ANALYSIS OF FINANCIAL INFORMATION REQUIREMENTS AND IMPLEMENTATION OF A FINANCIAL DATA MANAGEMENT SYSTEM

by

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ABSTRACT

The requirements regarding the collection and use of financial information have been analyzed from a practical implementation perspective. Standard definitions and formulations of the theory of investment management constitute the basis for the study. The most important output of the study is a "Financial Data Management System" with functions for storing, processing, and reporting financial information for four main types of financial assets (common stocks, commodities, foreign currencies and bonds).

KISA ÖZET

Finansal bilgilerin toplanması ve kullanımı ile ilgili gereksinimler pratik uygulamaya yönelik bir bakış açısıyla incelenmiştir. Yatırım yönetimi teorisindeki standart tanım ve formüller çalışmanın temelini oluşturur. Dört ana finansal varlık çeşidi (yani hisse senetleri, ticari mallar, dövizler ve bonolar) ile ilgili finansal bilgileri saklama, işleme ve raporlama işlevlerine sahip bir "Finansal Veri Yönetim Sistemi"nin geliştirilmesi bu çalışmanın en önemli çıktısıdır.

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d_i	date of **i**th data item
sd_t	start date of interval **t**
ed_t	end date of interval **t**
l_p	length of period **p**
$v_{d_i,bop}$	beginning-of-period value on date $\mathbf{d_i}$
$v_{d_i,eop}$	end-of-period value on date $\mathbf{d_i}$
$r_{d_i,p,t}$	rate of return for period **p** on date $\mathbf{d_i}$ in interval
ad_j	adjustment date of **j**th adjustment
ar_j	adjustment ratio of **j**th adjustment
$ucp_{d_i,j}$	unadjusted closing price on date $\mathbf{d_i}$
$acp_{d_i,j}$	adjusted closing price on date $\mathbf{d_i}$ after **j**th adjustment
sp_{d_i}	selling price on date $\mathbf{d_i}$
l_{bp}	length of bond period **bp**
dr(b,id,bp)	discount rate for bond **b** issued on date **id** with bond period **bp**
iv_{d_i}	index value for on date $\mathbf{d_i}$
$ci_{d_i,t}$	calculated index on date $\mathbf{d_i}$ in interval **t**
$fv(b,id,bp)_k$	face value for **k**th combination of bond **b** issued on date **id** with bond period **bp**
w_{cs}	weight of common stocks
w_c	weight of commodities
w_{fc}	weight of foreign currencies
w_b	weight of bonds
$pv_{d_i,t}$	value of portfolio on date $\mathbf{d_i}$ in interval **t**

n_{cs}	number of common stocks
n_c	number of commodities
n_{fc}	number of foreign currencies
n_b	number of bonds
$n_{(b,id,bp)_k}$	number of bond combinations
$avr_{p,t}$	average rate of return for period **p** in interval **t**
$cov_{p,t}(x,y)$	covariance of any (**x** :) asset, market, or portfolio against any (**y** :) asset, market, or portfolio for period **p** in interval **t**

1. INTRODUCTION

Towards the end of the 20th century, financial data has gained more importance for the world economies. Globalization has led to a large volume of data flow throughout the world. Moreover, increasing number of financial instruments together with growing economies resulted in the need of storing larger volumes of financial data. On the other hand, more investors are interested in historic financial data for the performance analysis of several instruments. The need for a Financial Data Management System (FDMS) has arisen from this fact and the Turkish economy with its pretty new open structure did not have such an open system to provide financial data to the investors. Although the financial markets are suffering from the speculations and lack of stabilization, the use of financial data is inevitable for the investors. The aim of this system is to store and process financial data in an open environment in order to provide consistent and ready-to-use information to the users.

In the development of the system, four main types of assets have been included, i.e. common stocks, commodities, foreign currencies, and bonds. The system is capable of calculating the risks and returns for assets of these types, portfolios composed of assets, and markets where different types of assets are traded. Addition of other asset types is not a complicated process due to the generic structure of the system. Based on the data provided by this system, users can perform various statistical or technical analyses. In addition to this, the data can be used in portfolio optimization which may be of primary importance to most investors.

The best option for the storage of financial data was a relational database. For academic purposes, the use of a simple Personal Computer (PC) based database and an application

development tool seemed to be the most appropriate approach. Based on this approach, the system was developed with Microsoft (MS) tools, namely MS Access for application development and either Borland's Paradox or Microsoft's Access database for data storage. With the use of a Paradox database the system was opened to non-Microsoft tools, since data in a Paradox database can be used by many other tools, such as Borland's Quattro Pro. In the Microsoft environment with an MS Access database the data can be used by other tools like MS Excel.

In the financial world, with the existence of a high number of transactions, lots of financial instruments, and various performance analysis methods, the need for efficient data storage along with flexible retrieval and processing routines has been existing for twenty years, or so. All over the world, many systems have been implemented based on this requirement. Most of the financial markets have their own transaction processing systems and provide financial data for analysis purposes. The data is mostly stored in relational databases. This enables the investors to retrieve the data they need in a quick and flexible manner. After this, investors can perform their own analyses, where the method they choose is a matter of taste. For most of the analysis methods, the basic data requirements are trading volume, price, interest rate, rate of return, and measures of risk.

Financial markets in Turkey, in comparison to Western countries are pretty new. Until 1980s, bank deposits were the most popular investment opportunities since there were no competing instruments. With the newly emerging financial instruments of the globalized economy, the need for financial data processing increased suddenly. This resulted in disintegrated data stores and the standardization did not happen until now. In order to have such a standard, the best approach can be a relational database environment.

The purpose of this system is to propose such an environment for high level financial data, specifically selected for performance analysis of financial instruments. It is designed to be flexible for future enhancements, to include additional instruments or data items and to be open against new processing requirements. The system is powerful enough to cover the basic requirements.

2. SYSTEM DESCRIPTION

2.1 Development

The end product of this study is a Financial Data Management System (FDMS). Just like any information system, the development of FDMS passed through several phases including the analysis of requirements, converting these requirements to a list of system functions, entities and relationships, and the design work based on the system definitions. This approach is, actually, a standard system development methodology. The common needs in the financial environment built the core of the requirements analysis and the results were the selection of the four basic asset types, the construction of portfolios and markets, and the calculation logic for risks and returns. After this, a standard analysis of system functions, entities and relationships [1] has been carried out and the main outputs of this work are the "Entity Relationship Diagrams" which are given in the next section . Based on these, the system design and development work has been carried out in three integrated parts, namely database, user interface, and data processing modules [2].

2.2 System Entities and Relationships

This system is composed of two basic entity types, structures and data. This is very usual in most of the data processing and retrieval systems. The most important distinction between the two is the dynamic nature of data entities compared to the static nature of

the structure entities. Obviously, there are examples of entities which belong to both categories.

The structure entities of the system can be classified in two subcategories. The first type of structures are used to identify basic data parameters like periods or intervals. Definitions of assets, markets, or portfolios, on the other hand, constitute the second type of structures.

Data entities of the system are generally used to store input and output data, like asset prices and returns. There may be additional intermediate data entities that are used by the data processing routines.

In principle, the outputs of the system should have a dynamic link to the inputs identified by the data processing algorithms. However, in practice, due to performance reasons and technical constraints these links turn out to be established via static output entities that must be recalculated when the underlying inputs are changed.

The relationships between all these entities are very important for the efficiency and reliability of the system. In the theory of systems development, by applying the basic rules of the database normalization techniques, these relationships are easily implemented. Once all the entities together with their relationships are established, system development is a very straightforward issue.

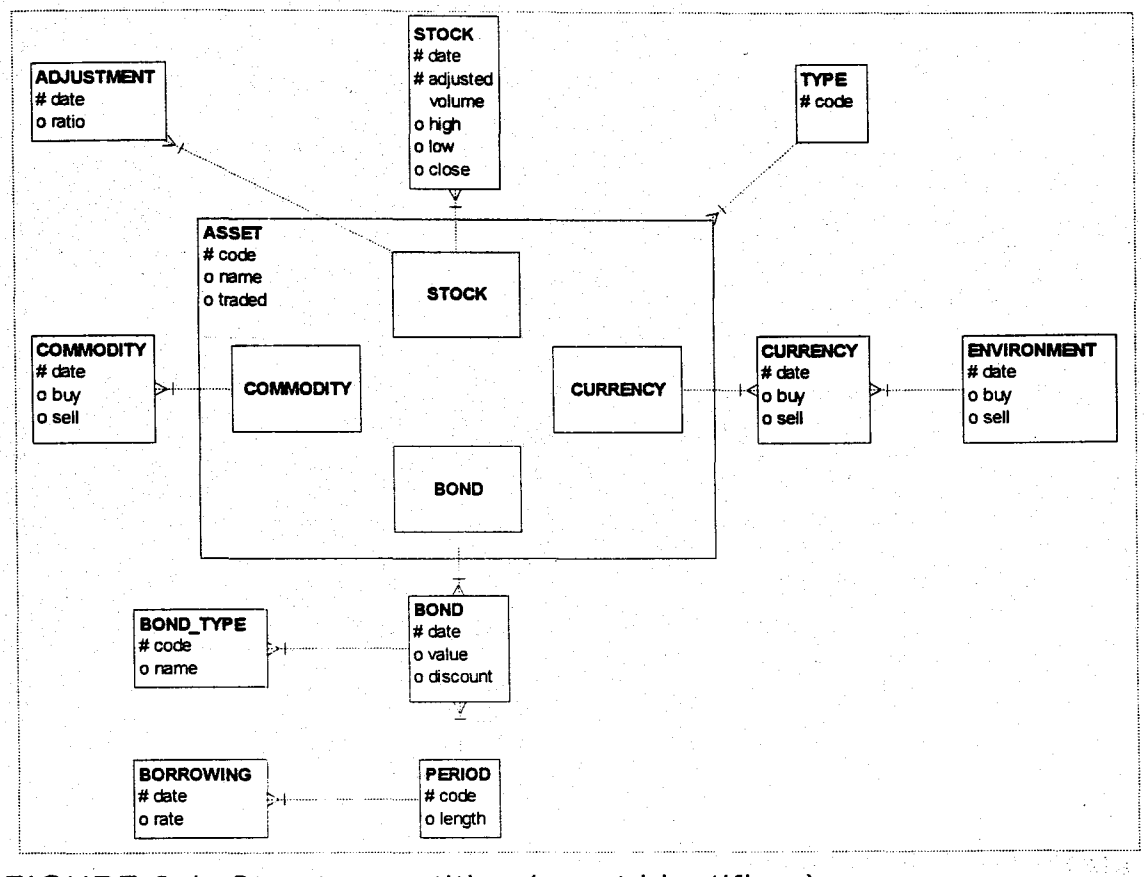

FIGURE 2.1. Structure entities (asset identifiers)

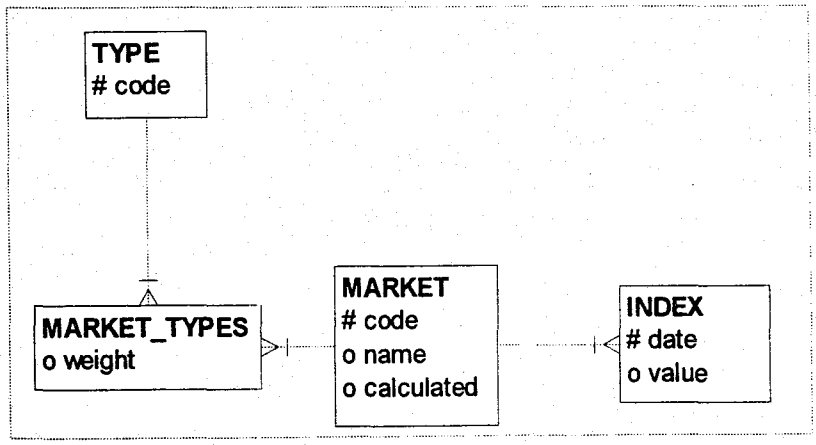

FIGURE 2.2. Structure entities (market identifiers)

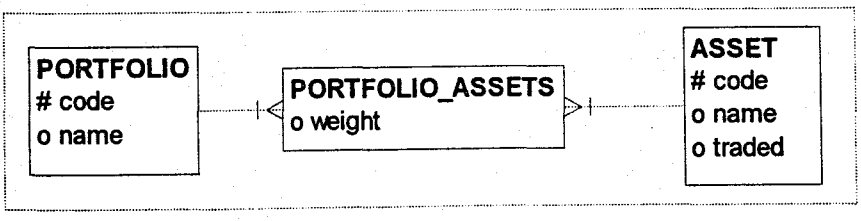

FIGURE 2.3. Structure entities (portfolio identifiers)

