

An efficient market test of the International Monetary Market : implications for hedging strategies
by Thomas William Miller

A thesis submitted in partial fulfillment of the requirements for the degree of MASTER OF SCIENCE
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Abstract:
This research examines a problem that international business firms must face — fluctuating exchange rates. These flexible exchange rates create uncertainty as to what the exchange rate will be at some time in the future. An international firm can protect itself from adverse price fluctuations via a futures market in international currencies. But, can a firm predict the exchange rate in the future? If it could, then it can hedge at the most favorable time.

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Date July 12, 1979

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by

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A thesis submitted in partial fulfillment
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ABSTRACT

This research examines a problem that international business firms must face -- fluctuating exchange rates. These flexible exchange rates create uncertainty as to what the exchange rate will be at some time in the future. An international firm can protect itself from adverse price fluctuations via a futures market in international currencies. But, can a firm predict the exchange rate in the future? If it could, then it can hedge at the most favorable time.

The currency futures market is assumed to be an efficient market. This means information about future events is contained in today's price.

The objective of this research was to test the efficiency of the currency futures market. This is done by setting up a general model of market equilibrium that specifies returns in currency futures markets is constant. Then, this model is tested by an autoregressive model that states post returns can be used to forecast future returns.

It was concluded that some statistical dependence existed in the returns of currency futures markets. Whether or not this dependence could be used to reap gains in the currency futures market is the unresolved question of this research -- although several strategies were tested using estimated coefficients and they did not yield gains.

Chapter 1

Introduction

A foreign exchange market facilitates trade between nations by providing a market where currencies can be exchanged. In this market money is treated like any other commodity -- it is bought and sold at a price. This market is known as a cash, or spot, market -- that is, this market exchanges dollars for other currencies. The price in this cash, or spot, market is called the exchange rate.

If a firm in the United States is doing business internationally, it must realize that the exchange rates between the dollar and other currencies are constantly changing. Because of these constant changes in the exchange rate, a firm does not know what the exchange rate will be at some time in the future. The exchange rate at some future date could be such that the international firm is adversely affected.

A firm can reduce the risk of adverse price fluctuations via a market where future exchange rates are bought and sold. This market is known as a futures market. Unlike the cash -- or spot -- market, the futures market deals with exchange rates in the future: whereas the cash market deals with exchange rates that prevail at present. The futures market in international currencies is the International Monetary Market division of the Chicago Mercantile Exchange. As in other futures markets, a firm can "lock-in" a price (an exchange rate) by purchasing the exchange rate today. This process, used by

importing firms, is known as a long hedge and its basic elements are discussed in the next chapter.

The existence of a futures market in foreign exchange provides firms with a vehicle to reduce the risk of unfavorable exchange rate changes. An unfavorable exchange rate change for an importing firm would be an increase in the exchange rate for a particular currency -- that is, if it took more dollars to buy the same number of Yen, Francs, or D-marks. The next chapter of this paper discusses this problem in detail.

Obviously, a firm would like to hedge or "lock-in" a price for a foreign currency at the "most favorable" time. For example, an importing firm would like to purchase the foreign currency necessary to complete international transactions at the lowest price possible. Then, it would like to "lock-in" this price on the futures market. However, can a firm determine when a price is the lowest possible price? If it can, then this implies that a firm can predict prices in the futures market.

Objectives

The primary objective of this study is to test the efficiency of five foreign currency futures markets on the International Monetary Market. These five currencies are: British Pound, Canadian Dollar, German Mark, Japanese Yen, and Swiss Franc.

As in the case of most auction markets, the foreign currency futures market is generally thought of as an efficient market.[1] In short, this is "generally understood" to mean that "all available" information concerning the price of a currency in the future is "fully reflected" in the price quoted at any time for the currency in the future. The statement that the current price of a futures contract "fully reflects" all market information implies that successive price changes, or successive returns, are independent. If this is the case, then a firm (or speculator) could not predict the price (or return) in the futures based upon previous price changes (or returns). This implies that a firm trying to decide when the "most favorable" time to place a hedge faces a difficult task.

Procedure

The efficient market hypothesis states that, in short, the prediction of futures prices is impossible. The reason for this, according to the efficient market hypothesis, is that all information concerning the price of a foreign currency in the future is already reflected in the current price of that foreign currency. Chapter Three of this study discusses the rudimentary elements of the theory of efficient markets.

