_{t-p} + (1-\alpha)(F_{t-1} + T_{t-1})$$

But the initial values required, are set at:

$F_1$ =26.3, $T_1$ =31.08 and $S_1$ =0.40949 because we are using yearly data.

The calculations required obtaining $F_{10}$, the smoothed value for the year 1973 is:

$F_{10} = 0.2X_{10} / S_9 + 0.8 (F_9 + T_9)$

$= 0.2(266.4) / 2.07131 + 0.8 (728.4+ 4.59)$

$= 25.722852 + 586.392$

$F_{10} = 612.115$

The values used can be seen in Appendix 6

The seasonality estimate for 1973, $S_{10}$ is thus calculated as:

$$S_t = \beta X_t \div F_t + (1-\beta)S_{t-p}$$

$S_{10} = 0.2X_{10} / F_{10} + 0.8S_9$

$= 0.2(266.4) /612.11485 + 0.8 (2.07131)$

$= 53.28/ 612.11485 +1.657048$

$S_{10} = 1.7441$

The trend estimate for 1973, $T_{10}$ is calculated as:

$$T_t = \gamma(F_t - F_{t-1}) + (1-\gamma)T_{t-1}$$

$T_{10} =0.2(F_{10} – F_9) + 0.8T_9$

$= 0.2(612.11485-728.4) +0.8(4.59)$

$T_{10} = -19.58403$

The forecast for 1973, $F_{11}$ could be made as follows:

$W_{t+m} = (F_t + mT_t)S_t$ for m=1 as

$W_{11} = (F_{10} + 1 \times T_{10})S_{10}$

$= (612.11485 + 1\,(-19.58403)1.7441$

$W_{11} = 1033.4330$

The actual forecast CPI value for the year 1973 is 1033.4330. The subsequent year values are also derived in the same way.

The run sequence plot of the Winters' exponential smoothing is shown below in Figure 13.

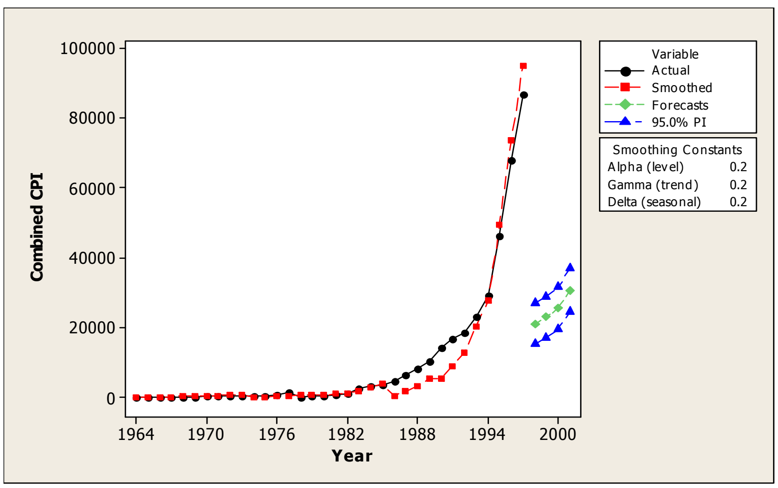


Figure 13: A plot of the CPI and Winters' exponential smoothing with forecasts

The forecasts values for 1998 to 2001 and also 95% confidence limits have been provided in Table 7.

**Table 7: Forecast figures from Winters' Exponential Smoothing**

| Period | Forecast | Lower | Upper |
|---|---|---|---|
| 1998 | 1199.9 | 15363.6 | 27036.2 |
| 1999 | 23095.1 | 17167.3 | 29022.9 |
| 2000 | 25622.0 | 19592.3 | 31651.7 |
| 2001 | 30823.6 | 24681.9 | 36965.2 |

From Table 7, the forecast for each year could be calculated.

**Accuracy Measures for the Smoothing Techniques of the Consumer Price Index**

After considering all the smoothing techniques it is very necessary to select the technique that will best fit the time series of the consumer price index. To be able to do this, a summary of the measures of accuracy for the smoothing techniques is shown in Table 8.

**Table 8: Accuracy Measures of Smoothing Techniques (old series)**

| Smoothing Technique | MAPE | MAD | MSD |
|---|---|---|---|
| Moving Average | 51 | 4,836 | 114,332,999 |
| Single Exponential | 102 | 1873 | 14,243,368 |
| Holt's Exponential | 75 | 947 | 4,931,872 |
| Winters' Exponential | 71 | 2382 | 19,405,109 |

From Table 8 the Holt's exponential smoothing has the least value for both the Mean Absolute Deviation and Mean Square Deviation. It also had second smallest value for the Mean Abolute Percentage Error therefore it confirms the first result. Based on the accuracy measures in Table 8, the most appropriate smoothing technique for the forecast of the Consumer Price Index for the old series is the Holt's Exponential Smoothing.

**Analysis of CPI for the period 1998 to 2009 (new series)**

**Moving Average (MA) Smoothing of the Consumer Price Index (CPI)**

Figure 14 shows the plot of both the CPI and the three (3) moving average.

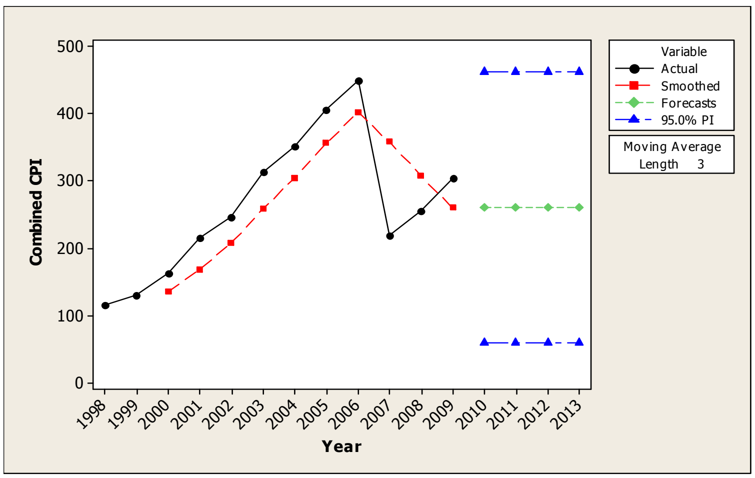


Figure 14: A plot of the CPI and moving average smoothing

In Figure 14, we can observe that the moving average $M_t$ curve is smoother than the actual CPI $Y_t$ curve. We have to calculate the seasonal index for each of the years before any forecast could be made. The last column of Appendix 3 gives the average of each year ratios thus giving the seasonal index for the year.

**Single exponential smoothing of the CPI**

The smoothing constant α value was 0.93 generated by the MINITAB Microsoft. The optimal α value generated provides forecast of CPI values as well as 95% confidence limits for each forecast. Also α value produced measures of accuracy for determining the extent of strength of the smoothing methods. Below is Figure 15 showing the single exponential smoothing and the consumer price index.

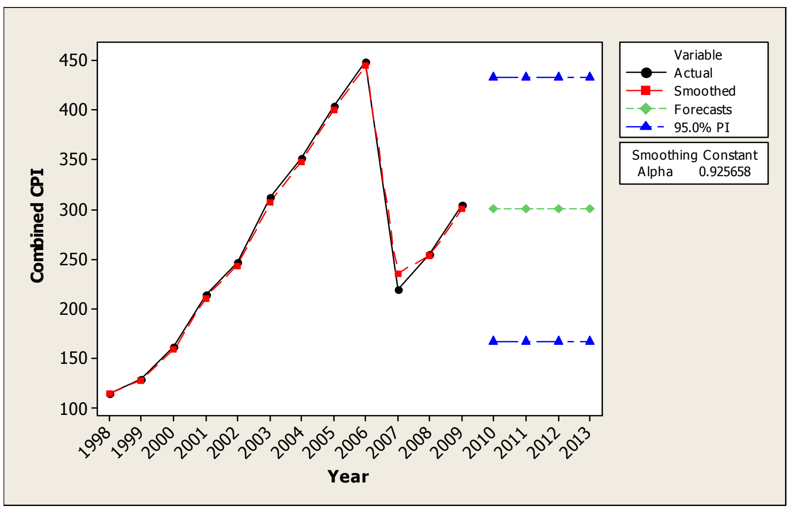


Figure 15: A plot of single exponential smoothing with forecasts

The forecast and the confidence limits for the years in 1998 and 2013 have been shown in Table 9. From Equation (8), the calculations of the forecast values for the year 2010 (ie. t = 13) is given by

$F_t = 0.925658A_t + 0.074342Y_t$

$F_{13} = 0.925658(303.93) + 0.074342 (253.433) = 300.1760$

The forecast CPI for the 2010 $F_{13}$, is therefore 300.176 and other future CPI will all be the same as 300.176 shown in Table 9.

**Table 9: Single exponential smoothing forecast figures**

| Period | Forecast | Lower | Upper |
|---|---|---|---|
| 2010 | 300.176 | 166.703 | 433.649 |
| 2011 | 300.176 | 166.703 | 433.649 |
| 2012 | 300.176 | 166.703 | 433.649 |
| 2013 | 300.176 | 166.703 | 433.649 |

The forecast CPI for each year is 300.176 and the limits lies within 166.703 and 433.649 with 95% confidence level.

**Holt's Exponential Smoothing of the Consumer Price Index**

From the MINITAB the two smoothing constants $\alpha$ and $\gamma$ is given as 0.779852 and 0.244980 respectively. A computation could for instance be made for the period 3 (2000) in Table 2, so t+1 = 3 for consumer price index value.

From Equations 9, 10 and 11 we have the smoothed value for the year 2000 as:

$$F_{t+1} = 0.779852\, X_t + (1- 0.779852)(F_t + T_t)$$

$$F_3 = 0.779852\, X_2 + (0.220148)(F_2 + T_2)$$

The values of $X_2$, $F_2$ and $F_3$ can be found in Appendix 5, but $T_2$ = 128.89-114.62=14.27 before the forecast value for the year 2000 we need the values of $F_3$ and $T_3$.

$$F_3 = 0.779852\,(128.89) + (0.220148)(121.747+14.27)$$

$$F_3 = 130.45899$$

$$T_{t+1} = 0.244980(F_{t+1} – F_t) + (1- 0.244980)\ T_t$$

$$T_3 = 0.244980\ (8.71199) + 0.75502\ (14.27)$$

$$T_3 =12.9083999$$

The forecast for the 2000 is calculated as

$$H_{t+m} = F_{t+1} + m \times T_{t+1}$$

$$H_3 = F_3 + 1\times\ T_3$$

$$H_3 = 130.45899 + 1\times(12.9083999)$$

$$H_3 = 143.3673899$$

The actual forecast CPI value for the 2000 is 143.3674. The subsequent year values are also derived in the same way.

The run sequence plot of the Holt's exponential smoothing is shown below.

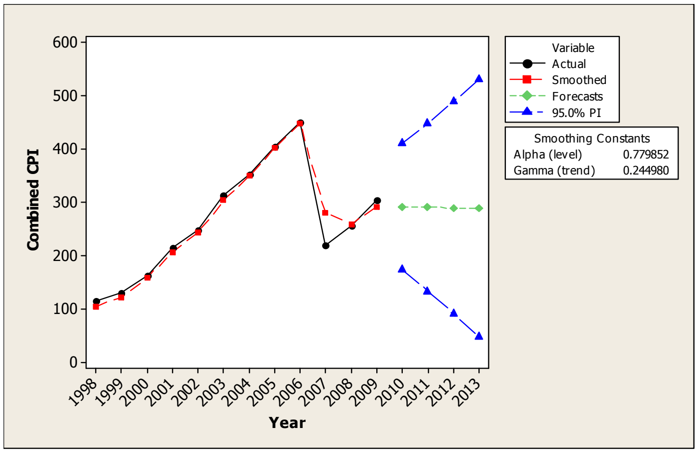


Figure 16: A run plot of Holt's exponential smoothing and the CPI with forecasts

The smoothed techniques allows for an extension of the graph to cover the forecast figures from the 2010 to 2013. The forecast has been provided within 95% confidence limits shown in Table 10.

**Table 10: Forecast figures from Holt's Exponential Smoothing**

| Period | Forecast | Lower | Upper |
|---|---|---|---|
| 2010 | 290.411 | 171.857 | 408.964 |
| 2011 | 289.600 | 132.525 | 446.676 |
| 2012 | 288.790 | 90.218 | 487.362 |
| 2013 | 287.980 | 46.466 | 529.494 |

From Table 10, the forecast for each year could be calculated. For instance the forecast for 2011is (289.600 ± 157.076) and the forecast for 2013 is (287.980 ± 241.514) respectively.

**Winters' Exponential Smoothing of the Consumer Price Index**

For instance the computations could be made for the 2002 with smoothing constants α = 0.2, β = 0.2 and γ = 0.2 from the MINITAB software.

From Equations 12, 13 and 14 we have:

$$F_t = \alpha X_t \div S_{t-p} + (1-\alpha)(F_{t-1} + T_{t-1})$$

But the initial values required are set at:

$F_1$ =67.438, $T_1$ =21.7905 and $S_1$ =0.50717 because we are using yearly data.

The calculations required obtaining $F_5$, the smoothed value for the year 2002 is:

$F_5 = 0.2X_5 / S_4 + 0.8 (F_4 + T_4)$

$= 0.2(246.15) / 0.84509 + 0.8 (200.078+ 24.0316)$

$= 58.25415045 + 179.28768$

$F_5 = 237.54183$

The values used can be seen in Appendix 6

The seasonality estimate for 2002, $S_5$ is calculated as:

$$S_t = \beta X_t \div F_t + (1-\beta)S_{t-p}$$

$S_5 = 0.2X_5 / F_5 + 0.8S_4$

$= 0.2(246.15) /237.54183 + 0.8 (0.84509)$

$= 49.23/ 237.54183 +0.676072$

$S_5 = 0.70332$

The trend estimate for 2002, $T_5$ is calculated as:

$$T_t = \gamma(F_t - F_{t-1}) + (1-\gamma)T_{t-1}$$

$T_5 =0.2(F_5 - F_4) + 0.8\times T_4$

$= 0.2(237.54183-200.078) +0.8(24.0316)$

$T_5 = 26.71805$

The forecast for 2002, $F_6$, could be made from

$W_{t+m} = (F_t + mT_t)S_t$ for m=1 as

$W_6 = (F_5 + 1 \times T_5)S_5$

$= (237.54183 + 1\ (26.71805))\ 0.70332$

$W_6 = 185.85926$

Therefore the actual forecast CPI value for the year 2002 is 185.85926. The subsequent year values are also derived in the same way.

The run sequence plot of the Winters' exponential smoothing is shown in Figure 17.