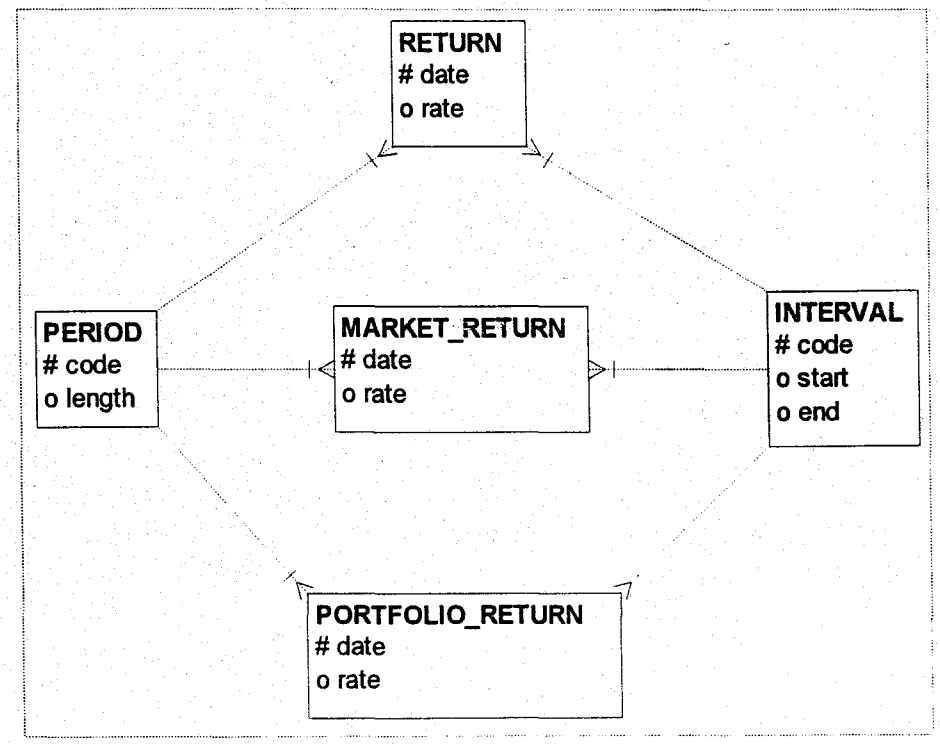

FIGURE 2.4. Data entities (returns)

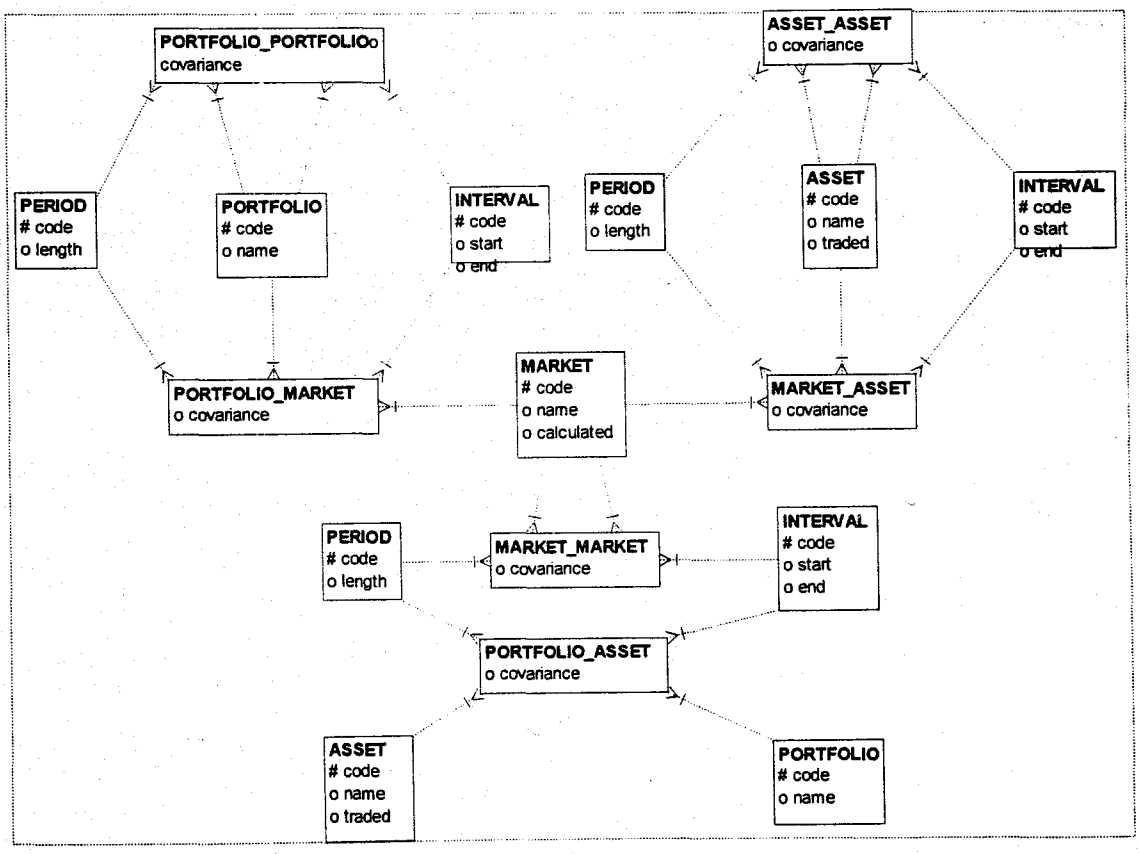

FIGURE 2.5. Data entities (risks)

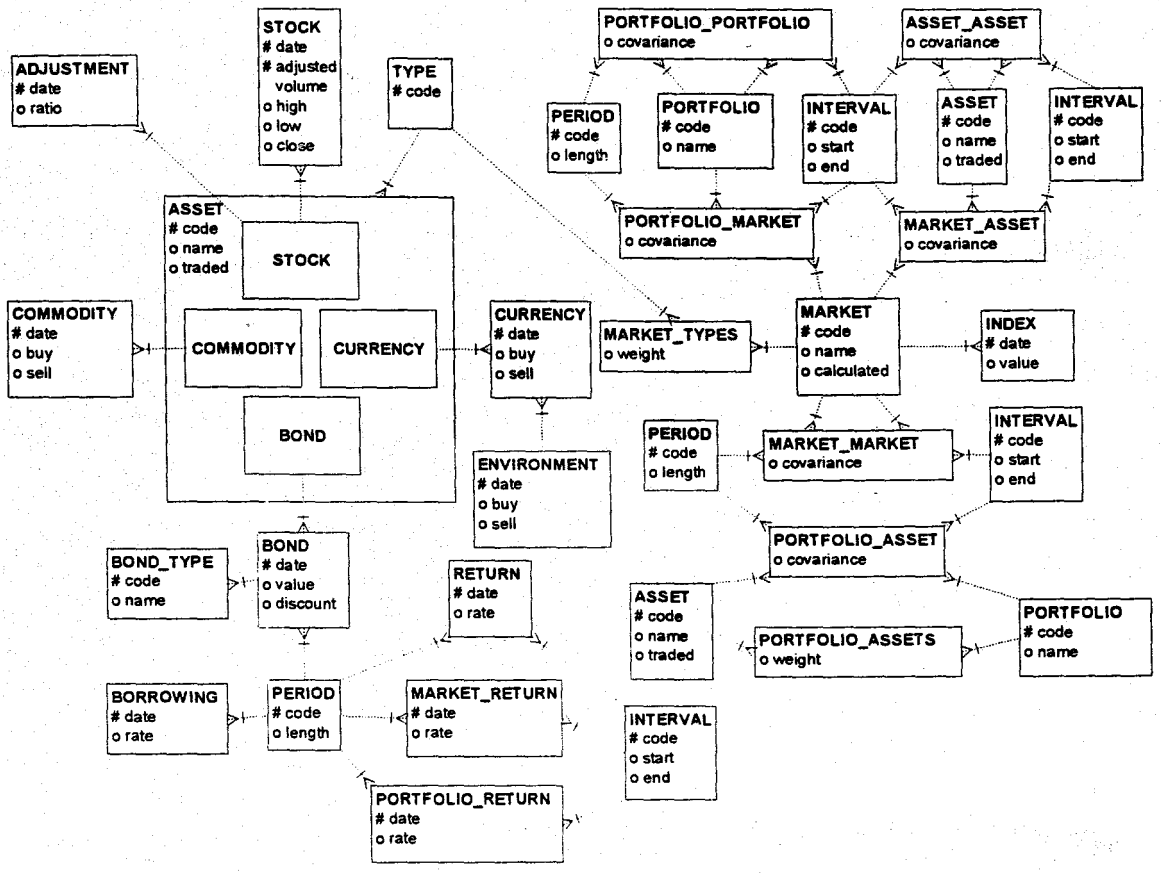

FIGURE 2.6. Entity Relationship Diagram (all entities)

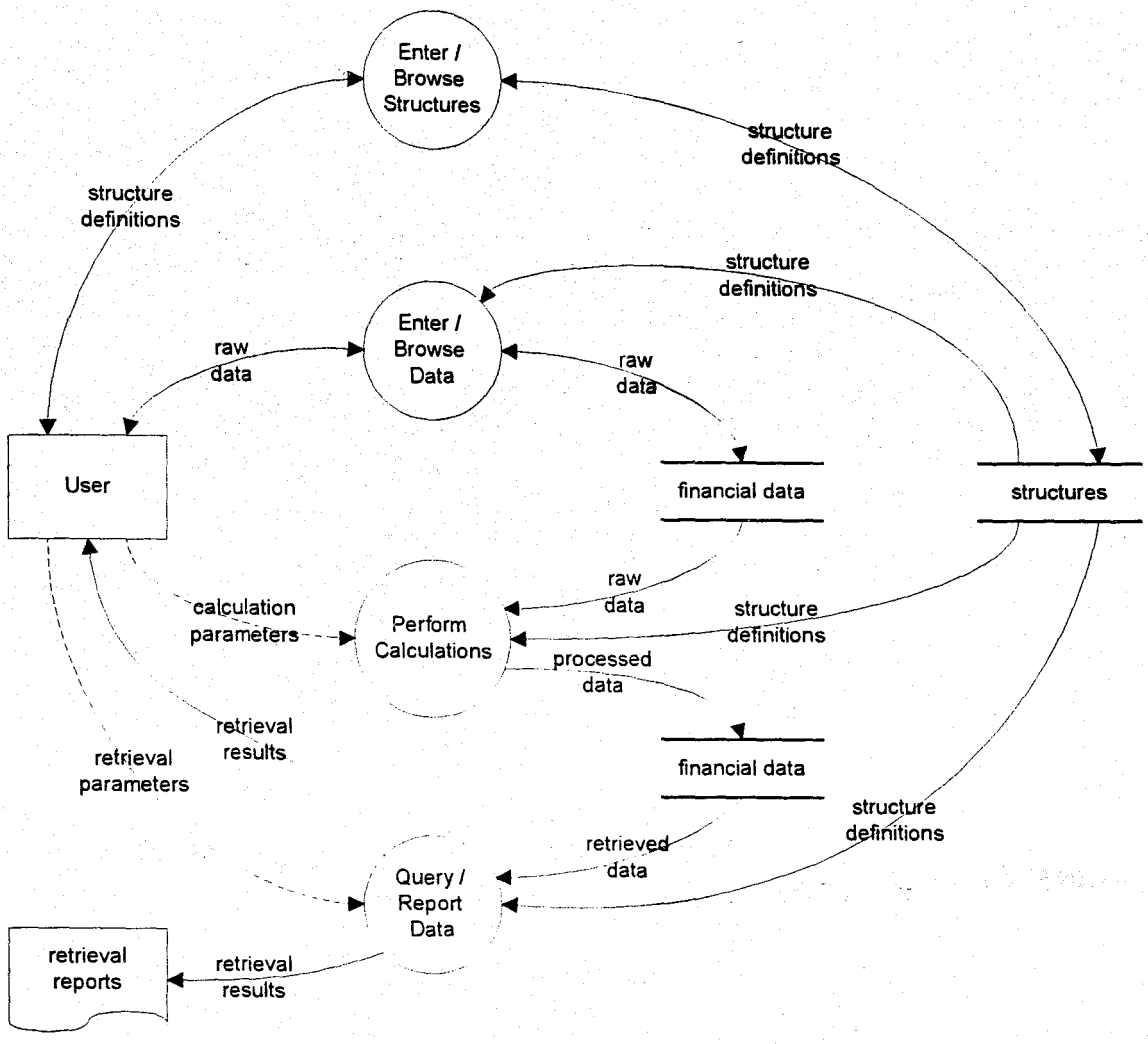

FIGURE 2.7 Data Flow Diagram

2.3 Features

The flexibility of the system is its most important feature. It is based on the principles of standard requirements for all financial instruments that constitute the major inputs to the system. Besides this, information requirements specific to various assets (e.g. trading volumes for common stocks) may be stored on the database. For the risk and return calculations [3], which are the main outputs of the system, the periods and date intervals are included as master items

that must be set by the users. Any asset type, that is going to be used must be defined and these are currently common stocks, foreign currencies, commodities, foreign currencies, and bonds. The setup of all master items is within the "Basic Definitions" of the system.