Tests of efficient markets are concerned with the effects of information upon market prices. The information set used in this

study is the set of past prices in the various currency futures markets. This information set is tested with an autocorrelation model developed in Chapter Three. Basically, this model tests the degree of statistical dependence between past returns in the futures market and present returns.

The results of this model are presented in Chapter Four while Chapter Five presents the results of trying to predict futures prices. Chapter Six contains the study summary, the conclusions, implications to hedgers, as well as suggestions for further research.

Chapter 2

THEORETICAL CONSIDERATIONS

An Introductory Perspective

An open economy is an economy that trades with other economies. As no country's economy in the world is self-sufficient, every country's economy can be classified as open. Trade between economies takes place in both goods and services -- Americans buy German cars and Europeans buy American brokers' services -- and in assets -- Americans buy Japanese stocks and Arabs buy American real estate. To facilitate this trade between nations, there must be a market in which, for example, an American can trade dollars for another currency in order to make foreign transactions.

The market where these currency transactions take place is the foreign exchange market. Simply stated, the conversion of one money into another is the sale of one currency for another. In this market money is treated like any other commodity -- it is bought and sold at a price. This price is called the foreign exchange rate. There are two basic foreign exchange rate systems. One of these is the fixed rate system and the other is a flexible or floating system.

Fixed Exchange Rates

The world was basically on a fixed rate system from 1946 to 1973, though there were occasional adjustments of exchange rates during that period. In the fixed rate system foreign central banks fix the

dollar price of their currencies, and stand ready to buy and sell U.S. dollars at that price. This means the central bank has to finance the excess demands for, or excess supplies of, U.S. dollars. (That is, the balance of payments deficits or surpluses.) The central banks do this by running down or adding to their reserves of U.S. dollars.

Flexible Exchange Rates

During 1973, exchange rates between the dollar and other currencies were allowed to float. This is the current system of exchange rates. In this system the exchange rate is determined by the supply of and demand for foreign exchange. Under the flexible exchange rate system the demands for, and supplies of, foreign currency can be made equal through movements in exchange rates. Under "clean" floating there is no central bank intervention and the balance of payments is zero. However, central banks sometimes intervene in a floating rate system -- this is engaging in so-called "dirty" float.

By no means is floating a universal practice. Only a small minority of the world's currencies float, yet these currencies are the major currencies in the world: they account for seventy percent of world trade. Of 122 member nations of the International Monetary Fund, 18 nations allow their currency to float (seven of these were tied together in a joint float).[2] The other 104 were pegged to the dollar, pound, mark, or some other currency. It must be remembered,

however, that when a currency is pegged to the dollar, it will float along with the dollar vis-a-vis other currencies.[3] Figure 2-1 is a representation of how the foreign exchange rate is determined.

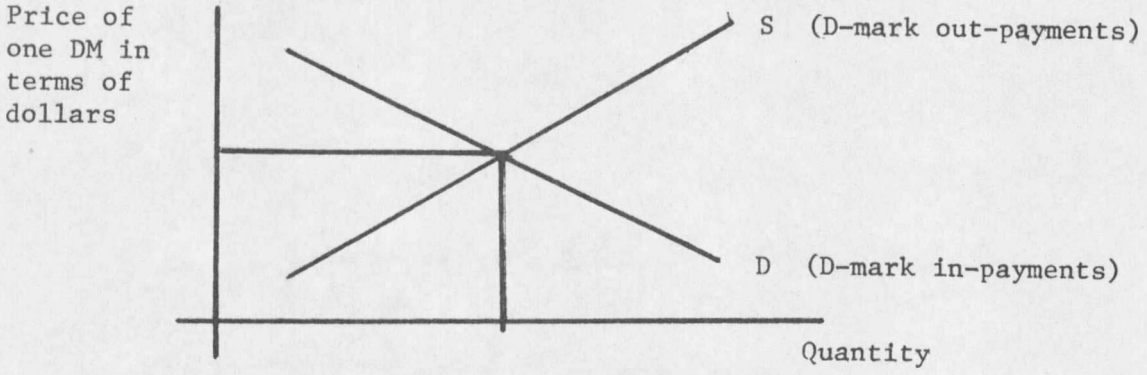


Figure 2-1. Supply and Demand Curves for D-marks in U.S.