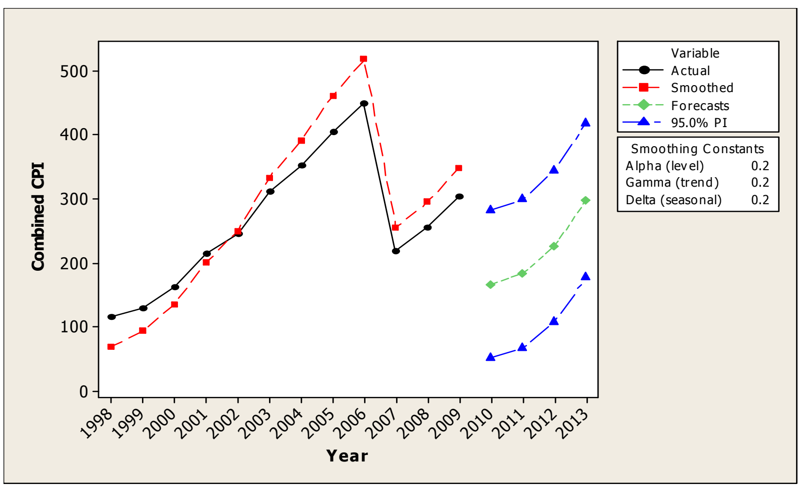


Figure 17: A plot of the CPI and Winters' exponential smoothing with forecasts

The forecasts values for 2010 to 2013 and also 95% confidence limits have been provided in Table 11.

**Table 11: Forecast figures from Winters' Exponential Smoothing**

| Period | Forecast | Lower | Upper |
|---|---|---|---|
| 2010 | 166.481 | 51.695 | 281.266 |
| 2011 | 182.578 | 65.994 | 299.162 |
| 2012 | 225.445 | 106.856 | 344.034 |
| 2013 | 297.769 | 176.978 | 418.560 |

From Table 11, the forecast for each year could be calculated.

## Accuracy Measures for the Smoothing Techniques of the Consumer Price Index for the new series

After considering all the smoothing techniques it is necessary to select the technique that will best fit the time series of the consumer price index. From the plots none of the exponential smoothing seems good to forecast the CPI for the new series.

Summary of the measures of accuracy for the smoothing techniques is shown in Table 12.

**Table 12: Accuracy Measures of Smoothing Techniques (new series)**

| Smoothing Technique | MAPE | MAD | MSD |
|---|---|---|---|
| Moving Average | 33.3 | 93.1 | 10524.8 |
| Single Exponential | 21.68 | 54.48 | 5990.71 |
| Holt's Exponential | 23.04 | 48.39 | 7071.29 |
| Winters' Exponential | 17.60 | 46.85 | 2920.25 |

From Table 12, though the Winter's exponential smoothing has the least value for all the measures of accurarcy, but its forecast values are very low as compare to the data therefore not appropriate.

We consider the ARIMA model to forecast the CPI for the new series. To use ARIMA to model time series behavior and to generate forecasts we first consider autocorrelation and partial autocorrelation plots to help identify a likely model.

Autocorrelation is the correlation between observations of a time series separated by *k* time units. We take a difference at *lag* 12 in order to induce stationarity and look at the autocorrelation of the differenced series. There may be some long-term trend in these data so we might consider taking another difference at *lag* 1 to induce stationarity.

The plot of the Autocorrelation Function (ACF) for CPI is shown in Figure 18.

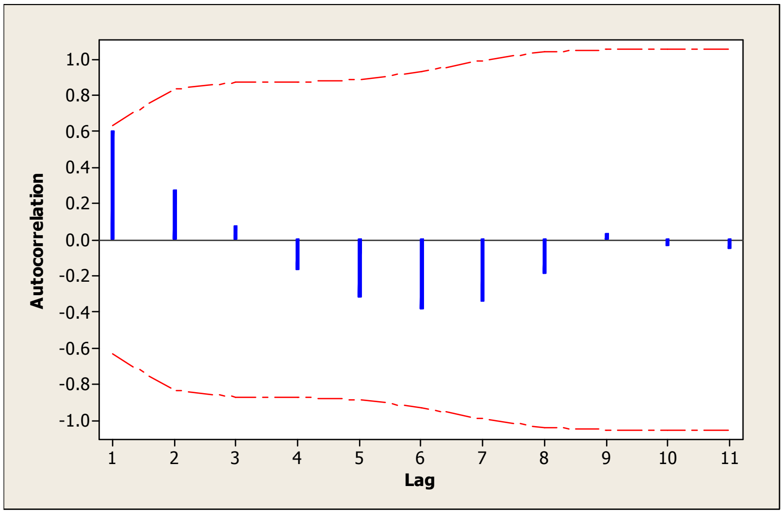


Figure 18: Autocorrelation Function (ACF) for CPI

Figure 18 shows large positive, significant spikes at *lags* 1 and 2 with subsequent positive autocorrelations that do not die off quickly. This pattern is typical of an autoregressive process.

Minitab displays the autocorrelations, associated t-statistics, and Ljung-Box Q statistics. The autocorrelation uses the default length of n / 4 for a series with less than or equal to 240 observations. It also generates an autocorrelation function (ACF) with approximate $\alpha = 0.05$ critical bands for the hypothesis that the correlations are equal to zero. The result from the ACF is shown in Table 13.

**Table 13: Result from Autocorrelation Function (ACF)**

| *Lag* | ACF | T | LBQ |
|---|---|---|---|
| 1 | 0.604293 | 2.09 | 5.58 |
| 2 | 0.272995 | 0.72 | 6.83 |
| 3 | 0.077087 | 0.19 | 6.94 |
| 4 | -0.166336 | -0.42 | 7.52 |
| 5 | -0.317863 | -0.79 | 9.95 |
| 6 | -0.384538 | -0.91 | 14.09 |
| 7 | -0.343202 | -0.76 | 18.04 |
| 8 | -0.187154 | -0.40 | 19.52 |
| 9 | 0.029553 | 0.06 | 19.56 |
| 10 | -0.034905 | -0.07 | 19.67 |
| 11 | -0.049930 | -0.10 | 20.09 |

From Table 13, we observed that the ACF for *lags* 1 and 2 are positive that is 0.6 and 0.3 respectively.The others recorded negative values except *lag* 3 and 9 which recorded small positive values. For the t-statistics, positive values were recorded for *lags* 1, 2, 3 and 9, the rest recorded negative values. We also observed that for the Ljung-Box Q statistics it increases as the *lag* increase.

Partial autocorrelations are correlations between sets of ordered data pairs of a time series. It measures the strength of relationship with other terms being accounted for. The partial autocorrelation at a *lag* of *k* is the correlation between residuals at time t from an autoregressive model and observations at *lag k* with terms for all intervening *lags* present in the autoregressive model.

The plot of the Partial Autocorrelation Function (PACF) for CPI is shown in Figure 19.

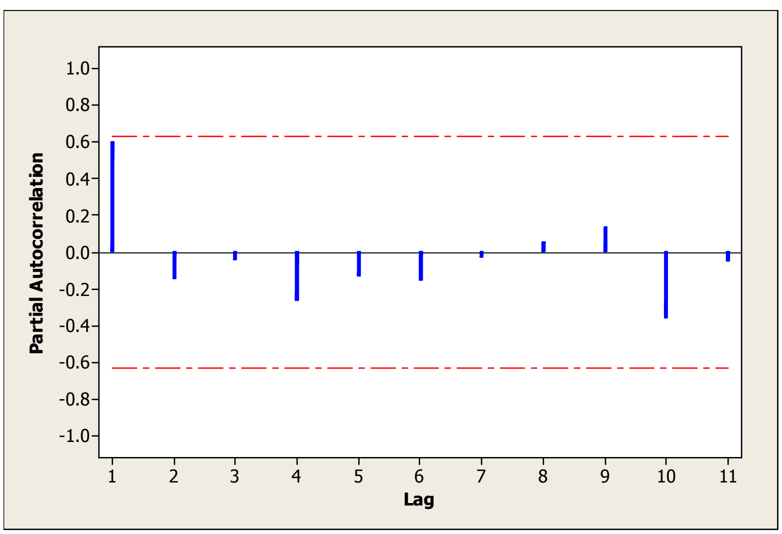


Figure 19: Partial Autocorrelation Function for CPI

In Figure 19, there was a single large spike of 0.6 at *lag* 1, which is typical of an autoregressive process of order one. There is also a small spike at *lag* 8 and 9, but we have no evidence of a nonrandom process occurring there.

Minitab generates a partial autocorrelation function with critical bands at approximately $\alpha = 0.05$ for the hypothesis that the correlations are equal to zero. It stores the partial autocorrelations and associated t-statistics.The result from the PACF is shown in Table 14.

**Table 14: Result from Partial Autocorrelation Function (PACF)**

| *Lag* | PACF | T |
|---|---|---|
| 1 | 0.604293 | 2.09 |
| 2 | -0.145196 | -0.50 |
| 3 | -0.038771 | -0.13 |
| 4 | -0.263502 | -0.91 |
| 5 | -0.127150 | -0.44 |
| 6 | -0.151933 | -0.53 |
| 7 | -0.027365 | -0.09 |
| 8 | 0.056303 | 0.20 |
| 9 | 0.134828 | 0.47 |
| 10 | -0.359009 | -1.24 |
| 11 | -0.044843 | -0.16 |

From Table 14, we observed that it is only at *lag* 1 that the PACF is positive that is also 0.6. The others recorded negative values except *lags* 8 and 9 which recorded small positive values. For the t-statistics, positive values were recorded for *lags* 1, 8 and 9, the rest recorded negative values.

The ACF and the PACF both exhibits large spikes at initial *lags* that do not die off quickly. This pattern is typical of an autoregressive process of order one.

The ARIMA model converged after twelve iterations. The AR(1) parameter had a t-value of 3.47. As a rule of thumb, you can consider values over two as indicating that the associated parameter can be judged as significantly different from zero. The MSE (6159.9) can be used to compare fits of different ARIMA models (Appendix 8).

The ACF and PACF of the residuals appeared to be uncorrelated and the spikes at *lag* 9 of PACFare the result of random events. The AR(1) model appears to fit well and the model is defined as:

$$X_t = \alpha X_{t-1} + Z_t \qquad |\alpha| < 1 \qquad (17)$$

where α is a contant and $Z_t$ is a purely random process. It can be used to forecast the CPI for the new series and the forecast for the next four years is shown in Table 15.

**Table 15: Forecasts from 2009**

| Period | Forecast value | Lower | Upper |
|---|---|---|---|
| 2010 | 289.384 | 135.522 | 443.246 |
| 2011 | 278.437 | 85.868 | 471.006 |
| 2012 | 270.198 | 58.826 | 481.570 |
| 2013 | 263.997 | 42.682 | 485.313 |

From Table 15, For instance the forecast value for 2010 is 289.384 percent and the forecast for 2012 is 270.198 percent.

# CHAPTER FIVE

# SUMMARY, DISCUSSION, CONCLUSIONS AND RECOMMENDATIONS

## Summary of Analysis

The data for the analysis were collected from the prices section of the Ghana Statistical Service. In order to achieve the objectives, a trend analysis was employed and during the analysis it was found out that the yearly combined consumer price index for the period showed an increasing trend. The trend model was used to forecast the yearly combined consumer price index for the next four years.

The four main types of smoothing which are Moving Average smoothing, Single Exponential smoothing, Holt’s Exponential smoothing and Winters’ Exponential smoothing were used to forecast the consumer price index for the old series while the ARIMA model was also used to forecast for the new series.

The Moving Average smoothing technique forecast are obtained by adjusting the last computed 3- quarterly moving average with the respective yearly seasonal index. For the old series, the moving average smoothing generated the accuracy measures of MAPE of 51, MAD of 4836 and MSD of 114,332,999. The Single Exponential smoothing generates only one forecast value with the confidence limits and the forecast was 96832.8. The accuracy measures of this technique were MAPE of 102, MAD of 1873 and MSD of 14,243368. The Holt’s Exponential smoothing is an extension of the single exponential smoothing that allows for the trend component of the consumer price index series. The accuracy measures are MAPE of 75, MAD of 947 and MSD of 4,931,872. Winters' Exponential smoothing is also an extension of Holt's exponential smoothing. It allows for both trend and seasonal components in the series. The accuracy measures are MAPE of 71, MAD of 2382 and MSD of 19,405,109. After the analysis Holt's exponential smoothing has the least value for both the Mean absolute deviation and the Mean square deviation and the Mean absolute percentage error also was the second lowest. Therefore what it could be said to be the most appropriate smoothing technique for the forecast of the Consumer Price Index for the old series.

For the new series, The ARIMA model was used and after the analysis AR(1) model appears to fit well and can be used to forecast the CPI for the new series.We use this fit to predict CPI for the next four years. The 95 percent limits forecast values are 289.384 in 2010, 278.437 in 2011, 270.198 in 2012 and 263.997 in 2013.

**Discussion**

Price Indices (CPI) have been compiled for a long period in Ghana dating back to 1957 which was only for the capital city Accra but for the whole country, it dates back to the 1970s. The study has shown that the percentage change of the index from 1965 to 1997 has increase to 72488.38 percentage points for the old series. The lowest percentage change of the index of 4.80 percent was recorded in 1999. It also revealed that the highest inflation rate of 121.35 percent over the twelve month period was recorded in the year 1983 and this might be the result of the severe draught and bush fire experience during that period in Ghana. It was followed by 116.88 percent in the year 1981 and 113.24 in 1977. Whilst the lowest inflation rate of -87.09 percent occurred in year 1978, -8.27 percent in the year 1967 and 3.75 in 1970.

For the period 1998 to 2009 it also shown that the percentage change of the index has increase to 165.15 percentage points. The index recorded an increase of 12.45 percent in 1999 over the level in 1998 and 25.15 percent in 2000 over that of the level in 1999. It also increased to 32.91 percent in 2001 as against the level in 2000.

In February 2003, the governments' intensions to regulate the petroleum sector resulted in about 90 percent upward adjustment in the prices of petroleum products and this resulted in an increase in the price of certain goods and services especially, products in the transport and communication sub-sector and this caused a spiral increases in the prices of most food items. Also favourable climatic change causes a fall in the prices of food items and subsequently reduced the food component of the CPI for that period.

The index in 2003 went up to 26.68 percent over the level in 2002. This was mainly due to the large increase in the non-food index (29.74%) as against the food index (24.04%). The highest inflation rate of 33.59 percent over the twelve month period was recorded in the year 2001 followed by 24.94 percent in the year 2000 and the lowest inflation rate of 10.73 percent occurred in year 2007 and 10.95 percent in the year 2006.