Following the basic definitions, three types of "Financial Definitions" have to be made by the users. These are assets, markets, and portfolios. All of these will be based on codes given by the users. Assets will have a type, markets will be defined as asset types involved, and portfolios will be defined as assets within that portfolio.

Inputs to the system will be entered as "Financial Data" for the three types of assets except stocks which may have adjustments, additionally. Commodity and foreign currency data may be entered as buying and selling prices whereas bond data is collected as issue date, face value, and discount rate together with the maturity period.

"Stock Data", on the other hand, may be entered as high, low, and closing prices with the trading volume. For all stocks, the adjustments are stored and adjusted stock prices are calculated.

For some markets, the market returns are not based on the information entered for their ingredients. For these markets, "Market Indices" are collected.

In addition to these data items that are collected and used in the calculations, risk-free "Borrowing Rates" may be stored on the database. This facility is useful for users if they want to optimize their portfolios using that information together with the price, risk, and return data.

In terms of calculations, the system is able to perform risk and return calculations for individual assets, markets, or portfolios.

The rates of "Return" of an asset for a given period within an interval is calculated as the logarithm of the ratio of the asset prices for two dates. For bonds, discount rates and maturity periods are used in the return calculations. For stocks, adjustments performed until the last adjustment date are taken into account.

"Market Returns" are calculated in a similar manner, using the daily values for all the assets of the types in a market with the weights of these types.

"Portfolio Returns" are based on returns of the assets in that portfolio and the weights of these assets.

The system can calculate the risks, or "Covariances" of "Assets", "Markets", or "Portfolios". For assets, markets, or portfolios, using the returns that are previously calculated, the covariances against any other asset, market, or portfolio (or themselves, giving their variance) can be calculated for any selected period and interval.

In summary, the main features of the system from a functional perspective are:

(a) setup (e.g. definition of asset types, periods, intervals, assets, markets, and portfolios),

(b) data entry (e.g. inputs to stock prices, bond discount rates),

(c) processing (e.g. calculation of period and interval based returns and covariances), and

(d) retrieval (e.g. querying and reporting of input and output data).

3. FUNCTIONAL SPECIFICATION

3.1 Assets

3.1.1. Definition of Assets

Four types of financial instruments, namely financial assets, have been selected out of a longer list of the investment opportunities [3] for this study. Each of these asset types provide a set of financial data items for analysis and processing purposes:

3.1.2. Common Stocks

Price and trading volume information is basically what most investors are interested in. For common stocks, the following data may be collected:

(a) trading volume

The volume information is not used in any calculation but may be used in technical or statistical analysis.

(b) high and low prices

Like the volume information, no calculations are performed with these data items, except the adjustments to stock prices. Besides these the data may be used in technical or statistical analysis.

(c) closing prices

The same operations as with the other prices are performed with closing prices. Additionally, all of the risk and return calculations are based on closing prices. The adjustments to stock prices also affect the closing prices.

3.1.3. Commodities

In the commodity markets generally two prices exist, buying and selling prices for each trading day:

(a) buying price

This is the price with which people are willing to buy the commodity in the market. This information may be used for technical or statistical analysis purposes.

(b) selling prices

This is the price with which investors can buy the security. In addition to technical or statistical analysis, the risk and return calculations are based on these prices.

3.1.4. Foreign Currencies

Foreign currencies are very similar to commodities in terms of the information that is being collected and analyzed. The only difference is that the exchange rates may have various sources. Therefore, the daily price information is collected for each environment separately:

(a) buying price

These buying prices are treated in the same manner as the buying prices of commodities.

(b) selling prices

The approach to commodity selling prices is applied to foreign currency selling prices with the only exception of selecting an environment, which is the 'free market', as the basis for risk and return calculations.

3.1.5. Bonds

This category of financial instruments can be used for several types of assets, such as Treasury bills or corporate bonds. These can also vary in the length of the maturity period for the data they provide to the system:

(a) issue date

The date on which a bond is issued is used in calculating its value until the maturity date.

(b) discount rate

For each bond, the discount rate for the specified period is used in the risk and return calculations.

(c) face value

Face value is additional information that is being used for current price calculations in order to have market and portfolio processing.

3.2 Markets

There may be as many markets as the user wants that are defined within the system. These markets can be representing physical markets such as commodity or bond markets, and logical markets, weighted combinations of two or more asset types.

Two types of markets can exist, these are distinguished in the definition of the basis for risk and return calculations. They can be based on:

(a) the index data of that market, or

(b) the price data of the ingredients of that market.

If the price data is to be used for the risk and return calculations, then all the assets of the asset types in that market are taken into account.

3.3 Portfolios

The approach to investing known as "modern portfolio theory" has been introduced by Markowitz in 1952 [5]. Following the analysis of individual assets, an investor can than construct portfolios of selected assets. The construction of a portfolio involves identifying specific assets in which to invest as well as determining the proportions of the investments for each asset.

Here, the issues of selectivity, timing, and diversification need to be addressed by the investor. Selectivity, also known as microforecasting, refers to analysis of assets and thus focuses on forecasting price movements of individual assets. Timing, also known as macroforecasting, involves the forecasting of price movements of variable income assets, such as common stocks, relative to fixed income assets, such as corporate bonds. Diversification involves constructing the investor's portfolio in a manner such that risk is minimized, subject to certain restrictions [6].

The portfolios constructed with these criteria have to be revised by the investors. This means the proportions, or weights, of a portfolio are set when constructing that portfolio and then changed with revisions resulting in new portfolios [6].

3.4 Returns

3.4.1. Definition of Returns

The result of any investment is the return realized by the end of the investment period. This can be positive or negative. For any investment the rate of return is calculated as the natural logarithm of the end-of-period value divided by the beginning-of-period value (alternatively, difference in value during the period divided by the beginning-of-period value [6]) and given in percentage format.

This rule can be applied to assets, markets, or portfolios. In general, the rate of return varies with the length of the investment period. There are two basic parameters used in these calculations:

(a) interval

The interval is used to group the base data by defining a start and an end date. The calculation of returns is performed using the data in the specified interval.

(b) period

Investment period, on the other hand, is used to define the time difference in days for the selection of proper beginning-of-period data for each end-of-period data. The returns are realized at the end of the period.

Based on these a more systematic definition of the realized rate of return is:

$$r_{d_i,p,t} = \ln \frac{v_{d_i,eop}}{v_{d_i,bop}}$$

$$sd_t < d_i \leq ed_t$$

for: *and*

$$d_{i,eop} - d_{i,bop} = l_p$$

where:

d_i : date of **i**th data item

sd_t : start date of interval **t**

ed_t : end date of interval **t**

l_p : length of period **p**

$v_{d_i,bop}$: beginning-of-period value on date $\mathbf{d_i}$

$v_{d_i,eop}$: end-of-period value on date $\mathbf{d_i}$

$r_{d_i,p,t}$: rate of return for period **p** on date $\mathbf{d_i}$ in interval **t**

There are alternative definitions of the end-of-period value:

$$v_{d_i,eop} = v_{d_i,bop} \cdot e^{r_{d_i,p,t}} ,$$

and the beginning-of-period value:

$$v_{d_i,bop} = \frac{v_{d_i,eop}}{e^{r_{d_i,p,t}}}.$$

Compound rates of return can be calculated by simply adding individual returns. The approach introduced above has to be combined with the derivation of asset values out of the base data. For each asset type, the calculation logic applied is given below.

3.4.2. Common Stocks

Buying common stocks is one of the most interesting investment opportunities. The rate of return of fixed income securities, such as bonds, does not change after the security is issued and purchased. Common stocks, on the other hand, are variable income securities. Investors do not know exactly what the rate of return for a specific period will be.

Another important feature of common stocks is the possibility of adjustments to stock prices due to changes in the capital structure of a company that issued these securities. Such a change would result in a sudden change of the stock prices on the adjustment date. Knowing the nominal adjustment ratio, it is easy to adjust stock prices prior to the adjustment date by multiplying with that ratio:

$$acp_{d_i,j}(cs) = acp_{d_i,j-1}(cs) \cdot ar_j$$

with: $acp_{d_i,0}(cs) = ucp_{d_i}(cs)$

for: $d_i \leq ad_j$

where:

ad_j : adjustment date of **j**th adjustment

ar_j : adjustment ratio of **j**th adjustment

$ucp_{d_i,j}(cs)$: unadjusted closing price for common stock (**cs**) on date $\mathbf{d_i}$

$acp_{d_i,j}(cs)$: adjusted closing price for common stock (**cs**) on date $\mathbf{d_i}$ after **j**th adjustment

Once these adjustments are made, the returns are based on adjusted closing prices, wherever applicable. For any common stock, the returns can be calculated in three different manners when selecting the price data to be used. The calculation method for the three options are given below:

(a) adjusted prices on beginning-of-period and end-of-period dates:

$$r_{d_i,p,t}(cs) = \ln \frac{acp_{d_i,eop}(cs)}{acp_{d_i,bop}(cs)}$$

$$sd_t < d_i \leq ad_j$$

for: *and*

$$d_{i,eop} - d_{i,bop} = l_p$$

(b) adjusted price on beginning-of-period date and unadjusted price on end-of-period date

$$r_{d_i,p,t}(cs) = \ln \frac{ucp_{d_i,eop}(cs)}{acp_{d_i,bop}(cs)}$$

$$d_i > ad_l$$

and

for: $d_i - ad_l \leq l_p$

and

$$d_{i,eop} - d_{i,bop} = l_p$$

(a) adjusted prices on beginning-of-period and end-of-period dates

$$r_{d_i,p,t}(cs) = \ln \frac{ucp_{d_i,eop}(cs)}{ucp_{d_i,bop}(cs)}$$

$$ad_l < d_i \leq ed_t$$

for: *and*

$$d_{i,eop} - d_{i,bop} = l_p$$

where:

ad_l : last adjustment date

$acp_{d_i,eop}(cs)$: adjusted end-of-period closing price for common stock **cs** on date d_i

$acp_{d_i,bop}(cs)$: adjusted beginning-of-period closing price for common stock **cs** on date d_i

$ucp_{d_i,eop}(cs)$: unadjusted end-of-period closing price for common stock **cs** on date d_i

$ucp_{d_i,bop}(cs)$: unadjusted beginning-of-period closing price for common stock **cs** on date d_i

$r_{d_i,p,t}(cs)$: rate of return for common stock **cs** for period **p** on date d_i in interval **t**

The union of the returns calculated with the three different methods gives a complete set of return data for common stocks.