The demand for D-marks in the U.S. (D-mark outpayments) represents such things as:

a) Purchasing German[4] goods (imports)
b) Buying German services
c) Transfer of capital to Germany for investment

The supply of D-marks in the U.S. (D-mark outpayments) represents such things as:

a) Selling domestic goods to Germany (exports)
b) Selling domestic service to Germany
c) inflow of German capital

The prediction of an exchange rate is very difficult. The supply of and the demand for foreign currencies depends on economic conditions and policies relative to the rest of the world. Anything that

affects prices, incomes, interest rates, consumer tastes and preferences, or any other economic variable at home or abroad influences the position of the supply and demand curves for foreign exchange and therefore affects the exchange rate. The exchange rate is deeply rooted in the economic conditions of the countries involved. It does bear emphasizing that in all cases it is the changes inside the country relative to changes in the rest of the world that counts.

The Mechanics of an Exchange Rate Change

Assume an exogenous change in American tastes toward lederhosen (leather walking shorts). Further, assume that 1) there are no artificial barriers to trade in this market and 2) Germany is the only exporter of lederhosen. (Of course, this is to keep within the two-country framework.) What will happen to the foreign exchange rate between Germany and the United States, ceteris paribus?

Figure 2-2 shows this change. The Americans must pay the German producers in Deutschemarks (D-marks). Americans must convert their dollars to D-marks, therefore there will be a shift in the demand for D-marks in the United States.

The exchange rate, the price of one D-mark in terms of dollars, will increase due to the change in consumer tastes that stimulated imports of lederhosen. Note that this means a dollar will buy fewer D-marks. When this happens, the dollar has "weakened" or depreciated

relative to the D-mark. Or, the D-mark has "strengthened" or appreciated relative to the dollar.

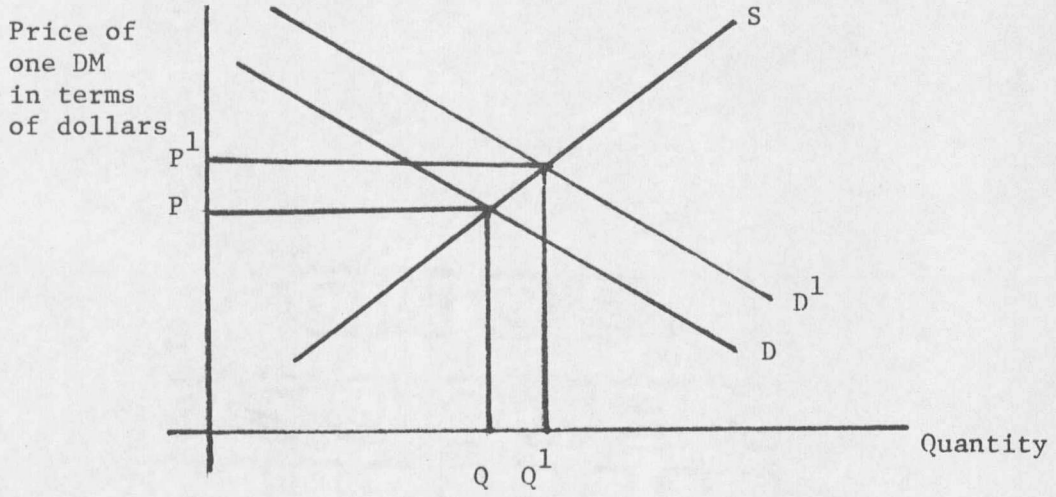


Figure 2-2. Shift in the Foreign Exchange Rate

The Uncertainty of Exchange Rates

The increase in the exchange rate in the preceding example will affect all firms dealing with Germany. If a firm is doing international business it must realize that it is doing so in a system of exchange rates that are constantly changing. What effect do fluctuating exchange rates have on international business firms?

Assume an importing firm -- National Blivit Company. This firm imports blivits from Germany for resale in the United States. Also, assume that there is a rather constant demand for blivits in the United States market. Further assume NBC signs a contract with a

German blivit producer under the following conditions: 10,000 blivits delivered in 90 days to the United States, payment in D-marks, at a price of 12.50 DM/blivit.