The yearly CPI shows an upward trend for both the new and old series. For the old series it shows that the average change of CPI from one year to the other is 43.891 percent. The forecast from the trend analysis for the next four years ranges from 55827 in 1998 to 103026 in 2001. However for the new series the average change of CPI from one year to the other is 139.882 percent. The forecast from the decomposition for the next four years are 367.059 in 2010, 420.975 in 2011, 469.756 in 2012 and 370.288 in 2013.

The research was to construct the best exponential smoothing model to estimate yearly CPI for the two periods to help forecasting. From the empirical evidence gathered the Holt's exponential smoothing is most significant for the old series and the AR(1) model is most significant for the new series. It provides 95% confidence limits around each forecast which is to capture many possible forecasts for the yearly CPI. The yearly forecast values from Holt's exponential smoothing for 1998 to 2001 are (105066, 123351, 141635 and 159919) percent respectively and the yearly forecast values from AR(1) model for 2010 to 2013 were also (289.384, 278.437, 270.198 and 263.997) percent, respectively.

## **Conclusions** and **Recommendations**

The study examined the consumer price indexes of Ghana from the period 1964 to 2009. The data were categorized into two time periods; hence we obtained an old series and a new series that covered, respectively, the periods (1964- 1997) and (1998- 2009). The main aim was to determine a suitable model that could be used to make forecast of future consumer price indexes for the two categories of data. Several times series analysis techniques were used in the analysis of the data. The analysis revealed that the yearly consumer price indexes shows an upward trend for both the new and old series. The Holt's Exponential smoothing technique is most significant for the forecasting of the Consumer Price Index for the old series (1964- 1997) while the AutoRegressive of order one AR(1) was the most appropriate technique for the forecast of the Consumer Price Index for the new series (1998- 2009).

Currently, the Ghana Statistical Service generates the new series. On the basis of the findings of this study, it is recommended that the Bank of Ghana and the government should use the AR(1) model to forecast the Consumer Price Index. It is envisaged that forecasts based on this model would yield more reliable figures for planning.

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APPENDIX I

**Monthly Consumer Price Index**

| | Consumer Price Index | | | Inflation over 12 months | | |
|---|---|---|---|---|---|---|
| Month | Combined | Food | Non-Food | Combined | Food | Non-Food |
| Weigths | 100.0 | 51.9 | 48.1 | % | % | % |
| Jan 1964 | 113.1 | 116.2 | 109.8 | | | |
| Feb " | 114.3 | 118.3 | 110.0 | | | |
| Mar " | 116.3 | 121.2 | 111.0 | 16.3 | 21.2 | 11.0 |
| Apr " | 117.2 | 122.4 | 111.6 | 14.5 | 18.1 | 10.4 |
| May " | 118.7 | 124.8 | 112.1 | 13.9 | 17.4 | 10.0 |
| Jun " | 122.5 | 130.8 | 113.5 | 13.4 | 15.6 | 10.8 |
| Jul " | 121.7 | 128.3 | 114.6 | 12.7 | 12.8 | 12.5 |
| Aug " | 120.2 | 125.0 | 115.0 | 11.3 | 11.3 | 11.3 |
| Sep" | 121.3 | 127.1 | 115.0 | 10.5 | 11.1 | 9.7 |
| Oct " | 120.8 | 126.5 | 114.6 | 6.9 | 5.6 | 8.5 |
| Nov " | 123.1 | 131.8 | 113.7 | 6.6 | 8.2 | 4.6 |
| Dec " | 127.1 | 136.2 | 117.3 | 17.1 | 26.7 | 7.0 |
| Jan 1965 | 128.1 | 140.6 | 114.6 | 13.3 | 21.0 | 4.4 |
| Feb " | 135.3 | 149.0 | 120.5 | 18.4 | 26.0 | 9.6 |
| Mar " | 137.8 | 153.9 | 120.4 | 18.5 | 27.0 | 8.5 |
| Apr " | 145.2 | 165.7 | 123.1 | 23.9 | 35.4 | 10.3 |
| May " | 152.0 | 176.7 | 125.3 | 28.1 | 41.6 | 11.8 |
| Jun " | 155.6 | 180.8 | 128.4 | 27.0 | 38.2 | 13.1 |
| Jul " | 162.8 | 191.9 | 131.4 | 33.8 | 49.6 | 14.7 |
| Aug " | 157.5 | 181.3 | 131.8 | 31.0 | 45.0 | 14.6 |
| Sep" | 159.4 | 182.3 | 134.7 | 31.4 | 43.4 | 17.1 |
| Oct " | 158.5 | 180.1 | 135.2 | 31.2 | 42.4 | 17.9 |
| Nov " | 158.5 | 180.3 | 135.0 | 28.8 | 36.8 | 18.7 |
| Dec " | 165.0 | 189.4 | 138.7 | 29.8 | 39.1 | 18.2 |
| Jan 1966 | 168.2 | 192.6 | 141.9 | 31.3 | 37.0 | 23.8 |
| Feb " | 172.3 | 196.6 | 146.1 | 27.3 | 31.9 | 21.2 |
| Mar " | 169.3 | 192.2 | 144.6 | 22.9 | 24.9 | 20.1 |
| Apr " | 173.0 | 200.4 | 143.4 | 19.1 | 20.9 | 16.5 |
| May " | 176.2 | 208.3 | 141.6 | 15.9 | 17.9 | 12.9 |
| Jun " | 184.9 | 224.9 | 141.7 | 18.8 | 24.4 | 10.4 |
| Jul " | 183.7 | 221.6 | 142.8 | 12.8 | 15.5 | 8.7 |
| Aug " | 177.0 | 211.4 | 139.9 | 12.4 | 16.6 | 6.1 |
| Sep" | 164.7 | 188.6 | 138.9 | 3.3 | 3.5 | 3.1 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Oct " | 162.1 | 184.1 | 138.4 | 2.3 | 2.2 | 2.3 |
| Nov " | 163.2 | 184.8 | 139.9 | 3.0 | 2.5 | 3.6 |
| Dec " | 161.9 | 182.3 | 139.9 | -1.9 | -3.7 | 0.9 |
| Jan 1967 | 158.8 | 179.6 | 136.4 | -5.6 | -6.7 | -3.9 |
| Feb " | 156.1 | 172.5 | 138.4 | -9.4 | -12.3 | -5.3 |
| Mar " | 155.3 | 169.6 | 139.9 | -8.3 | -11.8 | -3.3 |
| Apr " | 157.5 | 173.0 | 140.8 | -9.0 | -13.7 | -1.9 |
| May " | 159.4 | 176.2 | 141.3 | -9.5 | -15.4 | -0.2 |
| Jun " | 163.7 | 182.5 | 143.4 | -11.5 | -18.9 | 1.2 |
| Jul " | 161.5 | 178.0 | 143.7 | -12.1 | -19.7 | 0.6 |
| Aug " | 157.1 | 168.6 | 144.7 | -11.2 | -20.2 | 3.4 |
| Sep" | 151.5 | 156.1 | 146.5 | -8.0 | -17.2 | 5.5 |
| Oct " | 153.1 | 156.9 | 149.0 | -5.6 | -14.8 | 7.7 |
| Nov " | 153.1 | 157.9 | 147.9 | -6.2 | -14.6 | 5.7 |
| Dec " | 157.2 | 164.5 | 149.3 | -2.9 | -9.8 | 6.7 |
| Jan 1968 | 161.6 | 172.6 | 149.7 | 1.8 | -3.9 | 9.8 |
| Feb " | 161.0 | 170.6 | 150.6 | 3.1 | -1.1 | 8.8 |
| Mar " | 160.1 | 170.5 | 148.9 | 3.1 | 0.5 | 6.4 |
| Apr " | 160.3 | 169.3 | 150.6 | 1.8 | -2.1 | 7.0 |
| May " | 164.0 | 175.8 | 151.3 | 2.9 | -0.2 | 7.1 |
| Jun " | 169.2 | 183.7 | 153.6 | 3.4 | 0.7 | 7.1 |
| Jul " | 175.4 | 194.5 | 154.8 | 8.6 | 9.3 | 7.7 |
| Aug " | 174.4 | 192.6 | 154.8 | 11.0 | 14.2 | 7.0 |
| Sep" | 175.0 | 193.0 | 155.6 | 15.5 | 23.6 | 6.2 |
| Oct " | 179.3 | 198.4 | 158.7 | 17.1 | 26.4 | 6.5 |
| Nov " | 178.5 | 196.8 | 158.8 | 16.6 | 24.6 | 7.3 |
| Dec " | 176.8 | 193.3 | 159.0 | 12.5 | 17.5 | 6.5 |
| Jan 1969 | 174.3 | 186.9 | 160.7 | 7.9 | 8.3 | 7.3 |
| Feb " | 174.6 | 188.2 | 159.9 | 8.4 | 10.3 | 6.2 |
| Mar " | 174.6 | 188.5 | 159.6 | 9.1 | 10.6 | 7.2 |
| Apr " | 179.4 | 197.6 | 159.8 | 11.9 | 16.7 | 6.1 |
| May " | 183.8 | 206.2 | 159.6 | 12.1 | 17.3 | 5.5 |
| Jun " | 191.7 | 218.5 | 162.8 | 13.3 | 18.9 | 6.0 |
| Jul " | 195.4 | 224.9 | 163.6 | 11.4 | 15.6 | 5.7 |
| Aug " | 185.5 | 206.8 | 162.5 | 6.4 | 7.4 | 5.0 |
| Sep" | 178.0 | 191.7 | 163.2 | 1.7 | -0.7 | 4.9 |
| Oct " | 180.5 | 197.0 | 162.7 | 0.7 | -0.7 | 2.5 |
| Nov " | 181.3 | 196.5 | 164.9 | 1.6 | -0.2 | 3.9 |
| Dec " | 182.5 | 197.6 | 166.2 | 3.2 | 2.2 | 4.5 |
| Jan 1970 | 182.4 | 199.6 | 163.8 | 4.6 | 6.8 | 2.0 |
| Feb " | 186.4 | 206.0 | 165.3 | 6.8 | 9.5 | 3.3 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Mar " | 186.2 | 205.4 | 165.5 | 6.6 | 9.0 | 3.7 |
| Apr " | 186.9 | 207.3 | 164.9 | 4.2 | 4.9 | 3.2 |
| May " | 193.7 | 219.8 | 165.5 | 5.4 | 6.6 | 3.7 |
| Jun " | 194.9 | 222.3 | 165.3 | 1.7 | 1.7 | 1.6 |
| Jul " | 193.6 | 219.0 | 166.2 | -0.9 | -2.6 | 1.6 |
| Aug " | 195.2 | 223.7 | 164.4 | 5.2 | 8.2 | 1.2 |
| Sep" | 188.4 | 209.9 | 165.2 | 5.8 | 9.5 | 1.2 |
| Oct " | 185.6 | 204.5 | 165.2 | 2.8 | 3.8 | 1.5 |
| Nov " | 185.0 | 203.2 | 165.4 | 2.0 | 3.4 | 0.3 |
| Dec " | 183.8 | 199.8 | 166.5 | 0.7 | 1.1 | 0.2 |
| Jan 1971 | 185.9 | 202.1 | 168.4 | 1.9 | 1.3 | 2.8 |
| Feb " | 194.2 | 216.6 | 170.0 | 4.2 | 5.1 | 2.9 |
| Mar " | 194.7 | 217.2 | 170.4 | 4.6 | 5.7 | 3.0 |
| Apr " | 199.5 | 225.5 | 171.4 | 6.7 | 8.8 | 4.0 |
| May " | 212.8 | 250.5 | 172.1 | 9.9 | 14.0 | 4.0 |
| Jun " | 225.6 | 273.5 | 173.9 | 15.8 | 23.0 | 5.2 |
| Jul " | 222.7 | 266.9 | 175.0 | 15.0 | 21.9 | 5.3 |
| Aug " | 211.9 | 246.0 | 175.1 | 8.6 | 10.0 | 6.5 |
| Sep" | 208.3 | 237.9 | 176.4 | 10.6 | 13.3 | 6.8 |
| Oct " | 207.1 | 235.8 | 176.1 | 11.6 | 15.3 | 6.6 |
| Nov " | 205.3 | 232.0 | 176.5 | 11.0 | 14.2 | 6.7 |
| Dec " | 203.8 | 229.3 | 176.3 | 10.9 | 14.8 | 5.9 |
| Jan 1972 | 218.3 | 228.0 | 207.8 | 17.4 | 12.8 | 23.4 |
| Feb " | 214.7 | 242.4 | 184.8 | 10.6 | 11.9 | 8.7 |
| Mar " | 219.4 | 253.2 | 182.9 | 12.7 | 16.6 | 7.3 |
| Apr " | 229.5 | 272.0 | 183.6 | 15.0 | 20.6 | 7.1 |
| May " | 231.1 | 273.6 | 185.2 | 8.6 | 9.2 | 7.6 |
| Jun " | 252.1 | 313.0 | 186.4 | 11.7 | 14.4 | 7.2 |
| Jul " | 227.5 | 261.6 | 190.7 | 2.2 | -2.0 | 9.0 |
| Aug " | 223.4 | 253.0 | 191.5 | 5.4 | 2.8 | 9.3 |
| Sep" | 224.0 | 251.6 | 194.2 | 7.5 | 5.8 | 10.1 |
| Oct " | 224.1 | 251.4 | 194.6 | 8.2 | 6.6 | 10.5 |
| Nov " | 226.9 | 254.2 | 197.4 | 10.5 | 9.6 | 11.9 |
| Dec " | 229.6 | 258.2 | 198.7 | 12.7 | 12.6 | 12.7 |
| Jan 1973 | 231.4 | 259.4 | 201.2 | 6.0 | 13.8 | -3.2 |
| Feb " | 238.1 | 268.3 | 205.5 | 10.9 | 10.7 | 11.2 |
| Mar " | 243.9 | 277.8 | 207.3 | 11.2 | 9.7 | 13.3 |
| Apr " | 254.1 | 296.0 | 208.9 | 10.7 | 8.8 | 13.7 |
| May " | 259.9 | 307.0 | 209.1 | 12.5 | 12.2 | 12.9 |
| Jun " | 267.1 | 319.8 | 210.2 | 6.0 | 2.2 | 12.8 |
| Jul " | 289.6 | 355.6 | 218.4 | 27.3 | 35.9 | 14.5 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Aug " | 284.0 | 344.2 | 219.0 | 27.1 | 36.0 | 14.4 |
| Sep" | 281.6 | 335.8 | 223.1 | 25.7 | 33.5 | 14.9 |
| Oct " | 277.4 | 325.3 | 225.7 | 23.8 | 29.4 | 16.0 |
| Nov " | 282.3 | 331.8 | 228.9 | 24.4 | 30.5 | 15.9 |
| Dec " | 287.8 | 339.2 | 232.3 | 25.3 | 31.4 | 16.9 |
| Jan 1974 | 285.9 | 328.9 | 239.5 | 23.6 | 26.8 | 19.0 |
| Feb " | 292.6 | 338.2 | 243.4 | 22.9 | 26.1 | 18.4 |
| Mar " | 295.7 | 338.8 | 249.2 | 21.2 | 22.0 | 20.2 |
| Apr " | 304.7 | 352.2 | 253.4 | 19.9 | 19.0 | 21.3 |
| May " | 313.2 | 363.7 | 258.7 | 20.5 | 18.5 | 23.7 |
| Jun " | 319.5 | 374.1 | 260.6 | 19.6 | 17.0 | 23.9 |
| Jul " | 331.0 | 390.5 | 266.8 | 14.3 | 9.8 | 22.2 |
| Aug " | 331.0 | 385.3 | 272.4 | 16.5 | 11.9 | 24.4 |
| Sep" | 324.2 | 369.2 | 275.6 | 15.1 | 9.9 | 23.5 |
| Oct " | 322.6 | 263.3 | 386.6 | 16.3 | -19.1 | 71.3 |
| Nov " | 329.4 | 372.5 | 282.9 | 16.7 | 12.3 | 23.6 |
| Dec " | 334.1 | 375.2 | 289.8 | 16.1 | 10.6 | 24.7 |
| Jan 1975 | 343.8 | 384.6 | 299.8 | 20.3 | 16.9 | 25.2 |
| Feb " | 348.8 | 392.4 | 301.8 | 19.2 | 16.0 | 24.0 |
| Mar " | 355.8 | 409.5 | 297.9 | 20.3 | 20.9 | 19.5 |
| Apr " | 380.1 | 438.7 | 316.9 | 24.7 | 24.6 | 25.0 |
| May " | 390.1 | 452.6 | 322.7 | 24.6 | 24.4 | 24.7 |
| Jun " | 411.5 | 486.9 | 330.1 | 28.8 | 30.2 | 26.7 |
| Jul " | 425.5 | 502.7 | 342.2 | 28.5 | 28.7 | 28.3 |
| Aug " | 433.4 | 503.4 | 357.9 | 30.9 | 30.7 | 31.4 |
| Sep" | 442.2 | 515.9 | 362.7 | 36.4 | 39.7 | 31.6 |
| Oct " | 447.7 | 520.3 | 369.4 | 38.8 | 97.6 | -4.5 |
| Nov " | 459.0 | 531.2 | 381.1 | 39.3 | 42.6 | 34.7 |
| Dec " | 469.0 | 544.9 | 387.1 | 40.4 | 45.2 | 33.6 |
| Jan 1976 | 495.8 | 575.0 | 410.3 | 44.2 | 49.5 | 36.9 |
| Feb " | 519.4 | 610.7 | 420.9 | 48.9 | 55.6 | 39.5 |
| Mar " | 533.8 | 634.7 | 424.9 | 50.0 | 55.0 | 42.7 |
| Apr " | 556.4 | 672.1 | 431.6 | 46.4 | 53.2 | 36.2 |
| May " | 587.6 | 729.1 | 434.9 | 50.6 | 61.1 | 34.8 |
| Jun " | 627.3 | 791.7 | 449.9 | 52.4 | 62.6 | 36.3 |
| Jul " | 690.7 | 899.3 | 465.6 | 62.3 | 78.9 | 36.1 |
| Aug " | 704.4 | 922.0 | 469.6 | 62.5 | 83.2 | 31.2 |
| Sep" | 721.9 | 938.8 | 487.9 | 63.3 | 82.0 | 34.5 |
| Oct " | 725.1 | 936.5 | 497.0 | 62.0 | 80.0 | 34.6 |
| Nov " | 725.8 | 930.0 | 505.5 | 58.1 | 75.1 | 32.6 |
| Dec " | 783.3 | 1027.2 | 520.1 | 67.0 | 88.5 | 34.4 |