3.4.3. Commodities

Commodities are simple financial assets in terms of the return calculations. The return calculations are based on the selling prices:

$$r_{d_i,p,t}(c) = \ln \frac{sp_{d_i,eop}(c)}{sp_{d_i,bop}(c)}$$

$$sd_t < d_i \leq ed_t$$

for: *and*

$$d_{i,eop} - d_{i,bop} = l_p$$

where:

$sp_{d_i,eop}(c)$: end-of-period selling price for commodity **c** on date $\mathbf{d_i}$

$sp_{d_i,bop}(c)$: beginning-of-period selling price for commodity **c** on date $\mathbf{d_i}$

$r_{d_i,p,t}(cs)$: rate of return for commodity **c** for period **p** on date $\mathbf{d_i}$ in interval **t**

3.4.4. Foreign Currencies

The return calculations for foreign currencies is very similar to that of commodities. An additional identifier is the environment setting up the prices. Free market is taken as the basis for return calculations of foreign currencies:

$$r_{d_i,p,t}(fc) = \ln \frac{sp_{d_i,eop}(fc,fm)}{sp_{d_i,bop}(fc,fm)}$$

$$sd_t < d_i \leq ed_t$$

for: *and*

$$d_{i,eop} - d_{i,bop} = l_p$$

where:

$sp_{d_i,eop}(fc,fm)$: end-of-period selling price for foreign currency **fc** on free market **fm** on date $\mathbf{d_i}$

$sp_{d_i,bop}(fc,fm)$: beginning-of-period selling price for foreign currency **fc** on free market **fm** on date $\mathbf{d_i}$

$r_{d_i,p,t}(fc)$: rate of return for foreign currency **fc** for period **p** on date $\mathbf{d_i}$ in interval **t**

3.4.5. Bonds

The fixed income alternatives to common stocks are bonds, e.g. Treasury or corporate bonds. These securities are identified by the face value, the issue date, the maturity period and the discount rate with which the bond's price on any date is calculated. In order to calculate the rate of return for a bond, only the discount rate and the length of the maturity period is enough. Nevertheless, for the price on any date, which will form the basis for market and portfolio risks and returns, the face value is to be used, additionally. The rate of return for a bond is calculated as:

$$r_{d_i,p,t}(b,id,bp) = -\frac{l_p}{l_{bp}} \cdot dr(b,id,bp)$$

$$sd_t \leq d_i \leq ed_t$$

and

for: $id < d_i \leq id + l_{bp}$

and

$$l_p \leq l_{bp}$$

where:

l_{bp} : length of bond period **bp**

$dr(b,id,bp)$: discount rate for bond **b** issued on date **id** with bond period **bp**

$r_{d_i,p,t}(b,id,bp)$: rate of return for bond **b** issued on date **id** with bond period **bp** for period **p** on date $\mathbf{d_i}$ in interval **t**

In the return calculations, bonds are assumed to be zero-coupon ones and they can be traded any time after the issue date and during the bond period.

3.5 Market Returns

3.5.1. Definition of Markets

As it is mentioned earlier, the market returns can be calculated in two different ways. One method uses the index data collected for a market. Alternatively, if this index data either does not exist or is not collected, the rate of return for a market can be based on the data of its ingredients [7]. The calculation method for the two market types are given below.

3.5.2. Index Based Market Returns

The calculation of returns is straightforward with this method. A simple calculation with the general end-of-period vs. beginning-of-period formulation is the method that has been used here:

$$r_{d_i,p,t}(m) = \ln \frac{iv_{d_i,eop}(m)}{iv_{d_i,bop}(m)}$$

$$sd_t < d_i \leq ed_t$$

for: *and*

$$d_{i,eop} - d_{i,bop} = l_p$$

where:

$iv_{d_i,eop}(m)$: end-of-period index value for market **m** on date $\mathbf{d_i}$

$iv_{d_i,bop}(m)$: beginning-of-period index value for market **m** on date $\mathbf{d_i}$

$r_{d_i,p,t}(m)$: rate of return for market **m** for period **p** on date $\mathbf{d_i}$ in interval **t**

3.5.3. Ingredients Based Market Returns

In this alternative, the approach is to calculate an index value based on all the ingredients in a market with a grouping by asset type. This grouping is used together with the weights of these asset types, in determining the contributions to the calculated market index. The calculation method for each asset type is given below:

(a) common stocks

For common stocks, this calculation is simply the sum of all closing prices on each date within the return interval:

$$ci_{d_i,t}(cs) = \sum_{k=1}^{n_{cs}} acp_{d_i}(cs_k) \quad \text{for:} \quad d_i \leq ad_l$$

$$ci_{d_i,t}(cs) = \sum_{k=1}^{n_{cs}} ucp_{d_i}(cs_k) \quad \text{for:} \quad d_i > ad_l$$

for: $sd_t \leq d_i \leq ed_t$ *and* $sd_t \leq ad_l \leq ed_t$

where:

n_{cs} : number of common stocks

$acp_{d_i}(cs_k)$: adjusted closing price for **k**th common stock on date $\mathbf{d_i}$

$ucp_{d_i}(cs_k)$: unadjusted closing price for **k**th common stock on date $\mathbf{d_i}$

$ci_{d_i,t}(cs)$: calculated index for common stocks on date $\mathbf{d_i}$ in interval **t**

(b) commodities

The sum of selling prices for all assets of the commodity type gives the calculated index value of commodities for each date within the return interval:

$$ci_{d_i,t}(c) = \sum_{k=1}^{n_c} sp_{d_i}(c_k)$$

for: $sd_t \leq d_i \leq ed_t$

where:

n_c : number of commodities

$sp_{d_i}(c_k)$: selling price for **k**th commodity on date $\mathbf{d_i}$

$ci_{d_i,t}(c)$: calculated index for commodities on date $\mathbf{d_i}$ in interval **t**

(c) foreign currencies

Free market based exchange rates as selling prices of all foreign currencies are summed up for each date to find out the calculated index value of foreign currencies within the interval:

$$ci_{d_i,t}(fc) = \sum_{k=1}^{n_{fc}} sp_{d_i}(fc_k, fm)$$

for: $sd_t \leq d_i \leq ed_t$

where:

n_{fc} : number of foreign currencies

$sp_{d_i}(fc_k, fm)$: selling price for **k**th foreign currency on free market **fm** on date $\mathbf{d_i}$

$ci_{d_i,t}(fc)$: calculated index for foreign currencies on date $\mathbf{d_i}$ in interval **t**

(d) bonds

The face value together with the discount rate of a bond is used in determining the current value of that bond which constitutes the basis for the calculated index of bonds:

$$ci_{d_i,t}(b) = \sum_{k=1}^{n_{(b,id,bp)_k}} fv(b,id,bp)_k \cdot e^{\frac{l_{bp} - (d_i - id)}{l_{bp}} \cdot dr(b,id,bp)_k}$$

for: $sd_t \leq d_i \leq ed_t$ *and* $id < d_i \leq id + l_{bp}$

where:

$n_{(b,id,bp)_k}$: number of bond combinations

$dr(b,id,bp)_k$: discount rate for **k**th combination of bond **b** issued on date **id** with bond period **bp**

$fv(b,id,bp)_k$: face value for **k**th combination of bond **b** issued on date **id** with bond period **bp**

$ci_{d_i,t}(b)$: calculated index for bonds on date $\mathbf{d_i}$ in interval **t**

3.5.4. Market Returns

Following these index calculations, the calculated market index is based on the formula:

$$\begin{aligned} ci_{d_i,t}(m) = {} & w_{cs}(m) \cdot ci_{d_i,t}(cs) \\ & + w_c(m) \cdot ci_{d_i,t}(c) \\ & + w_{fc}(m) \cdot ci_{d_i,t}(fc) \\ & + w_b(m) \cdot ci_{d_i,t}(b) \end{aligned}$$

for: $sd_t \leq d_i \leq ed_t$

where:

$w_{cs}(m)$: weight of common stocks in market **m**

$w_c(m)$: weight of commodities in market **m**

$w_{fc}(m)$: weight of foreign currencies in market **m**

$w_b(m)$: weight of bonds in market **m**

The market returns based on the ingredients can be calculated as:

$$r_{d_i,p,t}(m) = \ln \frac{ci_{d_i,eop}(m)}{ci_{d_i,bop}(m)}$$

$$sd_t < d_i \leq ed_t$$

for: *and*

$$d_{i,eop} - d_{i,bop} = l_p$$

where:

$ci_{d_i,eop}(m)$: end-of-period calculated market index for market **m** on date $\mathbf{d_i}$

$ci_{d_i,bop}(m)$: beginning-of-period calculated market index for market **m** on date $\mathbf{d_i}$

$r_{d_i,p,t}(m)$: rate of return for market **m** for period **p** on date $\mathbf{d_i}$ in interval **t**

3.6 Portfolio Returns

3.6.1. Definition of Portfolios

The calculation of portfolio returns is basically similar to the calculation of ingredient based market returns. In this case, the calculated index is replaced by the portfolio value. The assets in a portfolio are grouped by asset type and the portfolio value for each asset type is calculated as follows:

(a) common stocks

$$pv_{d_i,t}(pf,cs) = \sum_{k=1}^{n_{cs}(pf)} w_{cs}(pf) \cdot acp_{d_i}(cs_k) \quad \text{for: } d_i \le ad_l$$

$$pv_{d_i,t}(pf,cs) = \sum_{k=1}^{n_{cs}(pf)} w_{cs}(pf) \cdot ucp_{d_i}(cs_k) \quad \text{for: } d_i > ad_l$$

$$sd_t \le d_i \le ed_t$$

for: *and*

$$sd_t \le ad_l \le ed_t$$

where:

$n_{cs}(pf)$: number of common stocks in portfolio **pf**

$w_{cs}(pf)$: weight of common stocks in portfolio **pf**

$pv_{d_i,t}(pf,cs)$: value of portfolio **pf** for common stocks on date d_i in interval **t**

(b) commodities

$$pv_{d_i,t}(pf,c) = \sum_{k=1}^{n_c(pf)} w_c(pf) \cdot sp_{d_i}(c_k)$$

for: $sd_t \leq d_i \leq ed_t$

where:

$n_c(pf)$: number of commodities in portfolio **pf**

$w_c(pf)$: weight of commodities in portfolio **pf**

$pv_{d_i,t}(pf,c)$: value of portfolio **pf** for commodities on date $\mathbf{d_i}$ in interval **t**

(c) foreign currencies

$$pv_{d_i,t}(pf,fc) = \sum_{k=1}^{n_{fc}(pf)} w_{fc}(pf) \cdot sp_{d_i}(fc_k,fm)$$

for: $sd_t \leq d_i \leq ed_t$

where:

$n_{fc}(pf)$: number of foreign currencies in portfolio **pf**

$w_{fc}(pf)$: weight of foreign currencies in portfolio **pf**

$pv_{d_i,t}(pf,fc)$: value of portfolio **pf** for foreign currencies on date $\mathbf{d_i}$ in interval **t**

(d) bonds

$$pv_{d_i,t}(pf,b) = \sum_{k=1}^{n_{(b,id,bp)_k}(pf)} w_{(b,id,bp)_k}(pf) \cdot fv(b,id,bp)_k \cdot e^{\frac{l_{bp} - (d_i - id)}{l_{bp}} \cdot dr(b,id,bp)_k}$$

$$sd_t \leq d_i \leq ed_t$$

for: *and*

$$id < d_i \leq id + l_{bp}$$

where:

$n_{(b,id,bp)_k}(pf)$: number of bond combinations in portfolio **pf**

$w_b(pf)$: weight of bonds in portfolio **pf**

$pv_{d_i,t}(pf,b)$: value of portfolio **pf** for bonds on date $\mathbf{d_i}$ in interval **t**

3.6.2. Portfolio Returns

Following these calculations, the value of a portfolio is based on the formula [6]:

$$\begin{aligned} pv_{d_i,t}(pf) = {} & pv_{d_i,t}(pf,cs) \\ & + pv_{d_i,t}(pf,c) \\ & + pv_{d_i,t}(pf,fc) \\ & + pv_{d_i,t}(pf,b) \end{aligned}$$

for: $sd_t \leq d_i \leq ed_t$

The portfolio returns based on the portfolio values can be calculated as:

$$r_{d_i,p,t}(pf) = \ln \frac{pv_{d_i,eop}(pf)}{pv_{d_i,bop}(pf)}$$

$$sd_t < d_i \leq ed_t$$

for: *and*

$$d_{i,eop} - d_{i,bop} = l_p$$

where:

$pv_{d_i,eop}(pf)$: end-of-period value of portfolio **pf** on date $\mathbf{d_i}$

$pv_{d_i,bop}(pf)$: beginning-of-period value of portfolio **pf** on date $\mathbf{d_i}$

$r_{d_i,p,t}(pf)$: rate of return for portfolio **pf** for period **p** on date $\mathbf{d_i}$ in interval **t**

3.7 Covariances

The relationship between two data sets is defined as the covariance. That is, it is a measure of how two random variables such as the returns on two securities "move together". A positive value for covariance indicates the securities' returns tend to go together. A negative covariance indicates a tendency for the returns to offset one another. A relatively small or zero absolute value for the covariance indicates that there is little or no relationship between the returns for the two securities [6].

The covariance is the main measure of risk for financial instruments. One can take any two of assets, markets, or portfolios and calculate the covariance of one against the other. If the same random variable is supplying both data sets, then the calculated figure represents the variance of that random variable.

The variance-covariance matrix for securities can be used along with the return data in the construction and optimization of portfolios. Additionally, covariances of markets determine the risk of securities or portfolios in that market. Basically, the covariance is defined as the average of the products of deviations for each data point pair.