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|---|---|---|---|---|---|---|
| Jan 1977 | 814.1 | 1066.8 | 541.4 | 64.2 | 85.5 | 31.9 |
| Feb " | 868.2 | 1159.1 | 554.3 | 67.2 | 89.8 | 31.7 |
| Mar " | 964.5 | 1333.0 | 566.9 | 80.7 | 110.0 | 33.4 |
| Apr " | 1128.7 | 1635.0 | 582.4 | 102.9 | 143.3 | 35.0 |
| May " | 1249.8 | 1867.5 | 583.3 | 112.7 | 156.1 | 34.1 |
| Jun " | 1534.6 | 2384.3 | 617.8 | 144.6 | 201.2 | 37.3 |
| Jul " | 1764.2 | 2792.7 | 654.4 | 155.4 | 210.5 | 40.6 |
| Aug " | 1729.2 | 2677.8 | 705.7 | 145.5 | 190.4 | 50.3 |
| Sep" | 1741.4 | 2647.6 | 763.6 | 141.2 | 182.0 | 56.5 |
| Oct " | 1589.9 | 2311.3 | 811.5 | 119.3 | 146.8 | 63.3 |
| Nov " | 1591.6 | 2270.7 | 858.8 | 119.3 | 144.2 | 69.9 |
| Dec " | 1613.6 | 2260.5 | 915.6 | 106.0 | 120.1 | 76.0 |
| Jan 1978 | 127.2 | 118.3 | 135.8 | -84.4 | -88.9 | -74.9 |
| Feb " | 132.7 | 130.4 | 134.9 | -84.7 | -88.7 | -75.7 |
| Mar " | 144.2 | 146.5 | 142.0 | -85.0 | -89.0 | -75.0 |
| Apr " | 153.2 | 153.6 | 152.8 | -86.4 | -90.6 | -73.8 |
| May " | 159.9 | 160.3 | 159.5 | -87.2 | -91.4 | -72.7 |
| Jun " | 167.7 | 160.5 | 174.7 | -89.1 | -93.3 | -71.7 |
| Jul " | 170.1 | 160.6 | 179.3 | -90.4 | -94.2 | -72.6 |
| Aug " | 172.7 | 155.3 | 189.6 | -90.0 | -94.2 | -73.1 |
| Sep" | 183.5 | 159.1 | 207.1 | -89.5 | -94.0 | -72.9 |
| Oct " | 199.9 | 166.9 | 231.9 | -87.4 | -92.8 | -71.4 |
| Nov " | 222.7 | 189.1 | 255.2 | -86.0 | -91.7 | -70.3 |
| Dec " | 243.3 | 212.3 | 273.3 | -84.9 | -90.6 | -70.1 |
| Jan 1979 | 258.6 | 229.1 | 287.2 | 103.3 | 93.7 | 111.4 |
| Feb " | 269.5 | 245.1 | 293.1 | 103.1 | 88.0 | 117.3 |
| Mar " | 282.5 | 261.2 | 303.1 | 95.9 | 78.3 | 113.5 |
| Apr " | 296.8 | 284.6 | 308.6 | 93.7 | 85.3 | 102.0 |
| May " | 310.9 | 297.4 | 324.0 | 94.4 | 85.5 | 103.1 |
| Jun " | 284.8 | 272.9 | 296.3 | 69.8 | 70.0 | 69.6 |
| Jul " | 241.6 | 238.7 | 244.4 | 42.0 | 48.6 | 36.3 |
| Aug " | 233.4 | 227.3 | 239.3 | 35.1 | 46.4 | 26.2 |
| Sep" | 234.9 | 227.6 | 242.0 | 28.0 | 43.1 | 16.8 |
| Oct " | 242.9 | 240.5 | 245.2 | 21.5 | 44.1 | 5.8 |
| Nov " | 264.2 | 271.0 | 257.6 | 18.6 | 43.3 | 0.9 |
| Dec " | 287.8 | 297.5 | 278.4 | 18.3 | 40.1 | 1.9 |
| Jan 1980 | 303.3 | 300.5 | 306.0 | 17.3 | 31.2 | 6.6 |
| Feb " | 307.0 | 297.2 | 316.5 | 13.9 | 21.3 | 8.0 |
| Mar " | 329.9 | 319.9 | 339.6 | 16.8 | 22.5 | 12.0 |
| Apr " | 356.6 | 351.1 | 361.9 | 20.1 | 23.4 | 17.3 |
| May " | 377.3 | 378.7 | 375.9 | 21.4 | 27.3 | 16.0 |

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|---|---|---|---|---|---|---|
| Jun " | 400.3 | 406.4 | 394.4 | 40.6 | 48.9 | 33.1 |
| Jul " | 404.7 | 401.6 | 407.7 | 67.5 | 68.2 | 66.8 |
| Aug " | 416.2 | 409.9 | 422.3 | 78.3 | 80.3 | 76.5 |
| Sep" | 428.3 | 417.1 | 439.1 | 82.3 | 83.3 | 81.5 |
| Oct " | 449.8 | 438.3 | 460.9 | 85.2 | 82.2 | 88.0 |
| Nov " | 500.1 | 482.0 | 517.6 | 89.3 | 77.9 | 100.9 |
| Dec " | 540.6 | 510.8 | 569.5 | 87.8 | 71.7 | 104.5 |
| Jan 1981 | 611.8 | 596.4 | 626.7 | 101.7 | 98.5 | 104.8 |
| Feb " | 673.8 | 656.7 | 690.4 | 119.5 | 121.0 | 118.1 |
| Mar " | 733.6 | 730.7 | 736.4 | 122.4 | 128.4 | 116.9 |
| Apr " | 783.5 | 785.4 | 781.7 | 119.7 | 123.7 | 116.0 |
| May " | 828.4 | 828.7 | 828.1 | 119.6 | 118.8 | 120.3 |
| Jun " | 873.5 | 875.4 | 871.7 | 118.2 | 115.4 | 121.0 |
| Jul " | 893.8 | 840.1 | 945.8 | 120.9 | 109.2 | 132.0 |
| Aug " | 922.0 | 858.4 | 983.6 | 121.5 | 109.4 | 132.9 |
| Sep" | 955.7 | 861.9 | 1046.5 | 123.1 | 106.6 | 138.3 |
| Oct " | 1014.4 | 920.8 | 1105.1 | 125.5 | 110.1 | 139.7 |
| Nov " | 1050.8 | 980.9 | 1118.5 | 110.1 | 103.5 | 116.1 |
| Dec " | 1083.3 | 1006.1 | 1158.1 | 100.4 | 97.0 | 103.4 |
| Jan 1982 | 1047.4 | 1011.3 | 1082.4 | 71.2 | 69.6 | 72.7 |
| Feb " | 949.1 | 934.0 | 963.7 | 40.9 | 42.2 | 39.6 |
| Mar " | 955.4 | 984.0 | 927.7 | 30.2 | 34.7 | 26.0 |
| Apr " | 978.6 | 1017.9 | 940.5 | 24.9 | 29.6 | 20.3 |
| May " | 1016.5 | 1098.8 | 936.8 | 22.7 | 32.6 | 13.1 |
| Jun " | 1028.0 | 1115.0 | 943.7 | 17.7 | 27.4 | 8.3 |
| Jul " | 1078.3 | 1201.5 | 959.0 | 20.6 | 43.0 | 1.4 |
| Aug " | 1048.6 | 1111.1 | 988.1 | 13.7 | 29.4 | 0.5 |
| Sep" | 1080.9 | 1150.5 | 1013.5 | 13.1 | 33.5 | -3.2 |
| Oct " | 1131.5 | 1218.4 | 1047.3 | 11.5 | 32.3 | -5.2 |
| Nov " | 1171.1 | 1266.2 | 1079.0 | 11.4 | 29.1 | -3.5 |
| Dec " | 1264.1 | 1407.8 | 1124.9 | 16.7 | 39.9 | -2.9 |
| Jan 1983 | 1388.0 | 1574.4 | 1186.9 | 32.5 | 55.7 | 9.7 |
| Feb " | 1543.6 | 1826.6 | 1238.2 | 62.6 | 95.6 | 28.5 |
| Mar " | 1743.8 | 2190.0 | 1262.3 | 82.5 | 122.6 | 36.1 |
| Apr " | 2039.6 | 2658.9 | 1371.4 | 108.4 | 161.2 | 45.8 |
| May " | 2517.8 | 2331.6 | 2718.7 | 147.7 | 112.2 | 190.2 |
| Jun " | 2818.2 | 3728.9 | 1835.6 | 174.1 | 234.4 | 94.5 |
| Jul " | 2599.3 | 3078.4 | 2082.4 | 141.1 | 156.2 | 117.1 |
| Aug " | 2520.3 | 2793.8 | 2225.2 | 140.3 | 151.4 | 125.2 |
| Sep" | 2570.0 | 2791.3 | 2331.2 | 137.8 | 142.6 | 130.0 |
| Oct " | 2728.6 | 2849.7 | 2597.9 | 141.1 | 133.9 | 148.1 |

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|---|---|---|---|---|---|---|
| Nov " | 2875.1 | 3025.3 | 2713.0 | 145.5 | 138.9 | 151.4 |
| Dec " | 3064.4 | 3206.6 | 2911.0 | 142.4 | 127.8 | 158.8 |
| Jan 1984 | 3136.8 | 3303.6 | 2956.8 | 126.0 | 109.8 | 149.1 |
| Feb " | 3357.4 | 3468.7 | 3237.3 | 117.5 | 89.9 | 161.4 |
| Mar " | 3459.9 | 3583.7 | 3326.3 | 98.4 | 63.6 | 163.5 |
| Apr " | 3552.3 | 3624.9 | 3474.0 | 74.2 | 36.3 | 153.3 |
| May " | 3606.8 | 3651.8 | 3558.2 | 43.3 | 56.6 | 30.9 |
| Jun " | 3491.2 | 3349.8 | 3643.8 | 23.9 | -10.2 | 98.5 |
| Jul " | 3352.1 | 3078.8 | 3647.0 | 29.0 | 0.0 | 75.1 |
| Aug " | 3132.0 | 2702.8 | 3595.1 | 24.3 | -3.3 | 61.6 |
| Sep" | 3106.5 | 2547.1 | 3710.1 | 20.9 | -8.7 | 59.1 |
| Oct " | 3105.1 | 2469.0 | 3791.5 | 13.8 | -13.4 | 45.9 |
| Nov " | 3102.1 | 2414.8 | 3843.7 | 7.9 | -20.2 | 41.7 |
| Dec " | 3247.9 | 2507.3 | 4047.0 | 6.0 | -21.8 | 39.0 |
| Jan 1985 | 3408.3 | 2645.7 | 4231.1 | 8.7 | -19.9 | 43.1 |
| Feb " | 3495.4 | 2745.6 | 4304.4 | 4.1 | -20.8 | 33.0 |
| Mar " | 3575.9 | 2819.2 | 4392.4 | 3.4 | -21.3 | 32.0 |
| Apr " | 3613.5 | 2803.3 | 4487.7 | 1.7 | -22.7 | 29.2 |
| May " | 3647.9 | 2831.1 | 4529.2 | 1.1 | -22.5 | 27.3 |
| Jun " | 3728.0 | 2871.0 | 4652.7 | 6.8 | -14.3 | 27.7 |
| Jul " | 3693.4 | 2726.7 | 4736.5 | 10.2 | -11.4 | 29.9 |
| Aug " | 3665.1 | 2630.7 | 4781.2 | 17.0 | -2.7 | 33.0 |
| Sep" | 3648.2 | 2548.8 | 4834.5 | 17.4 | 0.1 | 30.3 |
| Oct " | 3672.1 | 2560.4 | 4871.6 | 18.3 | 3.7 | 28.5 |
| Nov " | 3737.0 | 3633.3 | 3848.9 | 20.5 | 50.5 | 0.1 |
| Dec " | 3881.2 | 2797.1 | 5050.9 | 19.5 | 11.6 | 24.8 |
| Jan 1986 | 4047.2 | 2928.6 | 5254.2 | 18.7 | 10.7 | 24.2 |
| Feb " | 4179.0 | 3050.9 | 5396.2 | 19.6 | 11.1 | 25.4 |
| Mar " | 4301.5 | 3162.2 | 5530.8 | 20.3 | 12.2 | 25.9 |
| Apr " | 4394.1 | 3228.2 | 5652.1 | 21.6 | 15.2 | 25.9 |
| May " | 4499.2 | 3337.1 | 5753.1 | 23.3 | 17.9 | 27.0 |
| Jun " | 4590.9 | 3399.1 | 5876.9 | 23.1 | 18.4 | 26.3 |
| Jul " | 4575.2 | 3309.3 | 5941.1 | 23.9 | 21.4 | 25.4 |
| Aug " | 4542.3 | 3237.8 | 5949.9 | 23.9 | 23.1 | 24.4 |
| Sep" | 4517.8 | 3168.9 | 5973.3 | 23.8 | 24.3 | 23.6 |
| Oct " | 4734.9 | 3287.4 | 6296.8 | 28.9 | 28.4 | 29.3 |
| Nov " | 4959.8 | 3468.3 | 6569.1 | 32.7 | -4.5 | 70.7 |
| Dec " | 5175.0 | 3647.2 | 6823.5 | 33.3 | 30.4 | 35.1 |
| Jan 1987 | 5400.4 | 3841.2 | 7082.8 | 33.4 | 31.2 | 34.8 |
| Feb " | 5616.3 | 3983.2 | 7378.4 | 34.4 | 30.6 | 36.7 |
| Mar " | 5914.2 | 4167.7 | 7798.7 | 37.5 | 31.8 | 41.0 |

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|---|---|---|---|---|---|---|
| Apr " | 6195.6 | 4399.6 | 8133.5 | 41.0 | 36.3 | 43.9 |
| May " | 6404.3 | 4617.8 | 8331.9 | 42.3 | 38.4 | 44.8 |
| Jun " | 6605.0 | 4838.2 | 8511.4 | 43.9 | 42.3 | 44.8 |
| Jul " | 6634.0 | 4800.2 | 8612.7 | 45.0 | 45.1 | 45.0 |
| Aug " | 6610.9 | 4720.9 | 8650.2 | 45.5 | 45.8 | 45.4 |
| Sep" | 6591.8 | 4649.5 | 8687.5 | 45.9 | 46.7 | 45.4 |
| Oct " | 6596.0 | 4626.8 | 8720.8 | 39.3 | 40.7 | 38.5 |
| Nov " | 6710.5 | 4729.9 | 8847.6 | 35.3 | 36.4 | 34.7 |
| Dec " | 6943.8 | 4950.4 | 9094.7 | 34.2 | 35.7 | 33.3 |
| Jan 1988 | 7232.0 | 5196.2 | 9428.6 | 33.9 | 35.3 | 33.1 |
| Feb " | 7533.6 | 5444.8 | 9787.4 | 34.1 | 36.7 | 32.6 |
| Mar " | 7875.0 | 5762.2 | 10154.7 | 33.2 | 38.3 | 30.2 |
| Apr " | 8208.0 | 6087.9 | 10495.6 | 32.5 | 38.4 | 29.0 |
| May " | 8553.5 | 6424.9 | 10850.3 | 33.6 | 39.1 | 30.2 |
| Jun " | 8808.0 | 6692.3 | 11090.8 | 33.4 | 38.3 | 30.3 |
| Jul " | 8722.0 | 6453.0 | 11170.3 | 31.5 | 34.4 | 29.7 |
| Aug " | 8625.6 | 6233.5 | 11206.7 | 30.5 | 32.0 | 29.6 |
| Sep" | 8571.5 | 6105.0 | 11232.9 | 30.0 | 31.3 | 29.3 |
| Oct " | 8569.8 | 6060.2 | 11277.7 | 29.9 | 31.0 | 29.3 |
| Nov " | 8639.3 | 6128.7 | 11348.2 | 28.7 | 29.6 | 28.3 |
| Dec " | 8787.8 | 6263.9 | 11511.1 | 26.6 | 26.5 | 26.6 |
| Jan 1989 | 9132.7 | 6526.9 | 11944.4 | 26.3 | 25.6 | 26.7 |
| Feb " | 9456.9 | 6818.1 | 12304.2 | 25.5 | 25.2 | 25.7 |
| Mar " | 9829.0 | 7183.1 | 12683.9 | 24.8 | 24.7 | 24.9 |
| Apr " | 10209.1 | 7533.7 | 13095.9 | 24.4 | 23.7 | 24.8 |
| May " | 10544.2 | 7872.6 | 13426.9 | 23.3 | 22.5 | 23.7 |
| Jun " | 10813.1 | 8130.3 | 13707.8 | 22.8 | 21.5 | 23.6 |
| Jul " | 10775.0 | 7976.9 | 13794.2 | 23.5 | 23.6 | 23.5 |
| Aug " | 10677.4 | 7697.9 | 13892.3 | 23.8 | 23.5 | 24.0 |
| Sep" | 10663.2 | 7597.5 | 13971.1 | 24.4 | 24.4 | 24.4 |
| Oct " | 10764.1 | 7633.9 | 14141.6 | 25.6 | 26.0 | 25.4 |
| Nov " | 11062.7 | 7893.7 | 14482.1 | 28.1 | 28.8 | 27.6 |
| Dec " | 11464.4 | 8261.3 | 14920.6 | 30.5 | 31.9 | 29.6 |
| Jan 1990 | 12150.4 | 8747.2 | 15822.5 | 33.0 | 34.0 | 32.5 |
| Feb " | 12856.3 | 9278.0 | 16717.3 | 35.9 | 36.1 | 35.9 |
| Mar " | 13374.2 | 9845.3 | 17181.9 | 36.1 | 37.1 | 35.5 |
| Apr " | 13885.1 | 10410.2 | 17634.5 | 36.0 | 38.2 | 34.7 |
| May " | 14298.6 | 10980.8 | 17878.5 | 35.6 | 39.5 | 33.2 |
| Jun " | 14751.0 | 11407.6 | 18358.5 | 36.4 | 40.3 | 33.9 |
| Jul " | 14978.0 | 11597.0 | 18626.1 | 39.0 | 45.4 | 35.0 |
| Aug " | 14971.0 | 11438.5 | 18782.6 | 40.2 | 48.6 | 35.2 |

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|---|---|---|---|---|---|---|
| Sep" | 15073.4 | 11309.5 | 19134.7 | 41.4 | 48.9 | 37.0 |
| Oct " | 14996.8 | 10963.6 | 19348.6 | 39.3 | 43.6 | 36.8 |
| Nov " | 15182.8 | 10822.4 | 19887.7 | 37.2 | 37.1 | 37.3 |
| Dec " | 15580.3 | 10904.1 | 20625.9 | 35.9 | 32.0 | 38.2 |
| Jan 1991 | 15841.7 | 11100.3 | 20957.7 | 30.4 | 26.9 | 32.5 |
| Feb " | 16277.9 | 11333.1 | 21613.3 | 26.6 | 22.2 | 29.3 |
| Mar " | 16701.9 | 11595.1 | 22212.1 | 24.9 | 17.8 | 29.3 |
| Apr " | 16980.7 | 11901.9 | 22460.7 | 22.3 | 14.3 | 27.4 |
| May " | 17125.7 | 12044.7 | 22608.1 | 19.8 | 9.7 | 26.5 |
| Jun " | 17302.8 | 12031.0 | 22991.1 | 17.3 | 5.5 | 25.2 |
| Jul " | 17267.2 | 11871.9 | 23088.7 | 15.3 | 2.4 | 24.0 |
| Aug " | 17157.8 | 11608.2 | 23145.8 | 14.6 | 1.5 | 23.2 |
| Sep" | 17066.4 | 11480.6 | 23093.5 | 13.2 | 1.5 | 20.7 |
| Oct " | 17088.5 | 11390.9 | 23236.2 | 13.9 | 3.9 | 20.1 |
| Nov " | 17140.0 | 11402.0 | 23331.3 | 12.9 | 5.4 | 17.3 |
| Dec " | 17178.7 | 11401.5 | 23412.3 | 10.3 | 4.6 | 13.5 |
| Jan 1992 | 17217.7 | 11422.9 | 22830.0 | 8.7 | 2.9 | 8.9 |
| Feb " | 17535.3 | 11752.5 | 23136.1 | 7.7 | 3.7 | 7.0 |
| Mar " | 17925.4 | 12311.7 | 23362.4 | 7.3 | 6.2 | 5.2 |
| Apr " | 18374.7 | 12702.5 | 23868.2 | 8.2 | 6.7 | 6.3 |
| May " | 18645.1 | 13126.2 | 23990.2 | 8.9 | 9.0 | 6.1 |
| Jun " | 18751.3 | 13198.2 | 24129.5 | 8.4 | 9.7 | 5.0 |
| Jul " | 19034.4 | 13265.0 | 24622.1 | 10.2 | 11.7 | 6.6 |
| Aug " | 19164.1 | 13240.3 | 24901.3 | 11.7 | 14.1 | 7.6 |
| Sep" | 19025.6 | 13013.5 | 24848.3 | 11.5 | 13.4 | 7.6 |
| Oct " | 19090.9 | 13018.2 | 24972.3 | 11.7 | 14.3 | 7.5 |
| Nov " | 19324.2 | 13212.8 | 25243.1 | 12.7 | 15.9 | 8.2 |
| Dec " | 19469.0 | 13341.5 | 25403.5 | 13.3 | 17.0 | 8.5 |
| Jan 1993 | 20912.4 | 14151.0 | 27460.8 | 21.5 | 23.9 | 20.3 |
| Feb " | 21562.7 | 14670.1 | 28238.2 | 23.0 | 24.8 | 22.1 |
| Mar " | 22096.7 | 15302.2 | 28677.2 | 23.3 | 24.3 | 22.7 |
| Apr " | 22609.3 | 15693.1 | 29307.7 | 23.0 | 23.5 | 22.8 |
| May " | 23106.7 | 16222.6 | 29774.0 | 23.9 | 23.6 | 24.1 |
| Jun " | 23634.9 | 16475.3 | 30569.0 | 26.0 | 24.8 | 26.7 |
| Jul " | 23826.7 | 16410.3 | 31009.5 | 25.2 | 23.7 | 25.9 |
| Aug " | 23997.2 | 16517.5 | 31241.3 | 25.2 | 24.8 | 25.5 |
| Sep" | 24141.2 | 16517.8 | 31524.5 | 26.9 | 26.9 | 26.9 |
| Oct " | 24148.9 | 16497.0 | 31559.8 | 26.5 | 26.7 | 26.4 |
| Nov " | 24466.5 | 16637.1 | 32049.3 | 26.6 | 25.9 | 27.0 |
| Dec " | 24853.2 | 16840.7 | 32613.5 | 27.7 | 26.2 | 28.4 |
| Jan 1994 | 25682.0 | 17251.0 | 33847.5 | 22.8 | 21.9 | 23.3 |