With this definition, the calculation of any covariance may be formulated as:

$$cov_{p,t}(x,y) = \frac{1}{n_t}\sum_{i=1}^{n_t}\left[\left[r_{d_i,p,t}(x) - avr_{p,t}(x)\right] \cdot \left[r_{d_i,p,t}(y) - avr_{p,t}(y)\right]\right]$$

$$avr_{p,t}(x) = \frac{1}{n_t}\sum_{k=1}^{n_t} r_{d_i,p,t}(x)$$

with: *and*

$$avr_{p,t}(y) = \frac{1}{n_t}\sum_{k=1}^{n_t} r_{d_i,p,t}(y)$$

for: $sd_t \leq d_i \leq ed_t$

where:

$cov_{p,t}(x,y)$: covariance of any (**x** :) **a**sset, **m**arket, or **p**ortfolio against any (**y** :) **a**sset, **m**arket, or **p**ortfolio for period **p** in interval **t**

$r_{d_i,p,t}(x)$: rate of return of any (**x** :) **a**sset, **m**arket, or **p**ortfolio for period **p** on date $\mathbf{d_i}$ in interval **t**

$r_{d_i,p,t}(y)$: rate of return of any (**y** :) **a**sset, **m**arket, or **p**ortfolio for period **p** (**x** :) **a**sset, **m**arket, or **p**ortfolio for period **p** on date $\mathbf{d_i}$ in interval **t**

$avr_{p,t}(x)$: average rate of return of (**x** :) **a**sset, **m**arket, or **p**ortfolio for period **p** in interval **t**

$avr_{p,t}(y)$: average rate of return of (**y** :) **a**sset, **m**arket, or **p**ortfolio for period **p** in interval **t**

4. TECHNICAL SPECIFICATION

4.1 Hardware

The system was developed in the MS Windows environment with the MS Access tool on a 486-PC with 8 megabytes of memory. The system is capable of dealing with large data volumes with such a configuration. In order to improve processing and/or retrieval performance, the memory can be expanded to 16 megabytes.

4.2 Software

In the MS Windows environment, MS Access is a very advanced Fourth Generation Language (4GL) tool with its relational database, Structured Query Language (SQL) based queries, powerful programming language and the friendly user interface. Today's application development tools provide most of the basic features, such as screen processing and report generation to the developers. In MS Access, these features are supported by a strong relational database using the worldwide proven Rushmore technology and the standard MS Visual Basic compatible Access Basic programming language.

FDMS is by default a multi-user system, which can be used with any networking software that can provide file sharing for the database. The database of the system can be any relational database that MS Access can connect to. Paradox files have been the first alternative to the MS Access database and the system has supported

this structure, where the data resides in Paradox files but all the processing is performed by MS Access routines.

MS Access has a runtime version which will be enough to use the system under MS Windows without having the complete set of MS Access. The runtime version of FDMS can be created with the MS Access Distribution Kit.

5. CONCLUSION and SUGGESTIONS for FURTHER WORK

The system developed in this study is capable of accomplishing the basic requirements on financial data processing and retrieval. These basic functions for both academic or business requirements include the risk / return calculations and the input / output facilities. The system has been developed in a very modern environment and it is, therefore, open to future enhancements and additions of new asset types and calculation rules.

The user interface of the system has been shown with sample screen layouts of various functions in Appendix A. Financial data from the first half of September 1994 has been used as the data sample to demonstrate the functionality of the system.

An important feature of the system is the underlying entity - relationship based database structure. Implementation of the database in other relational database management systems is very easy. The code written for data processing is a maintainable combination of SQL statements and Access Basic.

Further enhancements to FDMS may include links from other tools, such as spreadsheets, to the database. Examples of these links are Quattro Pro retrieving data in Paradox files or MS Excel retrieving data in the MS Access database.

Another possible enhancement to the study is portfolio optimization functionality. Currently, the outputs of the system can be used in a simple spreadsheet application for this purpose. However, further work on this subject including the implementation of an optimization algorithm, can integrate this feature to the system. The performance of the system, on the other hand, has not been

optimized, interest has been given to functions rather than performance.

A functional enhancement, which can be very useful from an investor's point of view, can be the exception reporting. Based on a selected criteria set, the system can produce a set of outputs showing those assets, markets or portfolios that match this criteria.

A complete set of the system files is available. Those who are interested in FDMS can ask for the diskettes from Prof. Vedat Akgiray in the Management Department of Boğaziçi University.