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|---|---|---|---|---|---|---|
| Feb " | 26298.6 | 17689.0 | 34537.0 | 22.0 | 20.6 | 22.3 |
| Mar " | 26855.0 | 18160.8 | 35275.4 | 21.5 | 18.7 | 23.0 |
| Apr " | 27368.8 | 18660.5 | 35802.8 | 21.1 | 18.9 | 22.2 |
| May " | 27958.4 | 19266.8 | 36376.2 | 21.0 | 18.8 | 22.2 |
| Jun " | 28572.5 | 19821.5 | 37047.9 | 20.9 | 20.3 | 21.2 |
| Jul " | 29145.4 | 20363.4 | 37650.8 | 22.3 | 24.1 | 21.4 |
| Aug " | 29680.9 | 20818.0 | 38264.7 | 23.7 | 26.0 | 22.5 |
| Sep" | 30441.7 | 21245.7 | 39348.1 | 26.1 | 28.6 | 24.8 |
| Oct " | 31258.9 | 21974.4 | 40251.0 | 29.4 | 33.2 | 27.5 |
| Nov " | 32223.2 | 22756.3 | 41391.9 | 31.7 | 36.8 | 29.2 |
| Dec " | 33347.7 | 23508.5 | 42780.2 | 34.2 | 39.6 | 31.2 |
| Jan 1995 | 34819.5 | 24485.8 | 44827.7 | 35.6 | 41.9 | 32.4 |
| Feb " | 36394.4 | 25430.2 | 47013.3 | 38.4 | 43.8 | 36.1 |
| Mar " | 38561.4 | 26603.7 | 50142.5 | 43.6 | 46.5 | 42.1 |
| Apr " | 41034.4 | 28337.8 | 53331.1 | 49.9 | 51.9 | 49.0 |
| May " | 43647.6 | 30404.7 | 56473.4 | 56.1 | 57.8 | 55.2 |
| Jun " | 46246.0 | 32471.9 | 59586.3 | 61.9 | 63.8 | 60.8 |
| Jul " | 48731.2 | 34748.1 | 62273.9 | 67.2 | 70.6 | 65.4 |
| Aug " | 50438.6 | 35998.0 | 64424.4 | 69.9 | 72.9 | 68.4 |
| Sep" | 51691.0 | 37188.0 | 65736.2 | 69.8 | 75.0 | 67.1 |
| Oct " | 52871.4 | 38021.0 | 67254.5 | 69.1 | 73.0 | 67.1 |
| Nov " | 54856.0 | 38770.0 | 70436.3 | 70.2 | 70.4 | 70.2 |
| Dec " | 56964.2 | 39471.8 | 73905.8 | 70.8 | 67.9 | 72.8 |
| Jan 1996 | 58914.0 | 40392.0 | 76853.4 | 69.2 | 65.0 | 71.4 |
| Feb " | 61154.4 | 42001.0 | 79704.5 | 68.0 | 65.2 | 69.5 |
| Mar " | 63543.0 | 42892.0 | 83543.6 | 64.8 | 61.2 | 66.6 |
| Apr " | 65763.0 | 43668.2 | 87161.9 | 60.3 | 54.1 | 63.4 |
| May " | 67323.3 | 44266.9 | 89653.6 | 54.2 | 45.6 | 58.8 |
| Jun " | 68639.2 | 44912.3 | 91618.8 | 48.4 | 38.3 | 53.8 |
| Jul " | 69511.8 | 45047.4 | 93205.6 | 42.6 | 29.6 | 49.7 |
| Aug " | 70218.0 | 44973.1 | 94667.8 | 39.2 | 24.9 | 46.9 |
| Sep " | 70564.7 | 45039.1 | 95286.3 | 36.5 | 21.1 | 45.0 |
| Oct " | 71001.4 | 45162.4 | 96026.6 | 34.3 | 18.8 | 42.8 |
| Nov " | 73050.7 | 46122.4 | 99131.0 | 33.2 | 19.0 | 40.7 |
| Dec " | 75569.7 | 47662.5 | 102598.0 | 32.7 | 20.8 | 38.8 |
| Jan"1997 | 77477.1 | 48970.6 | 105085.7 | 31.5 | 21.2 | 36.7 |
| Feb " | 79841.0 | 50056.9 | 108687.0 | 30.6 | 19.2 | 36.4 |
| Mar " | 82108.0 | 51496.8 | 111755.1 | 29.2 | 20.1 | 33.8 |
| Apr " | 84894.3 | 53868.0 | 114943.4 | 29.1 | 23.4 | 31.9 |
| May " | 87232.5 | 55197.6 | 118258.4 | 29.6 | 24.7 | 31.9 |
| Jun " | 88576.5 | 55771.3 | 120348.6 | 29.0 | 24.2 | 31.4 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Jul " | 89788.8 | 56237.5 | 122283.3 | 29.2 | 24.8 | 31.2 |
| Aug " | 90033.1 | 55237.0 | 123733.3 | 28.2 | 22.8 | 30.7 |
| Sep " | 90133.4 | 54187.0 | 124947.7 | 27.7 | 20.3 | 31.1 |
| Oct " | 90467.0 | 54214.4 | 125577.8 | 27.4 | 20.0 | 30.8 |
| Nov " | 90723.5 | 54057.8 | 126234.4 | 24.2 | 17.2 | 27.3 |
| Dec " | 91311.8 | 54274.9 | 127182.2 | 20.8 | 13.9 | 24.0 |
| Jan 1998 | 103.0 | 103.9 | 102.3 | 19.8 | 15.0 | 21.6 |
| Feb " | 106.0 | 108.7 | 103.7 | 19.6 | 17.7 | 19.2 |
| Mar " | 109.6 | 113.7 | 106.0 | 20.3 | 19.6 | 18.5 |
| Apr " | 115.9 | 124.4 | 108.3 | 23.1 | 25.2 | 17.8 |
| May " | 119.0 | 129.0 | 110.2 | 22.9 | 26.6 | 16.4 |
| Jun " | 119.7 | 128.7 | 111.8 | 21.8 | 25.1 | 16.1 |
| Jul " | 118.2 | 125.9 | 111.2 | 18.7 | 21.3 | 13.6 |
| Aug " | 118.4 | 125.4 | 112.0 | 18.6 | 23.0 | 13.1 |
| Sep " | 117.4 | 121.9 | 113.2 | 17.4 | 21.9 | 13.2 |
| Oct " | 115.8 | 118.0 | 113.7 | 17.1 | 21.4 | 13.2 |
| Nov " | 115.6 | 117.9 | 113.5 | 16.2 | 21.5 | 11.3 |
| Dec " | 116.9 | 119.8 | 114.2 | 15.7 | 21.8 | 10.3 |
| Jan 1999 | 118.7 | 122.7 | 115.1 | 15.3 | 18.1 | 12.5 |
| Feb " | 121.9 | 125.2 | 118.8 | 15.0 | 15.2 | 14.6 |
| Mar " | 124.6 | 127.8 | 121.6 | 13.7 | 12.4 | 14.7 |
| Apr " | 127.8 | 130.9 | 124.8 | 10.2 | 5.2 | 15.2 |
| May " | 130.2 | 133.9 | 126.7 | 9.4 | 3.8 | 15.0 |
| Jun " | 132.0 | 136.2 | 128.1 | 10.3 | 5.8 | 14.6 |
| Jul " | 133.2 | 137.2 | 129.5 | 12.7 | 9.0 | 16.5 |
| Aug " | 132.6 | 135.2 | 130.2 | 12.0 | 7.8 | 16.2 |
| Sep " | 131.2 | 131.3 | 131.2 | 11.8 | 7.7 | 15.9 |
| Oct " | 130.4 | 128.2 | 132.5 | 12.6 | 8.6 | 16.5 |
| Nov " | 130.9 | 126.6 | 134.9 | 13.2 | 7.4 | 18.9 |
| Dec " | 133.0 | 127.7 | 137.9 | 13.8 | 6.6 | 20.8 |
| Jan 2000 | 135.7 | 128.3 | 142.4 | 14.3 | 4.6 | 23.7 |
| Feb " | 140.1 | 132.2 | 147.3 | 14.9 | 5.6 | 24.0 |
| Mar " | 144.0 | 136.8 | 150.6 | 15.6 | 7.0 | 23.8 |
| Apr " | 150.1 | 142.2 | 157.3 | 17.5 | 8.7 | 26.0 |
| May " | 154.5 | 144.4 | 163.8 | 18.7 | 7.8 | 29.3 |
| Jun " | 158.2 | 145.5 | 169.8 | 19.8 | 6.8 | 32.6 |
| Jul " | 162.6 | 147.8 | 176.2 | 22.1 | 7.7 | 36.0 |
| Aug " | 167.9 | 149.9 | 184.1 | 26.6 | 10.9 | 41.4 |
| Sep " | 173.6 | 151.8 | 193.2 | 32.3 | 15.6 | 47.3 |
| Oct " | 179.2 | 154.0 | 201.9 | 37.4 | 20.2 | 52.4 |
| Nov " | 182.7 | 155.9 | 207.0 | 39.5 | 23.2 | 53.4 |

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|---|---|---|---|---|---|---|
| Dec " | 187.0 | 158.6 | 212.6 | 40.5 | 24.3 | 54.2 |
| Jan 2001 | 191.2 | 162.1 | 217.6 | 40.9 | 26.3 | 52.9 |
| Feb " | 196.4 | 168.4 | 221.6 | 40.1 | 27.4 | 50.5 |
| Mar " | 204.4 | 173.3 | 232.6 | 41.9 | 26.7 | 54.5 |
| Apr " | 209.4 | 177.4 | 238.5 | 39.5 | 24.7 | 51.6 |
| May " | 213.1 | 179.6 | 243.5 | 37.9 | 24.4 | 48.7 |
| Jun " | 216.5 | 182.8 | 247.0 | 36.8 | 25.7 | 45.5 |
| Jul " | 219.4 | 185.8 | 249.8 | 34.9 | 25.7 | 41.8 |
| Aug " | 221.7 | 185.4 | 254.7 | 32.0 | 23.6 | 38.3 |
| Sep " | 222.7 | 183.6 | 258.3 | 28.3 | 21.0 | 33.7 |
| Oct " | 225.0 | 185.0 | 261.5 | 25.6 | 20.1 | 29.5 |
| Nov " | 226.0 | 184.5 | 263.7 | 23.7 | 18.3 | 27.4 |
| Dec " | 226.8 | 185.2 | 264.6 | 21.3 | 16.7 | 24.5 |
| Jan 2002 | 229.2 | 189.8 | 265.1 | 19.9 | 17.1 | 21.8 |
| Feb " | 232.3 | 196.1 | 265.2 | 18.3 | 16.4 | 19.7 |
| Mar " | 237.1 | 202.1 | 268.9 | 16.0 | 16.6 | 15.6 |
| Apr " | 240.6 | 209.1 | 269.1 | 14.9 | 17.9 | 12.9 |
| May " | 243.7 | 214.5 | 270.2 | 14.3 | 19.4 | 10.9 |
| Jun " | 246.1 | 218.7 | 271.0 | 13.7 | 19.6 | 9.7 |
| Jul " | 249.0 | 222.9 | 272.6 | 13.5 | 20.0 | 9.1 |
| Aug " | 250.8 | 218.9 | 279.8 | 13.1 | 18.1 | 9.8 |
| Sep " | 251.4 | 217.3 | 281.8 | 12.9 | 18.4 | 9.1 |
| Oct " | 254.7 | 220.0 | 285.7 | 13.2 | 18.9 | 9.3 |
| Nov " | 257.6 | 223.0 | 288.5 | 14.0 | 20.9 | 9.4 |
| Dec " | 261.2 | 225.8 | 292.7 | 15.2 | 22.0 | 10.6 |
| Jan 2003 | 266.5 | 231.7 | 297.6 | 16.3 | 22.1 | 12.2 |
| Feb " | 300.6 | 249.0 | 346.7 | 29.4 | 27.0 | 30.7 |
| Mar " | 308.0 | 257.2 | 353.5 | 29.9 | 27.3 | 31.5 |
| Apr " | 312.7 | 264.0 | 355.9 | 30.0 | 26.3 | 32.2 |
| May " | 316.3 | 269.6 | 357.8 | 29.8 | 25.7 | 32.4 |
| Jun " | 318.9 | 274.2 | 358.4 | 29.6 | 25.4 | 32.3 |
| Jul " | 321.2 | 276.7 | 360.6 | 29.0 | 24.1 | 32.3 |
| Aug " | 320.2 | 270.4 | 374.0 | 27.7 | 23.6 | 33.7 |
| Sep " | 318.7 | 263.9 | 379.8 | 26.8 | 21.4 | 34.8 |
| Oct " | 317.3 | 268.8 | 369.4 | 24.6 | 22.2 | 29.3 |
| Nov " | 318.8 | 273.1 | 367.1 | 23.8 | 22.5 | 27.2 |
| Dec " | 322.7 | 274.5 | 374.5 | 23.6 | 21.5 | 27.9 |
| Jan 2004 | 326.2 | 278.6 | 376.7 | 22.4 | 20.3 | 26.6 |
| Feb " | 334.5 | 287.4 | 383.9 | 11.3 | 15.4 | 10.7 |
| Mar " | 340.4 | 294.0 | 388.5 | 10.5 | 14.3 | 9.9 |
| Apr " | 347.6 | 305.3 | 389.8 | 11.2 | 15.7 | 9.5 |

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|---|---|---|---|---|---|---|
| May " | 351.9 | 311.9 | 390.6 | 11.2 | 15.7 | 9.2 |
| Jun " | 357.0 | 318.0 | 394.1 | 11.9 | 16.0 | 10.0 |
| Jul " | 360.9 | 321.8 | 398.1 | 12.4 | 16.3 | 10.4 |
| Aug " | 361.6 | 322.2 | 399.2 | 12.9 | 19.1 | 6.8 |
| Sep " | 358.9 | 316.9 | 400.0 | 12.6 | 20.1 | 5.3 |
| Oct " | 356.8 | 312.9 | 400.5 | 12.4 | 16.4 | 8.4 |
| Nov " | 358.0 | 314.3 | 401.5 | 12.3 | 15.1 | 9.4 |
| Dec " | 360.7 | 317.1 | 404.0 | 11.8 | 15.5 | 7.9 |
| Jan 2005 | 364.0 | 321.0 | 406.4 | 11.6 | 15.2 | 7.9 |
| Feb " | 381.4 | 330.3 | 434.0 | 14.0 | 14.9 | 13.1 |
| Mar " | 397.3 | 344.8 | 450.9 | 16.7 | 17.3 | 16.1 |
| Apr " | 405.2 | 356.2 | 453.6 | 16.6 | 16.7 | 16.4 |
| May " | 409.3 | 361.9 | 455.3 | 16.3 | 16.0 | 16.6 |
| Jun " | 413.2 | 367.3 | 456.9 | 15.7 | 15.5 | 15.9 |
| Jul " | 414.5 | 368.9 | 457.8 | 14.9 | 14.6 | 15.0 |
| Aug " | 414.9 | 369.2 | 458.5 | 14.7 | 14.6 | 14.8 |
| Sep " | 412.5 | 364.9 | 458.6 | 14.9 | 15.2 | 14.6 |
| Oct " | 411.9 | 362.9 | 459.9 | 15.4 | 16.0 | 14.8 |
| Nov " | 412.8 | 363.5 | 461.1 | 15.3 | 15.7 | 14.8 |
| Dec " | 414.2 | 364.6 | 463.0 | 14.8 | 15.0 | 14.6 |
| Jan 2006 | 417.0 | 367.7 | 465.1 | 14.6 | 14.6 | 14.5 |
| Feb " | 427.4 | 375.5 | 478.6 | 12.1 | 13.7 | 10.3 |
| Mar " | 436.5 | 384.3 | 487.7 | 9.9 | 11.4 | 8.2 |
| Apr " | 443.5 | 392.3 | 493.1 | 9.5 | 10.1 | 8.7 |
| May " | 451.1 | 399.2 | 501.2 | 10.2 | 10.3 | 10.1 |
| Jun " | 456.6 | 404.4 | 506.7 | 10.5 | 10.1 | 10.9 |
| Jul " | 461.7 | 399.6 | 524.9 | 11.4 | 8.3 | 14.7 |
| Aug " | 461.3 | 394.6 | 531.2 | 11.2 | 6.9 | 15.9 |
| Sep " | 457.2 | 389.1 | 529.3 | 10.8 | 6.6 | 15.4 |
| Oct " | 455.2 | 384.6 | 531.1 | 10.5 | 6.0 | 15.5 |
| Nov " | 455.4 | 384.8 | 531.3 | 10.3 | 5.8 | 15.2 |
| Dec " | 457.8 | 387.7 | 532.9 | 10.5 | 6.4 | 15.1 |
| Jan 2007 | 206.1 | 193.9 | 216.0 | 10.9 | 8.1 | 13.1 |
| Feb " | 208.6 | 198.4 | 216.9 | 10.4 | 9.5 | 11.1 |
| Mar " | 211.3 | 199.8 | 220.6 | 10.2 | 8.4 | 11.6 |
| Apr " | 214.5 | 204.4 | 222.8 | 10.5 | 9.1 | 11.5 |
| May " | 218.4 | 210.2 | 225.1 | 11.0 | 10.2 | 11.7 |
| Jun " | 220.0 | 211.5 | 226.9 | 10.7 | 9.9 | 11.3 |
| Jul " | 222.6 | 213.7 | 229.8 | 10.1 | 10.2 | 10.1 |
| Aug " | 223.0 | 211.5 | 232.4 | 10.4 | 10.0 | 10.7 |
| Sep " | 222.5 | 208.4 | 234.0 | 10.2 | 9.3 | 10.9 |