APPENDIX A. SAMPLE FDMS SCREENS

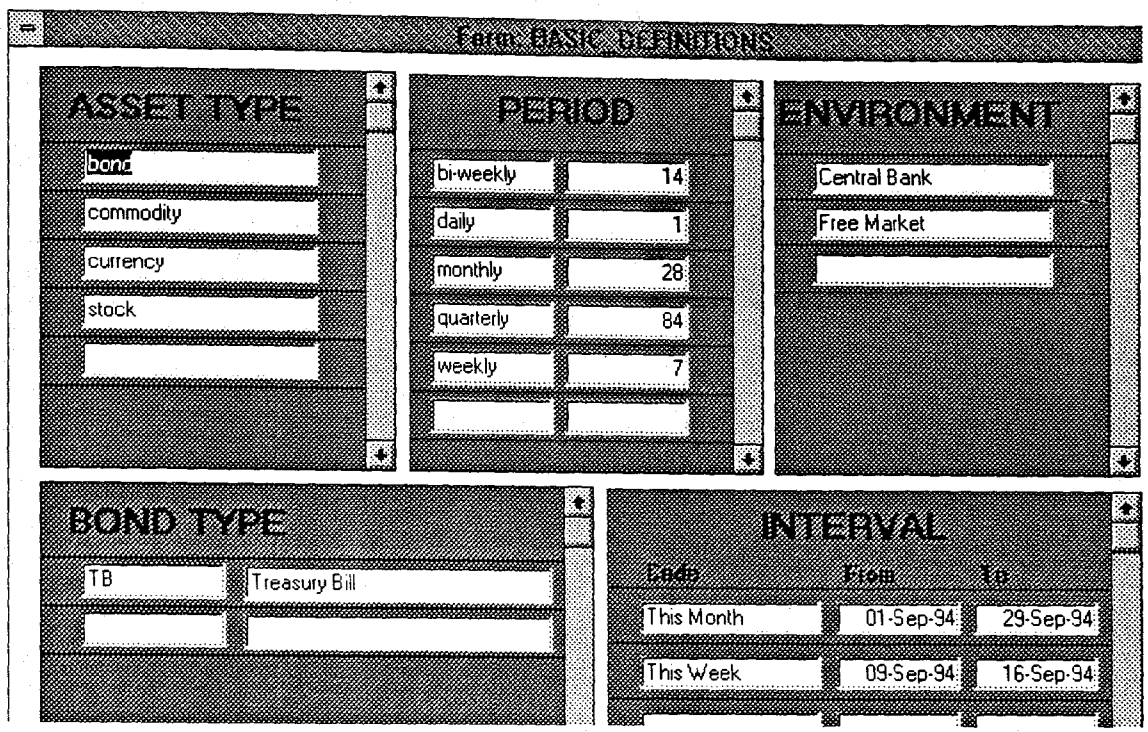

FIGURE A.1. Basic definitions screen

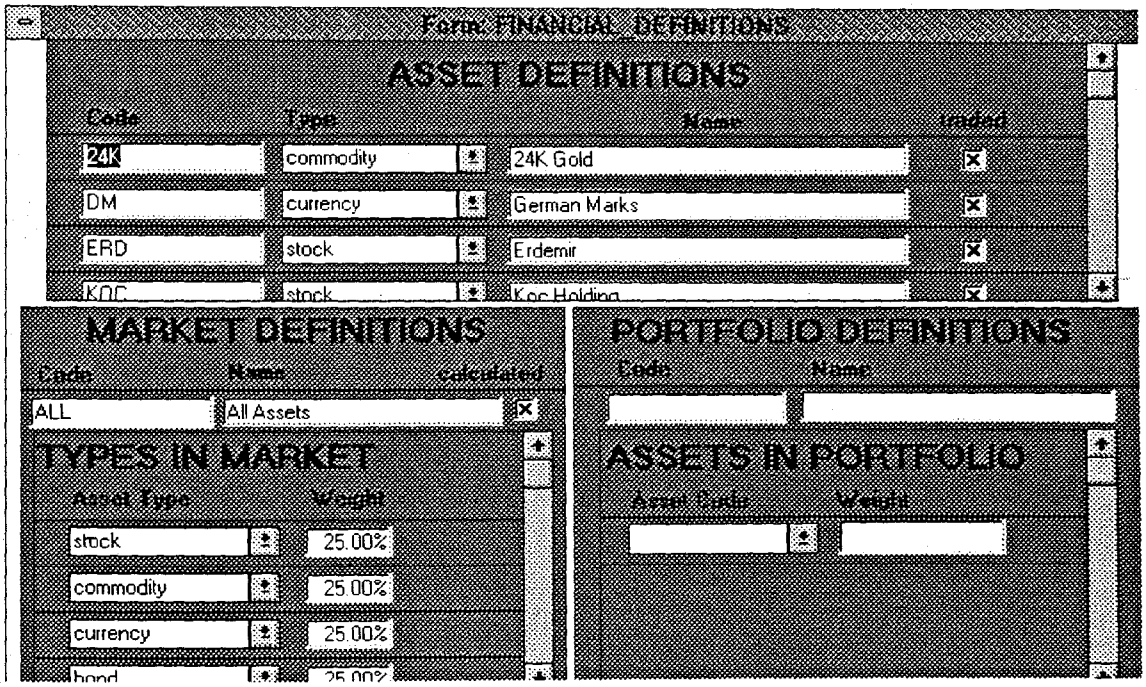

FIGURE A.2. Financial definitions screen

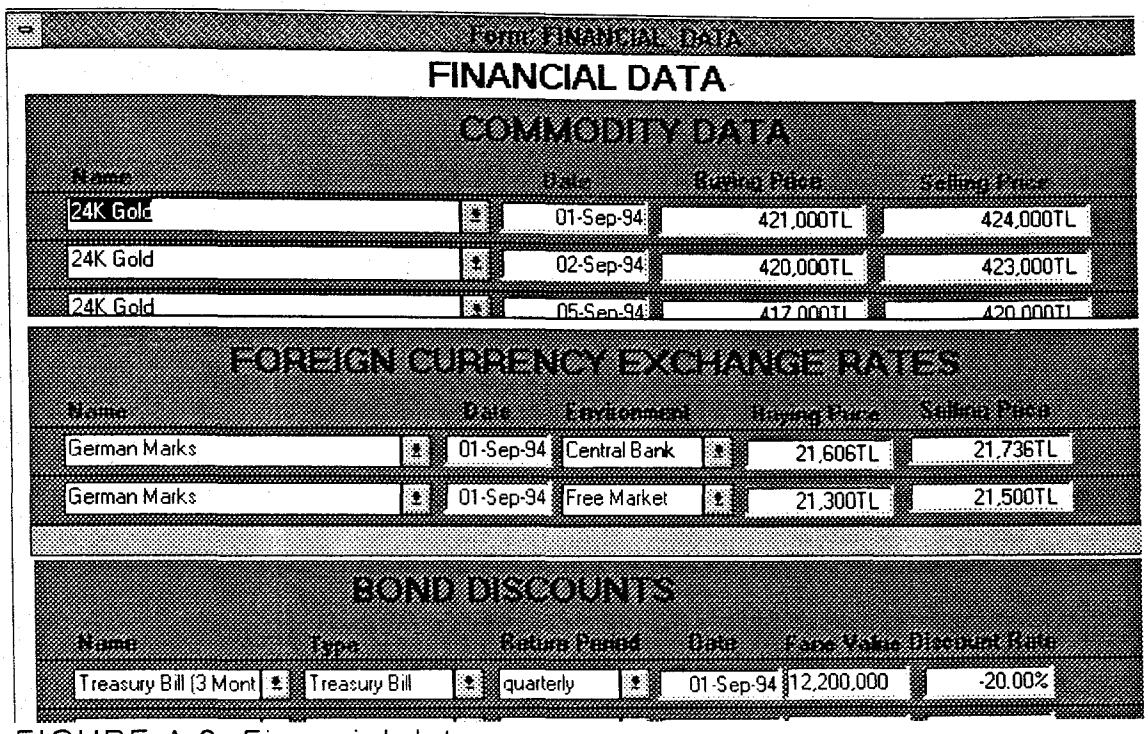

FIGURE A.3. Financial data screen

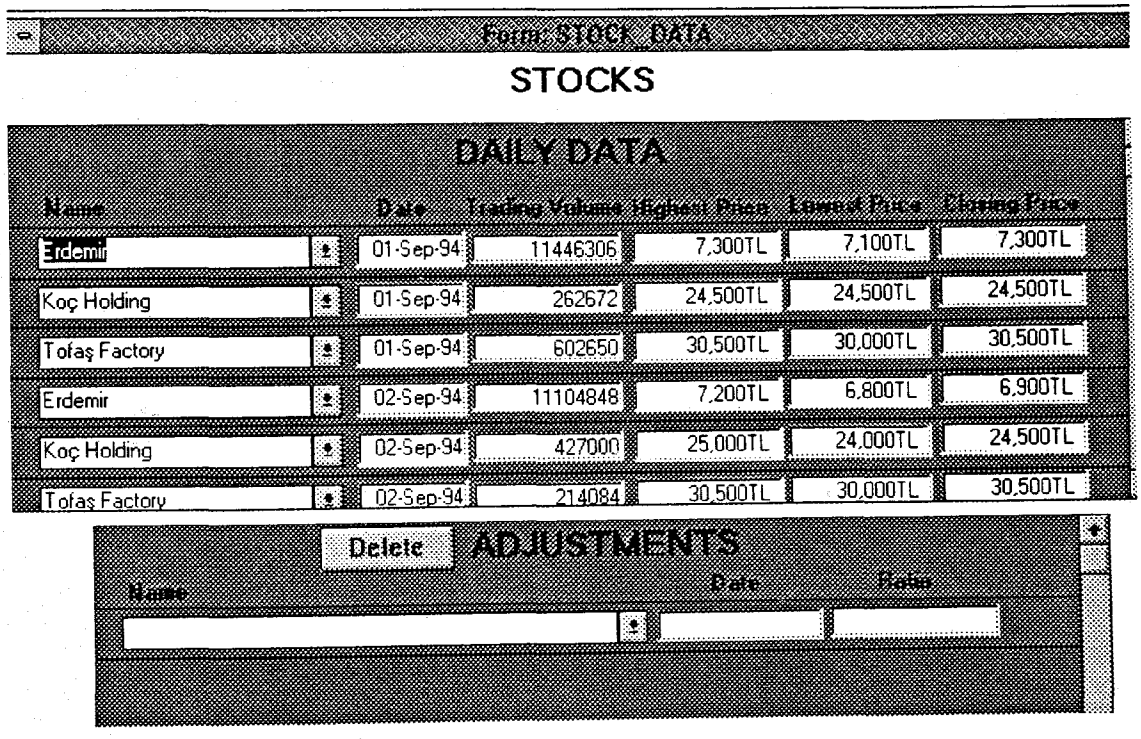

FIGURE A.4. Stock data screen

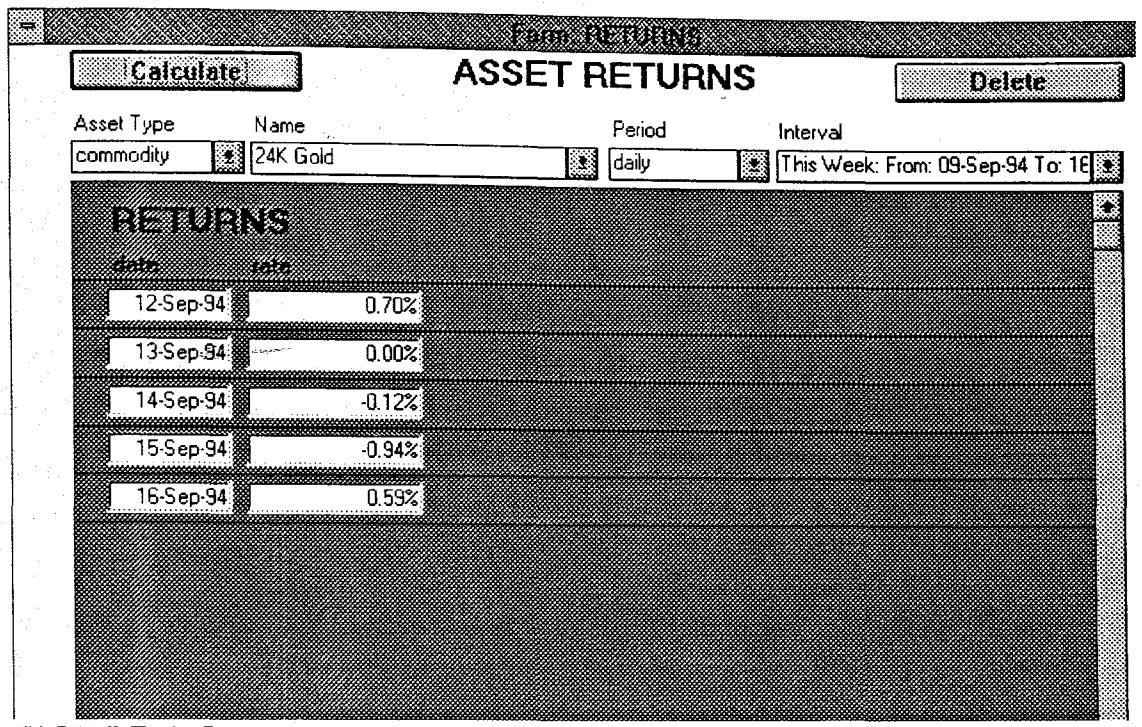

FIGURE A.5. Asset returns screen (daily commodity returns)

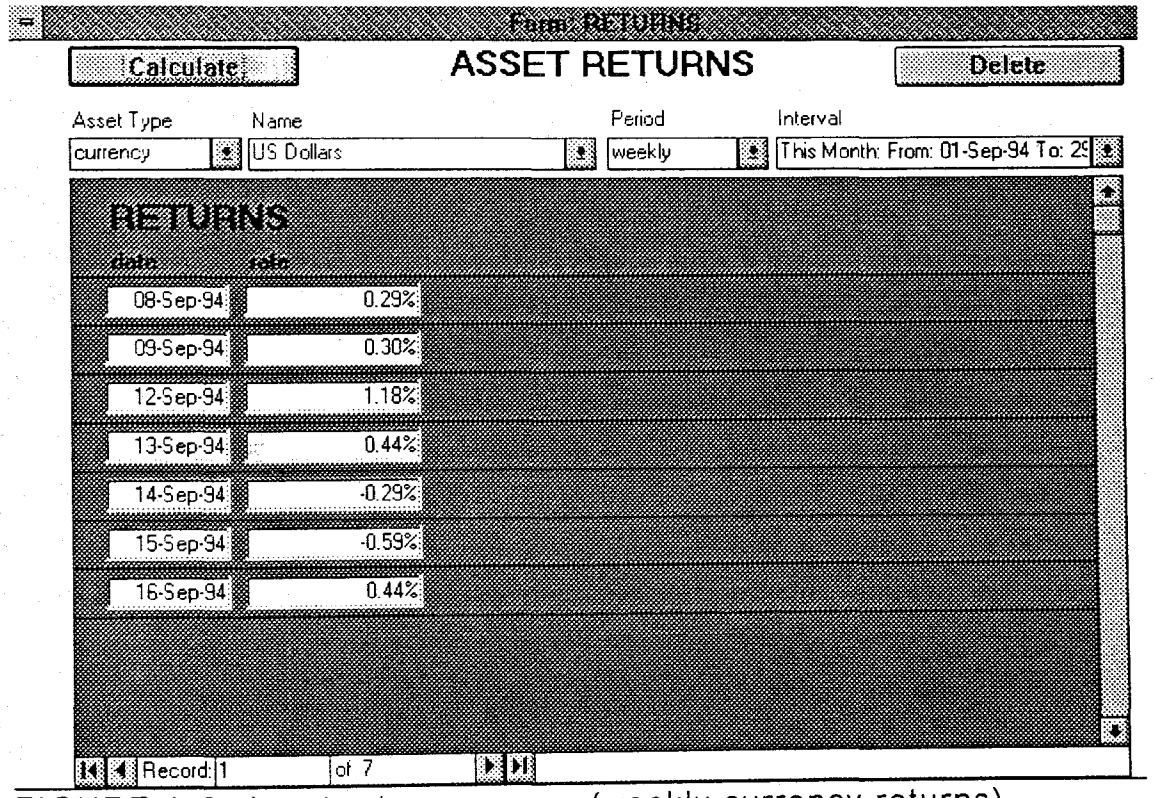

FIGURE A.6. Asset returns screen (weekly currency returns)

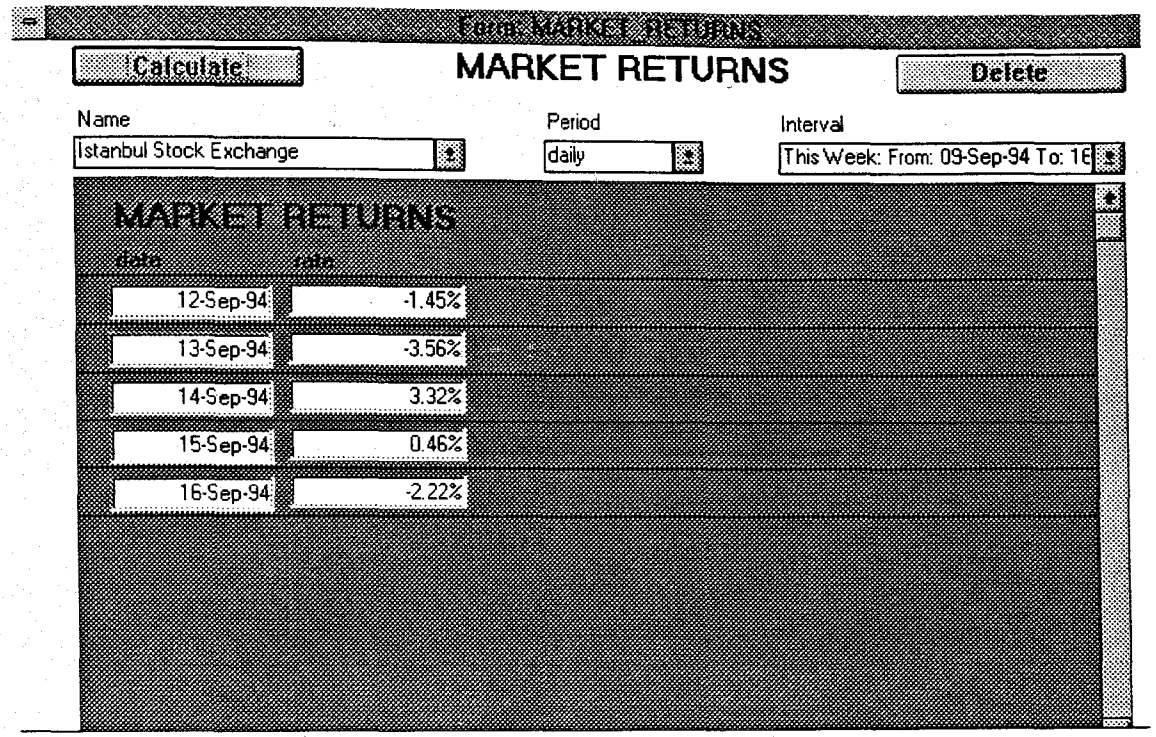

FIGURE A.7. Market returns screen (daily ISE returns)

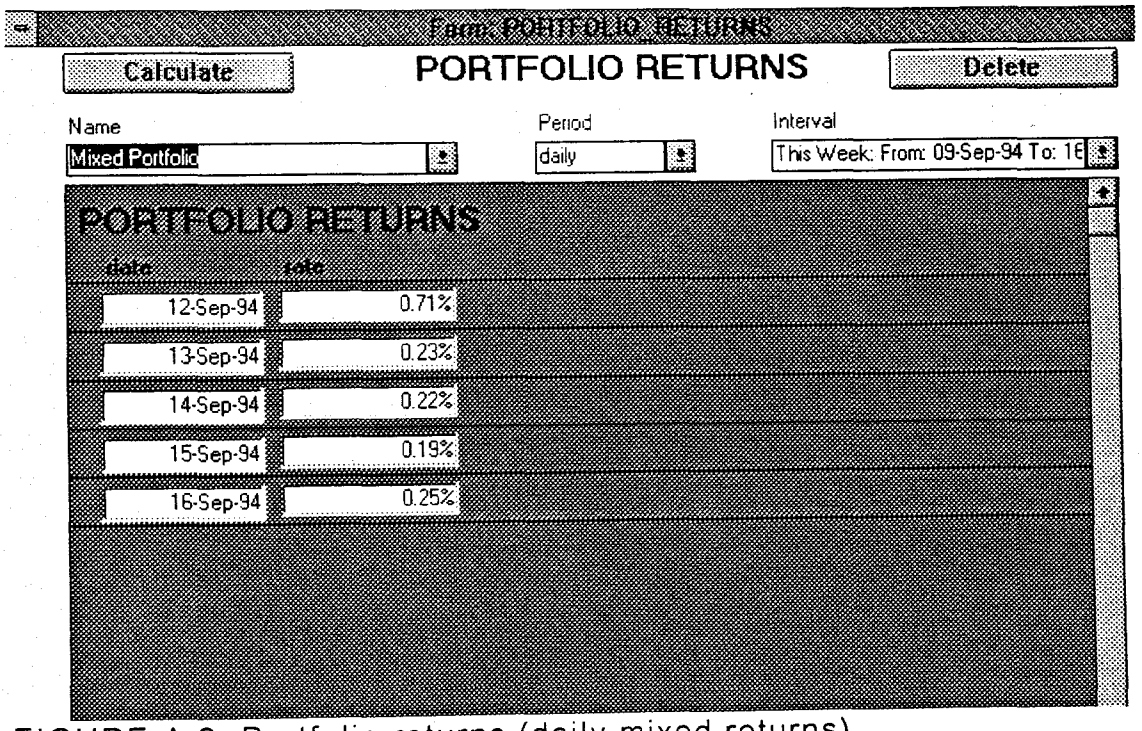

FIGURE A.8. Portfolio returns (daily mixed returns)