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|---|---|---|---|---|---|---|
| Oct " | 222.1 | 206.0 | 235.3 | 10.1 | 8.8 | 11.1 |
| Nov " | 225.7 | 208.2 | 240.0 | 11.4 | 9.5 | 12.8 |
| Dec " | 229.8 | 211.3 | 244.8 | 12.7 | 10.5 | 14.4 |
| Jan. 2008 | 232.5 | 214.5 | 247.1 | 12.8 | 10.6 | 14.4 |
| Feb " | 236.2 | 220.7 | 248.8 | 13.2 | 11.2 | 14.7 |
| Mar " | 240.4 | 225.7 | 252.4 | 13.8 | 12.9 | 14.4 |
| Apr " | 247.4 | 231.3 | 260.4 | 15.3 | 13.1 | 16.9 |
| May " | 255.3 | 243.5 | 264.9 | 16.9 | 15.8 | 17.7 |
| Jun " | 260.5 | 249.1 | 269.9 | 18.4 | 17.7 | 18.9 |
| Jul " | 263.4 | 251.0 | 273.4 | 18.3 | 17.5 | 19.0 |
| Aug " | 263.4 | 248.6 | 275.4 | 18.1 | 17.6 | 18.5 |
| Sep " | 262.3 | 243.8 | 277.4 | 17.9 | 17.0 | 18.5 |
| Oct " | 260.6 | 236.9 | 279.8 | 17.3 | 15.0 | 18.9 |
| Nov " | 265.1 | 241.1 | 284.5 | 17.4 | 15.8 | 18.6 |
| Dec " | 271.5 | 246.7 | 291.7 | 18.1 | 16.7 | 19.1 |
| Jan 2009 | 278.6 | 256.2 | 296.9 | 19.9 | 19.4 | 20.2 |
| Feb " | 284.2 | 262.5 | 301.9 | 20.3 | 18.9 | 21.3 |
| Mar " | 289.8 | 267.5 | 307.9 | 20.5 | 18.5 | 22.0 |
| Apr " | 298.2 | 276.0 | 316.3 | 20.6 | 19.3 | 21.5 |
| May " | 306.5 | 285.3 | 323.8 | 20.1 | 17.2 | 22.2 |
| Jun " | 314.6 | 287.8 | 336.4 | 20.7 | 15.5 | 24.7 |
| Jul " | 317.3 | 289.1 | 340.3 | 20.5 | 15.2 | 24.5 |
| Aug " | 315.1 | 285.3 | 339.5 | 19.6 | 14.7 | 23.3 |
| Sep " | 310.5 | 275.0 | 339.5 | 18.4 | 12.8 | 22.4 |
| Oct " | 307.6 | 269.0 | 339.0 | 18.0 | 13.5 | 21.2 |
| Nov " | 309.9 | 271.0 | 341.6 | 16.9 | 12.4 | 20.0 |
| Dec " | 314.8 | 275.9 | 346.6 | 16.0 | 11.8 | 18.8 |

## APPENDIX II

### Yearly Consumer Price Index

| Year | No | Consumer Price Index |
|---|---|---|
| 1964 | 1 | 119.69 |
| 1965 | 2 | 151.31 |
| 1966 | 3 | 171.38 |
| 1967 | 4 | 157.03 |
| 1968 | 5 | 169.63 |
| 1969 | 6 | 181.80 |
| 1970 | 7 | 188.51 |
| 1971 | 8 | 205.98 |
| 1972 | 9 | 226.72 |
| 1973 | 10 | 266.43 |
| 1974 | 11 | 315.33 |
| 1975 | 12 | 408.91 |
| 1976 | 13 | 639.29 |
| 1977 | 14 | 1382.48 |
| 1978 | 15 | 173.09 |
| 1979 | 16 | 267.33 |
| 1980 | 17 | 401.18 |
| 1981 | 18 | 868.72 |
| 1982 | 19 | 1062.46 |
| 1983 | 20 | 2367.39 |
| 1984 | 21 | 3304.18 |
| 1985 | 22 | 3647.17 |
| 1986 | 23 | 4543.08 |
| 1987 | 24 | 6351.90 |
| 1988 | 25 | 8343.84 |
| 1989 | 26 | 10449.32 |
| 1990 | 27 | 14341.49 |
| 1991 | 28 | 16927.44 |
| 1992 | 29 | 18629.81 |
| 1993 | 30 | 23279.70 |
| 1994 | 31 | 29069.43 |
| 1995 | 32 | 46354.65 |
| 1996 | 33 | 67937.77 |
| 1997 | 34 | 86882.24 |

| Year | No | Consumer Price Index |
|---|---|---|
| 1999 | 2 | 128.89 |
| 2000 | 3 | 161.31 |
| 2001 | 4 | 214.39 |
| 2002 | 5 | 246.15 |
| 2003 | 6 | 311.81 |
| 2004 | 7 | 351.19 |
| 2005 | 8 | 404.27 |
| 2006 | 9 | 448.39 |
| 2007 | 10 | 218.73 |
| 2008 | 11 | 254.87 |
| 2009 | 12 | 303.93 |

## APPENDIX III

**3-Yearly Moving Average Smoothing for the Consumer Price Index**

| Year | No | 3-Yearly moving average | Mt | Yt/Mt |
|---|---|---|---|---|
| 1964 | 1 | | | |
| 1965 | 2 | 147.5 | | |
| 1966 | 3 | 159.9 | | |
| 1967 | 4 | 166.0 | 147.5 | 9.6 |
| 1968 | 5 | 169.5 | 159.9 | 9.7 |
| 1969 | 6 | 180.0 | 166.0 | 15.8 |
| 1970 | 7 | 192.1 | 169.5 | 19.0 |
| 1971 | 8 | 207.1 | 180.0 | 26.0 |
| 1972 | 9 | 233.0 | 192.1 | 34.6 |
| 1973 | 10 | 269.5 | 207.1 | 59.4 |
| 1974 | 11 | 330.2 | 233.0 | 82.3 |
| 1975 | 12 | 454.5 | 269.5 | 139.4 |
| 1976 | 13 | 810.2 | 330.2 | 309.1 |
| 1977 | 14 | 731.6 | 454.5 | 928.0 |
| 1978 | 15 | 607.6 | 810.2 | -637.1 |
| 1979 | 16 | 280.5 | 731.6 | -464.3 |
| 1980 | 17 | 512.4 | 607.6 | -206.5 |
| 1981 | 18 | 777.5 | 280.5 | 588.2 |
| 1982 | 19 | 1432.9 | 512.4 | 550.1 |
| 1983 | 20 | 2244.7 | 777.5 | 1589.9 |
| 1984 | 21 | 3106.2 | 1432.9 | 1871.3 |
| 1985 | 22 | 3831.5 | 2244.7 | 1402.5 |
| 1986 | 23 | 4847.4 | 3106.2 | 1436.8 |
| 1987 | 24 | 6412.9 | 3831.5 | 2520.4 |
| 1988 | 25 | 8381.7 | 4847.4 | 3496.5 |
| 1989 | 26 | 11044.9 | 6412.9 | 4036.4 |
| 1990 | 27 | 13906.1 | 8381.7 | 5959.8 |
| 1991 | 28 | 16632.9 | 11044.9 | 5882.6 |
| 1992 | 29 | 19612.3 | 13906.1 | 4723.7 |
| 1993 | 30 | 23659.6 | 16632.9 | 6646.8 |
| 1994 | 31 | 32901.3 | 19612.3 | 9457.1 |
| 1995 | 32 | 47787.3 | 23659.6 | 22695.0 |
| 1996 | 33 | 67058.2 | 32901.3 | 35036.5 |
| 1997 | 34 | | 47787.3 | 39085.0 |

| Year | No | 3-Yearly moving average | Mt | Yt/Mt |
|---|---|---|---|---|
| 1999 | 2 | | | |
| 2000 | 3 | 134.9 | | |
| 2001 | 4 | 168.2 | 134.9 | 79.5 |
| 2002 | 5 | 207.3 | 168.2 | 78.0 |
| 2003 | 6 | 257.5 | 207.3 | 104.5 |
| 2004 | 7 | 303.1 | 257.5 | 93.7 |
| 2005 | 8 | 355.8 | 303.1 | 101.2 |
| 2006 | 9 | 401.3 | 355.8 | 92.6 |
| 2007 | 10 | 357.1 | 401.3 | -182.6 |
| 2008 | 11 | 307.3 | 357.1 | -102.3 |
| 2009 | 12 | 259.2 | 307.3 | -3.4 |

## APPENDIX IV

**Single Exponential Smoothing for the Consumer Price Index**

| Year | No | Consumer Price Index | Smooth | Predict | Error |
|---|---|---|---|---|---|
| 1964 | 1 | 119.7 | 340.4 | -135.3 | 254.9 |
| 1965 | 2 | 151.3 | -12.3 | 340.4 | -189.1 |
| 1966 | 3 | 171.4 | 330.4 | -12.3 | 183.7 |
| 1967 | 4 | 157.0 | 6.9 | 330.4 | -173.4 |
| 1968 | 5 | 169.6 | 310.5 | 6.9 | 162.7 |
| 1969 | 6 | 181.8 | 70.4 | 310.5 | -128.7 |
| 1970 | 7 | 188.5 | 290.7 | 70.4 | 118.1 |
| 1971 | 8 | 206.0 | 132.6 | 290.7 | -84.7 |
| 1972 | 9 | 226.7 | 308.2 | 132.6 | 94.1 |
| 1973 | 10 | 266.4 | 230.3 | 308.2 | -41.7 |
| 1974 | 11 | 315.3 | 388.9 | 230.3 | 85.0 |
| 1975 | 12 | 408.9 | 426.2 | 388.9 | 20.0 |
| 1976 | 13 | 639.3 | 823.7 | 426.2 | 213.1 |
| 1977 | 14 | 1382.5 | 1866.1 | 823.7 | 558.7 |
| 1978 | 15 | 173.1 | -1292.4 | 1866.1 | -1693.0 |
| 1979 | 16 | 267.3 | 1617.5 | -1292.4 | 1559.8 |
| 1980 | 17 | 401.2 | -651.7 | 1617.5 | -1216.3 |
| 1981 | 18 | 868.7 | 2184.8 | -651.7 | 1520.4 |
| 1982 | 19 | 1062.5 | 90.9 | 2184.8 | -1122.3 |
| 1983 | 20 | 2367.4 | 4337.9 | 90.9 | 2276.5 |
| 1984 | 21 | 3304.2 | 2409.3 | 4337.9 | -1033.7 |
| 1985 | 22 | 3647.2 | 4718.6 | 2409.3 | 1237.8 |
| 1986 | 23 | 4543.1 | 4391.1 | 4718.6 | -175.6 |
| 1987 | 24 | 6351.9 | 8049.2 | 4391.1 | 1960.8 |
| 1988 | 25 | 8343.8 | 8598.9 | 8049.2 | 294.6 |
| 1989 | 26 | 10449.3 | 12051.1 | 8598.9 | 1850.4 |
| 1990 | 27 | 14341.5 | 16324.1 | 12051.1 | 2290.4 |
| 1991 | 28 | 16927.4 | 17449.7 | 16324.1 | 603.3 |
| 1992 | 29 | 18629.8 | 19651.3 | 17449.7 | 1180.1 |
| 1993 | 30 | 23279.7 | 26420.5 | 19651.3 | 3628.4 |
| 1994 | 31 | 29069.4 | 31362.4 | 26420.5 | 2649.0 |
| 1995 | 32 | 46354.6 | 59332.2 | 31362.4 | 14992.2 |
| 1996 | 33 | 67937.8 | 75386.9 | 59332.2 | 8605.6 |
| 1997 | 34 | 86882.2 | 96832.8 | 75386.9 | 11495.3 |

| Year | No | Consumer Price Index | Smooth | Predict | Error |
|---|---|---|---|---|---|
| 1999 | 2 | 128.9 | 127.8 | 114.7 | 14.2 |
| 2000 | 3 | 161.3 | 158.8 | 127.8 | 33.5 |
| 2001 | 4 | 214.4 | 210.3 | 158.8 | 55.6 |
| 2002 | 5 | 246.1 | 243.5 | 210.3 | 35.9 |
| 2003 | 6 | 311.8 | 306.7 | 243.5 | 68.3 |
| 2004 | 7 | 351.2 | 347.9 | 306.7 | 44.5 |
| 2005 | 8 | 404.3 | 400.1 | 347.9 | 56.4 |
| 2006 | 9 | 448.4 | 444.8 | 400.1 | 48.3 |
| 2007 | 10 | 218.7 | 235.5 | 444.8 | -226.1 |
| 2008 | 11 | 254.9 | 253.4 | 235.5 | 19.3 |
| 2009 | 12 | 303.9 | 300.2 | 253.4 | 50.5 |