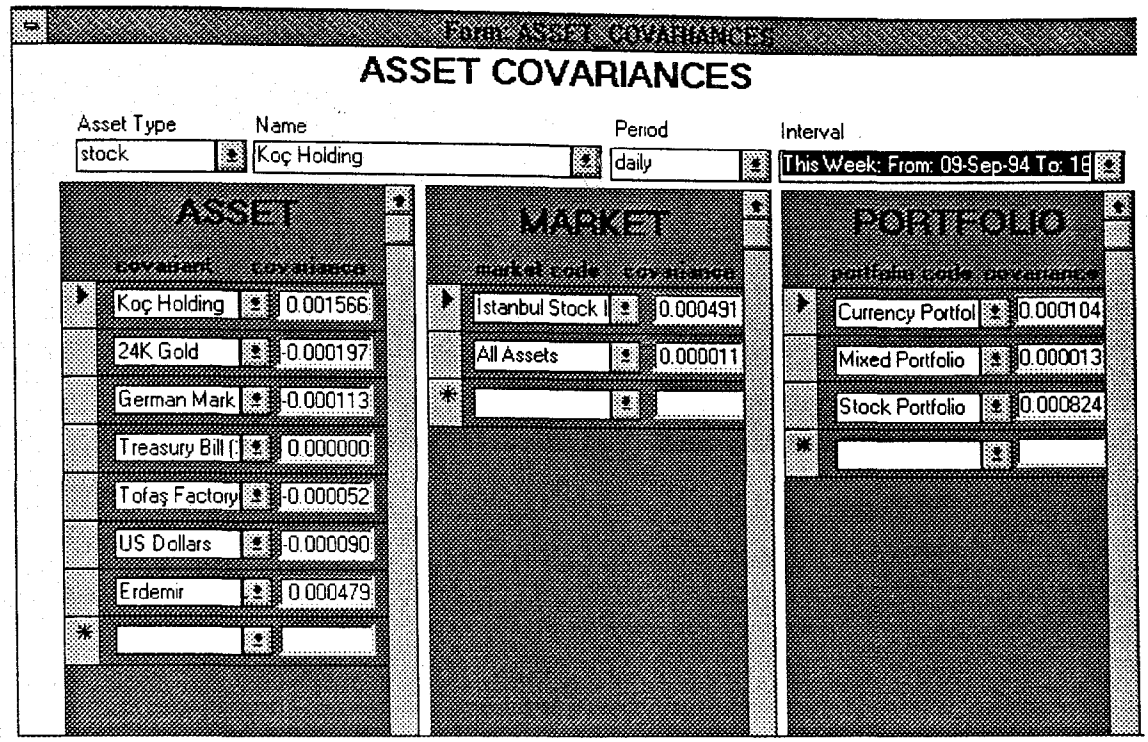

FIGURE A.9. Asset covariances

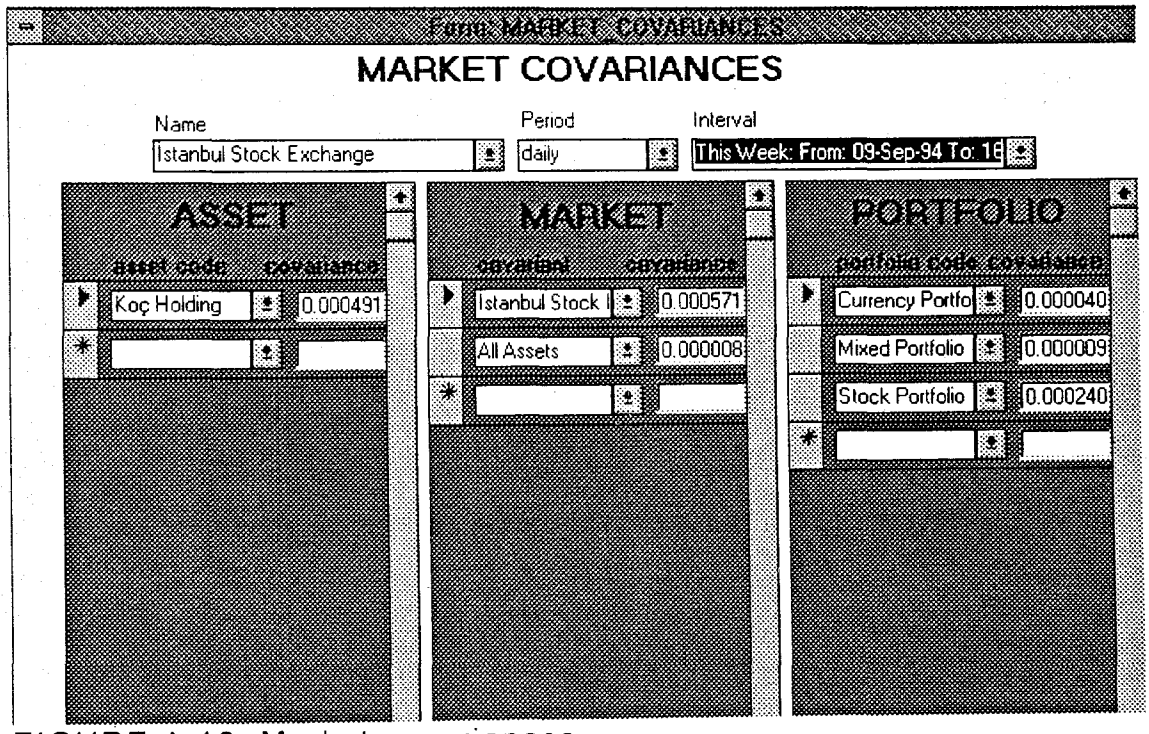

FIGURE A.10. Market covariances

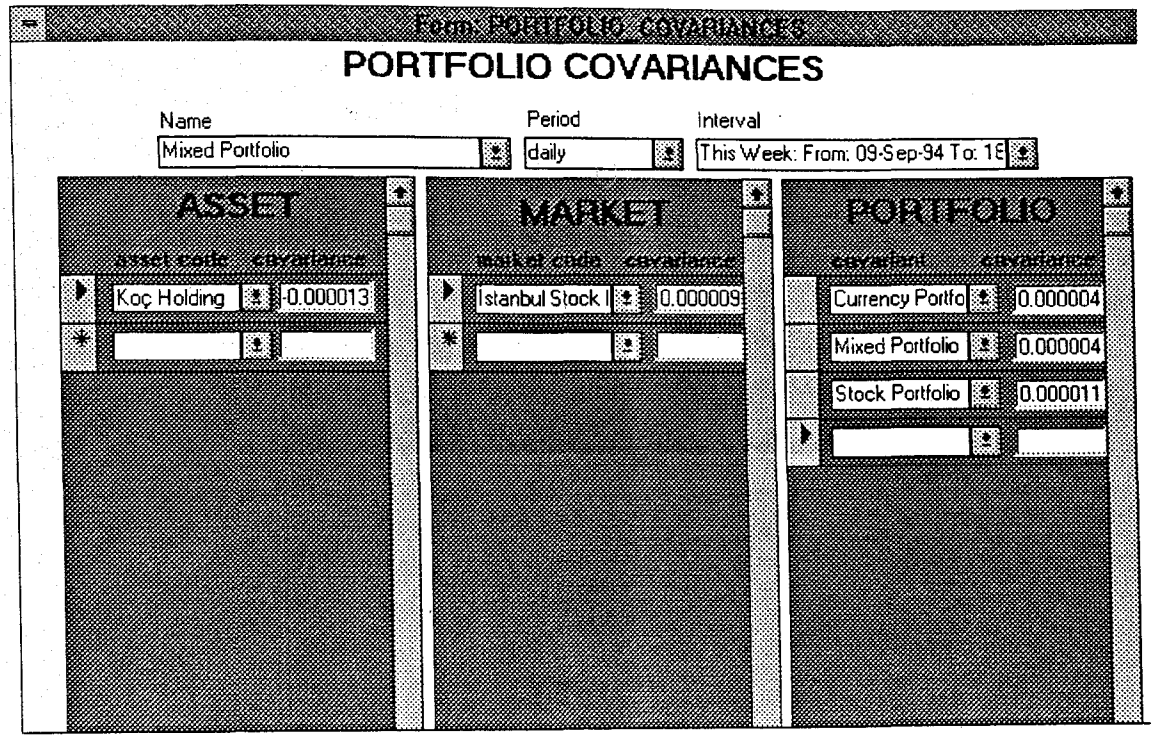

FIGURE A.11. Portfolio covariances

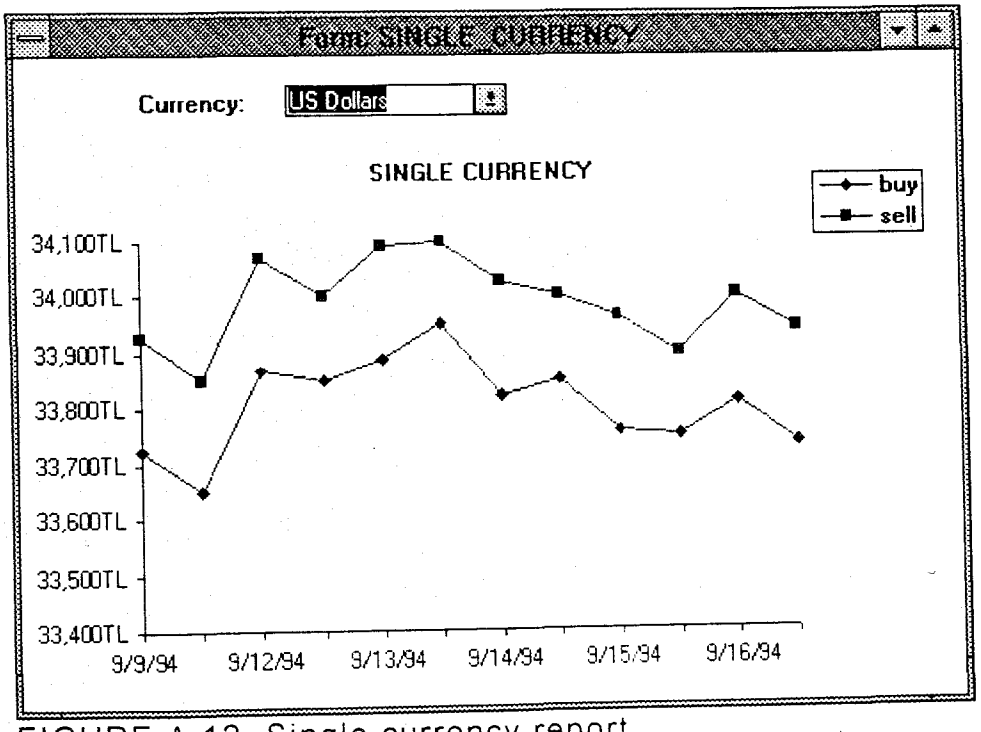

FIGURE A.12. Single currency report

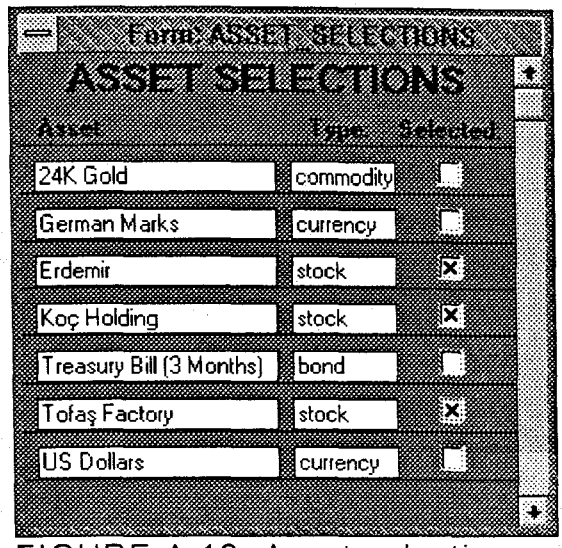

FIGURE A.13. Asset selection screen

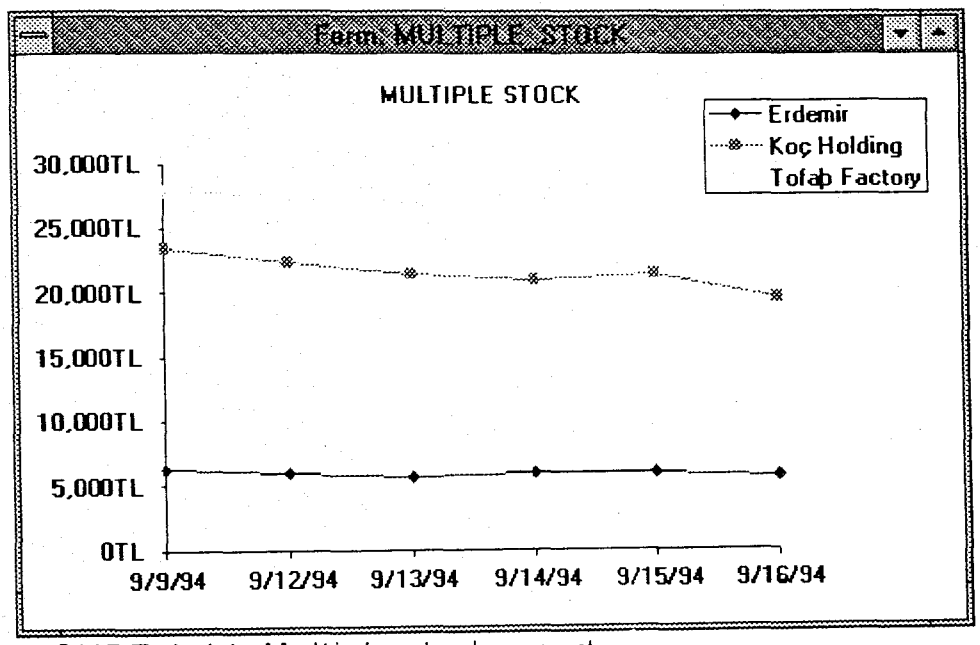

FIGURE A.14. Multiple stock report

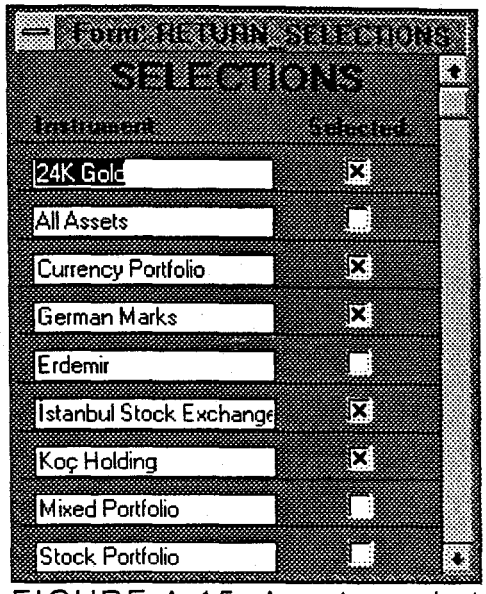

FIGURE A.15. Asset, market and portfolio selection screen

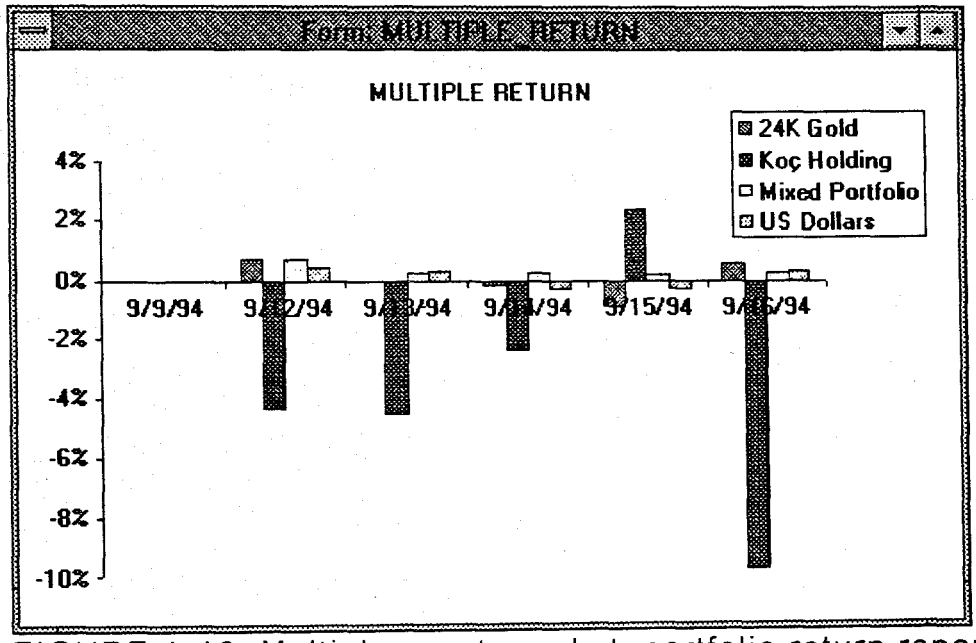

FIGURE A.16. Multiple asset, market, portfolio return report

Crosstab Query: VARIANCE_COVARIANCE

name	24K Gold	Koç Holding	Mixed Portfolio	US Dollars
24K Gold	3.43895805E-05	-0.00019684856		1.54602187E-05
Koç Holding	-0.00019684856	0.001565794178	-1.3432446E-05	-8.9717379E-05
Mixed Portfolio		-1.3432446E-05	3.83390571E-06	
US Dollars	1.54602187E-05	-8.9717379E-05		1.00484518E-05

Record: 1 of 4

FIGURE A.17. Variance-Covariance matrix of portfolios

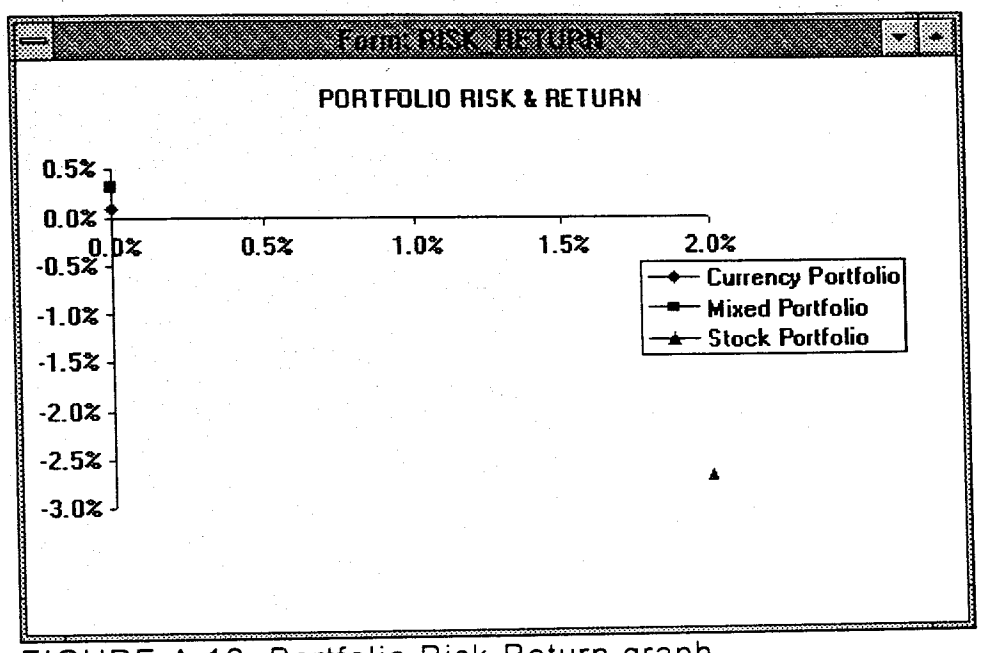

FIGURE A.18. Portfolio Risk-Return graph

APPENDIX B. DATA DICTIONARY

Table Name	Field Name	Type	Size
ADJUSTMENT			
	code	Text	20
	date	Date/Time	8
	ratio	Number (Double)	8
ASSET			
	code	Text	20
	name	Text	50
	traded	Number (Integer)	2
	type	Text	20
ASSET_ASSET			
	asset_code	Text	20
	covariance	Number (Double)	8
	covariant	Text	20
	interval	Text	20
	period	Text	20

Table Name	Field Name	Type	Size
BOND			
	code	Text	20
	date	Date/Time	8
	discount	Number (Double)	8
	period	Text	20
	type	Text	20
	value	Number (Double)	8
BOND_TYPE			
	code	Text	20
	name	Text	50
BORROWING			
	date	Date/Time	8
	period	Text	20
	rate	Number (Double)	8
COMMODITY			
	buy	Currency	8
	code	Text	20
	date	Date/Time	8
	sell	Currency	8

Table Name	Field Name	Type	Size
CURRENCY			
	buy	Currency	8
	code	Text	20
	date	Date/Time	8
	environment	Text	20
	sell	Currency	8
DATES			
	code	Text	20
	date	Date/Time	8
ENVIRONMENT			
	code	Text	20
INDEX			
	date	Date/Time	8
	market_code	Text	20
	value	Number (Double)	8
INTERVAL			
	code	Text	20
	end	Date/Time	8
	start	Date/Time	8

Table Name	Field Name	Type	Size
MARKET			
	calculated	Number (Integer)	2
	code	Text	20
	name	Text	50
MARKET_ASSET			
	asset_code	Text	20
	covariance	Number (Double)	8
	interval	Text	20
	market_code	Text	20
	period	Text	20
MARKET_MARKET			
	covariance	Number (Double)	8
	covariant	Text	20
	interval	Text	20
	market_code	Text	20
	period	Text	20

Table Name	Field Name	Type	Size
MARKET_RETURN			
	date	Date/Time	8
	interval	Text	20
	market_code	Text	20
	period	Text	20
	rate	Number (Double)	8
MARKET_TYPES			
	market_code	Text	20
	type	Text	20
	weight	Number (Double)	8
PERIOD			
	code	Text	20
	length	Number (Integer)	2
PORTFOLIO			
	code	Text	20
	name	Text	50

Table Name	Field Name	Type	Size
PORTFOLIO_ASSET			
	asset_code	Text	20
	covariance	Number (Double)	8
	interval	Text	20
	period	Text	20
	portfolio_code	Text	20
PORTFOLIO_ASSETS			
	asset_code	Text	20
	portfolio_code	Text	20
	weight	Number (Double)	8
PORTFOLIO_INDEX			
	date	Date/Time	8
	portfolio_code	Text	20
	value	Number (Double)	8

Table Name	Field Name	Type	Size
PORTFOLIO_MARKET			
	covariance	Number (Double)	8
	interval	Text	20
	market_code	Text	20
	period	Text	20
	portfolio_code	Text	20
PORTFOLIO_PORTFOLIO			
	covariance	Number (Double)	8
	covariant	Text	20
	interval	Text	20
	period	Text	20
	portfolio_code	Text	20
PORTFOLIO_RETURN			
	date	Date/Time	8
	interval	Text	20
	period	Text	20
	portfolio_code	Text	20
	rate	Number (Double)	8
RETURN			

Table Name	Field Name	Type	Size
RETURN			
	code	Text	20
	date	Date/Time	8
	interval	Text	20
	period	Text	20
	rate	Number (Double)	8
STOCK			
	adjusted	Number (Integer)	2
	close	Currency	8
	code	Text	20
	date	Date/Time	8
	high	Currency	8
	low	Currency	8
	volume	Number (Double)	8
TYPE			
	code	Text	20

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