## APPENDIX V

**Holt's Exponential Smoothing for the Consumer Price Index**

| Year | No | Consumer Price Index | Et α=1.04183 | Tt γ=1.20991 |
|---|---|---|---|---|
| 1964 | 1 | 119.7 | 119.6 | 122.1 |
| 1965 | 2 | 151.3 | 150.0 | 183.3 |
| 1966 | 3 | 171.4 | 170.9 | 183.7 |
| 1967 | 4 | 157.0 | 155.7 | 197.6 |
| 1968 | 5 | 169.6 | 171.1 | 133.9 |
| 1969 | 6 | 181.8 | 181.3 | 194.3 |
| 1970 | 7 | 188.5 | 188.5 | 188.7 |
| 1971 | 8 | 206.0 | 206.4 | 195.7 |
| 1972 | 9 | 226.7 | 226.7 | 226.6 |
| 1973 | 10 | 266.4 | 267.2 | 247.1 |
| 1974 | 11 | 315.3 | 315.5 | 312.0 |
| 1975 | 12 | 408.9 | 410.8 | 364.4 |
| 1976 | 13 | 639.3 | 644.5 | 515.8 |
| 1977 | 14 | 1382.5 | 1402.4 | 905.1 |
| 1978 | 15 | 173.1 | 85.6 | 2264.8 |
| 1979 | 16 | 267.3 | 349.2 | -1688.7 |
| 1980 | 17 | 401.2 | 374.4 | 1040.5 |
| 1981 | 18 | 868.7 | 894.2 | 259.9 |
| 1982 | 19 | 1062.5 | 1042.2 | 1547.1 |
| 1983 | 20 | 2367.4 | 2421.1 | 1084.2 |
| 1984 | 21 | 3304.2 | 3271.7 | 4080.6 |
| 1985 | 22 | 3647.2 | 3634.4 | 3952.5 |
| 1986 | 23 | 4543.1 | 4568.7 | 3930.3 |
| 1987 | 24 | 6351.9 | 6381.8 | 5637.0 |
| 1988 | 25 | 8343.8 | 8343.5 | 8351.2 |
| 1989 | 26 | 10449.3 | 10455.4 | 10303.6 |
| 1990 | 27 | 14341.5 | 14414.4 | 12599.2 |
| 1991 | 28 | 16927.4 | 16851.0 | 18754.4 |
| 1992 | 29 | 18629.8 | 18619.0 | 18888.1 |
| 1993 | 30 | 23279.7 | 23403.1 | 20330.5 |
| 1994 | 31 | 29069.4 | 29079.4 | 28832.1 |
| 1995 | 32 | 46354.6 | 46837.7 | 34807.5 |
| 1996 | 33 | 67937.8 | 67971.9 | 67121.3 |
| 1997 | 34 | 86882.2 | 86781.7 | 89284.7 |

| Year | No | Consumer Price Index | Et α=1.04183 | Tt γ=1.20991 |
|---|---|---|---|---|
| 1998 | 1 | 114.6 | 104.3 | 67.5 |
| 1999 | 2 | 128.9 | 121.7 | 96.4 |
| 2000 | 3 | 161.3 | 156.8 | 141.0 |
| 2001 | 4 | 214.4 | 205.3 | 173.1 |
| 2002 | 5 | 246.1 | 242.5 | 229.5 |
| 2003 | 6 | 311.8 | 302.6 | 269.8 |
| 2004 | 7 | 351.2 | 348.3 | 338.0 |
| 2005 | 8 | 404.3 | 400.3 | 386.2 |
| 2006 | 9 | 448.4 | 446.9 | 441.7 |
| 2007 | 10 | 218.7 | 278.4 | 489.6 |
| 2008 | 11 | 254.9 | 258.0 | 269.3 |
| 2009 | 12 | 303.9 | 291.2 | 246.2 |

## APPENDIX 6

**Winters' Exponential Smoothing for the Consumer Price Index**

| Year | Consumer Price Index | Smooth | Trend | Seasonal |
|---|---|---|---|---|
| 1964 | 119.7 | 26.3 | 31.1 | 0.4 |
| 1965 | 151.3 | 65.9 | 38.0 | 0.5 |
| 1966 | 171.4 | 112.7 | 41.1 | 0.5 |
| 1967 | 157.0 | 164.2 | 38.9 | 0.6 |
| 1968 | 169.6 | 200.6 | 35.5 | 0.6 |
| 1969 | 181.8 | 270.7 | 29.8 | 0.8 |
| 1970 | 188.5 | 342.2 | 22.6 | 0.9 |
| 1971 | 206.0 | 538.9 | 13.6 | 1.4 |
| 1972 | 226.7 | 728.4 | 4.6 | 2.1 |
| 1973 | 266.4 | 825.1 | -3.0 | 2.6 |
| 1974 | 315.3 | 62.5 | 36.1 | 0.4 |
| 1975 | 408.9 | 155.4 | 62.9 | 0.4 |
| 1976 | 639.3 | 247.3 | 98.7 | 0.5 |
| 1977 | 1382.5 | 400.0 | 177.9 | 0.6 |
| 1978 | 173.1 | 711.3 | 130.2 | 0.5 |
| 1979 | 267.3 | 741.7 | 92.2 | 0.5 |
| 1980 | 401.2 | 766.4 | 65.3 | 0.6 |
| 1981 | 868.7 | 906.6 | 60.7 | 0.8 |
| 1982 | 1062.5 | 1138.7 | 55.0 | 0.9 |
| 1983 | 2367.4 | 1813.5 | 68.1 | 1.5 |
| 1984 | 3304.2 | 2843.2 | 74.3 | 2.1 |
| 1985 | 3647.2 | 3865.2 | 68.0 | 2.6 |
| 1986 | 4543.1 | 534.6 | 519.5 | 0.5 |
| 1987 | 6351.9 | 1621.1 | 947.0 | 0.5 |
| 1988 | 8343.8 | 3110.7 | 1346.3 | 0.6 |
| 1989 | 10449.3 | 5520.6 | 1629.6 | 0.6 |
| 1990 | 14341.5 | 5512.4 | 2346.3 | 0.5 |
| 1991 | 16927.4 | 8839.4 | 2889.9 | 0.6 |
| 1992 | 18629.8 | 12829.5 | 3180.8 | 0.6 |
| 1993 | 23279.7 | 20343.2 | 3208.5 | 0.8 |
| 1994 | 29069.4 | 27625.8 | 3143.2 | 0.9 |
| 1995 | 46354.7 | 49658.4 | 2929.6 | 1.5 |
| 1996 | 67937.8 | 73926.8 | 2698.6 | 2.1 |
| 1997 | 86882.2 | 95243.9 | 2461.2 | 2.5 |

| Year | Consumer Price Index | Smooth | Trend | Seasonal |
|---|---|---|---|---|
| 1998 | 114.6 | 67.4 | 21.8 | 0.5 |
| 1999 | 128.9 | 93.1 | 23.7 | 0.5 |
| 2000 | 161.3 | 135.0 | 24.3 | 0.7 |
| 2001 | 214.4 | 200.1 | 24.0 | 0.8 |
| 2002 | 246.1 | 248.7 | 23.0 | 0.9 |
| 2003 | 311.8 | 333.5 | 21.3 | 1.2 |
| 2004 | 351.2 | 390.6 | 19.3 | 1.3 |
| 2005 | 404.3 | 461.0 | 17.0 | 1.5 |
| 2006 | 448.4 | 518.3 | 14.7 | 1.6 |
| 2007 | 218.7 | 254.0 | 12.3 | 0.8 |
| 2008 | 254.9 | 295.1 | 10.1 | 0.9 |
| 2009 | 303.9 | 349.0 | 8.0 | 1.1 |

## APPENDIX 7

**Model Summary and Parameter Estimates**

Dependent Variable:CPI (old series)

| Equation | Model Summary | | | | | Parameter Estimates | |
|---|---|---|---|---|---|---|---|
| | R Square | F | df1 | df2 | Sig. | Constant | b1 |
| Linear | .485 | 126.014 | 1 | 134 | .000 | -1.375E4 | 350.857 |
| Logarithmic | .219 | 37.539 | 1 | 134 | .000 | -2.858E4 | 9.871E3 |
| Exponential | .920 | 1.544E3 | 1 | 134 | .000 | 47.156 | .051 |

The independent variable is trend (year)

**Model Summary and Parameter Estimates**

Dependent Variable:CPI (new series)

| Equation | Model Summary | | | | | Parameter Estimates | |
|---|---|---|---|---|---|---|---|
| | R Square | F | df1 | df2 | Sig. | Constant | b1 |
| Linear | .408 | 31.651 | 1 | 46 | .000 | 149.092 | 4.658 |
| Logarithmic | .512 | 48.279 | 1 | 46 | .000 | 21.546 | 82.460 |
| Exponential | .505 | 47.021 | 1 | 46 | .000 | 143.849 | .021 |

The independent variable is trend (year).

## APPENDIX 8

**ARIMA Model: CPI**

Estimates at each iteration

| Iteration | SSE | Parameters | |
|---|---|---|---|
| 0 | 107508 | 0.100 | 236.981 |
| 1 | 90677 | 0.250 | 197.809 |
| 2 | 78216 | 0.400 | 158.260 |
| 3 | 70071 | 0.550 | 118.159 |
| 4 | 66704 | 0.664 | 86.847 |
| 5 | 66023 | 0.707 | 73.861 |
| 6 | 65849 | 0.729 | 67.509 |
| 7 | 65801 | 0.740 | 64.234 |
| 8 | 65788 | 0.746 | 62.501 |
| 9 | 65784 | 0.749 | 61.571 |
| 10 | 65783 | 0.751 | 61.067 |
| 11 | 65783 | 0.752 | 60.792 |
| 12 | 65783 | 0.753 | 60.643 |

Relative change in each estimate less than 0.0010

Final Estimates of Parameters

| Type | Coef | SE Coef | T | P |
|---|---|---|---|---|
| AR 1 | 0.7526 | 0.2169 | 3.47 | 0.006 |
| Constant | 60.64 | 22.68 | 2.67 | 0.023 |

Number of observations: 12
Residuals: SS = 61599.3 (backforecasts excluded)
MS = 6159.9 DF = 10

Modified Box-Pierce (Ljung-Box) Chi-Square statistic

| Lag | 12 | 24 | 36 | 48 |
|---|---|---|---|---|
| Chi-Square | * | * | * | * |
| DF | * | * | * | * |
| P-Value | * | * | * | * |

## APPENDIX 9

CPI 242 items

1 Guinea corn/sorghum
2 Maize
3 Maize, ground
4 Millet
5 Rice - Local
6 Rice - Imported
7 Bread - sugar bread
8 Biscuits
9 Flour
10 Cassava - fresh
11 Cocoyam
12 Plantain
13 Yam
14 Cassava - Kokonte
15 Cassava - Gari
16 Cassava dough
17 Small beans (white)
18 Bambara beans
19 Groundnuts (shelled)
20 Dawadawa
21 Red kolanut
22 Palmnut
23 Tender coconut
24 Cocoyam leaves (kontomire)
25 Garden eggs
26 Okro
27 Onions (large)
28 Onions (small/shallots)
29 Fresh pepper (red)
30 Tomatoes
31 Tomato puree (canned)
32 Banana
33 Orange
34 Pineapple
35 Pawpaw
36 Coconut oil
37 Groundnut oil

122 Child frock - 10 yrs
123 Trousers
124 Shorts
125 Blouse
126 Sports shirt
127 Shirt (65% cotton)
128 Shirt (100% cotton)
129 Pants (men)
130 Pants (women)
131 Vest
132 Brassiere
133 Pants (child)
134 Scarf
135 Artsilk
136 Pyjamas
137 Handkerchief
138 Men's shoes
139 Women's shoes
140 Sandals (men)
141 Sandals (women)
142 Canvas Shoes
143 Rubber sandals
144 Socks (men)
145 Socks (children)
146 Shoe repairs - Heel
147 Full sole
148 Half sole
149 Property taxes
150 Rental payment
151 Construction & repairs
152 Electricity
153 Gas for cooking
154 Kerosene
155 Charcoal (bag)
156 Charcoal (loose)
157 Firewood
158 Water

38 Palm kernel oil
39 Red palm oil
40 Shea butter
41 Margarine
42 Corned beef
43 Fresh beef - dear cut
44 Fresh beef - cheaper cut
45 Bushmeat
46 Goat (fresh)
47 Fresh mutton
48 Pork
49 Snails
50 Chicken
51 Guinea fowl
52 Chicken eggs
53 Smoked herring
54 Fresh prawns
55 Fresh herrings
56 Red fish
57 Kpala (Starvids)
58 Dried fish
59 Tinned sardines
60 Tinned milk (unsweetened)
61 Milk powder
62 Butter
63 Sugar-cube
64 Sugar-gran
65 Ice cream
66 Dried pepper (red)
67 Salt
68 Ginger
69 Cooked rice & stew
70 Fufu & soup
71 Tuo & soup
72 Banku & stew
73 Kenkey with fried fish
74 Coffee
75 Milo
76 Tea
77 Cocoa
78 Fanta

159 Bed sheet (70"x90")
160 Bed sheet (90"x100")
161 Blanket (45"x72")
162 Blanket (60"x80")
163 Towel (30"x60")
164 Mattress
165 Full size bedstead
166 Medium size bedstead
167 Table chair
168 Arm chair
169 Table (medium)
170 Floor mat
171 Sideboard
172 Glass tumbler
173 Plastic beaker/mug
174 2 plastic dinner plates
175 1 stainless steel dessert spoon
176 Aluminium cooking pot
177 Bucket
178 Cutlass (store)
179 Hurricane lamp
180 Broom
181 Electric fan
182 Electric fridge
183 Electric iron
184 Electric stove
185 Coalpot
186 Small radio
187 Radio/cassette
188 TV set
189 Repairs to appliances
190 Guardian soap
191 Key soap
192 Omo
193 Starch
194 Blue Sunshine
195 Vim
196 Parazone
197 Anti-mosquito coils
198 Matches
199 Toilet roll

79 Coca-Cola
80 Lemonade
81 Fruit juice
82 Club or Star
83 Dark beer (eg Guilder)
84 Palm wine
85 Pito
86 Akpeteshie
87 Whisky
88 Gin
89 Embassy
90 Tusker
91 555
92 Tobacco leaves
93 Cotton Local Super
94 Local Ordinary
95 Local Fancy
96 Imported (Dutch/British)
97 Cote d'Ivoire
98 Check ordinary
99 Drills expensive
100 Drills ordinary
101 Silk
102 Kente Men
103 Kente Women
104 Adinkra
105 Shirting material
106 Suiting material (woollen)
107 Trouser material
108 Shorts
109 Shirt (short sleeves)
110 Trousers drills
111 Trousers (woollen)
112 Dress
113 Knock about
114 Kaba
115 Knock about (child)
116 Frock (child)
117 Repairs to clothing
118 Suit
119 Smock
200 Light bulb
201 Shoe polish
202 Laundry charge
203 Paracetomol
204 Septrin
205 Tetracycline
206 Chloroquin
207 Vitamin B-Complex
208 Hospital operation
209 Food
210 Medicines
211 Doctors consulting fee
212 Native doctor
213 Car
214 Bicycle
215 Bicycle tyre
216 Wheel alignment
217 Petrol
218 Oil
219 Intercity bus fares
220 Trotro
221 Taxi charges
222 Standard postage within Ghana
223 EMS charge within Ghana
224 Telephone charges
225 Blank cassette
226 Video house
227 Graphic
228 Times
229 Students Ex book (20)
230 Teacher's notebook
231 School fees
232 Tuition fees
233 Uniform (10-12 yrs) Boy
234 Uniform (10-12 yrs) Girl
235 Charges for food & lodging
236 Hair cutting (gents)
237 Hair dressing (women)
238 Toothpaste
239 Razor Blades
240 Women's cosmetics

120 Ladies frock
121 Child frock - 1 year

241 Suitcase
242 Watch