At the time of the contract signing the exchange rate was $.50/1 DM. Situation (1) in table 2.1 is a pro forma income statement with the expected profit in 90 days represented at the bottom line. If the exchange rate happens to be $.50/1 DM, the firm will realize this profit. This situation is depicted in (2) in table 2.1. Suppose, however, the exchange rate in 90 days is $.55/1 DM. This situation is shown in (3) in table 2.1. Note that the profit before taxes is lower. In general, the relationship between the exchange rate and profit before taxes can be shown as:

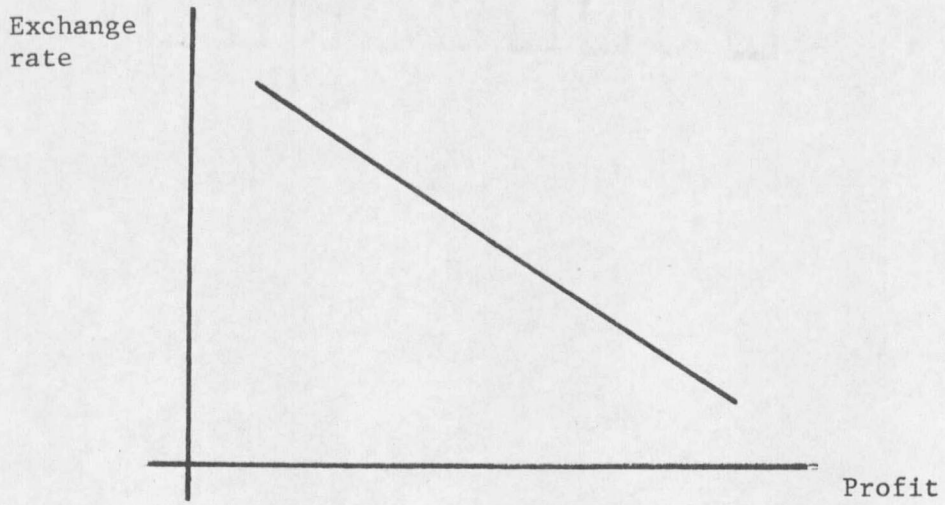


Figure 2-3. The Relationship Between the Exchange Rate and Profit Before Taxes.

Table 2.1

Income Statement for NBC
Some Possible Outcomes

	At the time the contract was signed	Exchange rate is the same (.50) in 90 days	Exchange rate is higher (.55) in 90 days	Exchange rate is lower (.45) in 90 days
	(1)	(2)	(3)	(4)
Sale of 10,000 blivits (at $10/blivit)	100,000	100,000	100,000	100,000
Cost of goods sold (at 12.50) DM/blivit)	62,500	62,500	68,750	56,250
Gross Profit from Sales	37,500	37,500	31,250	43,750
EXPENSES	20,000	20,000	20,000	20,000
PROFIT BEFORE TAXES	17,500	17,500	11,250	23,750

Figure 2-3 shows that when the exchange rate is higher (i.e. if it takes more dollars to buy the same amount of D-marks), profits before taxes will be lower.

The National Blivit Company can protect itself from this adverse price movement by a type of insurance called a hedge. The firm must buy D-marks in 90 days to pay for the imported blivits. To insure a favorable price, the firm could enter the futures market today and buy the D-marks. This transaction, known as a long hedge, is shown in Figure 2-4.

	SPOT MARKET	FUTURES MARKET
NOW		BUY*
90 days from now	BUY	SELL

Figure 2-4. Long Hedge in Currency Futures Market

In order to do this all a firm has to do is call a commodity broker and inform him of their desire to purchase a D-mark futures contract. (Specifications of IMM futures contracts can be found in Appendix I). The firm must issue a performance bond, called margin, which is kept in the firm's account with a broker. Margin must be put up to show good faith in meeting contract specifications. At this time the firm is long in the futures market. To close their position the firm calls the broker and informs him of their desire to sell a

contract. This action concludes what is known as a round-turn. At this time the firm must pay the broker a commission -- usually amounting to $45-$55.

Note that the transactions 90 days from now, more or less, cancel each other out. The firm, then, has effectively "locked in" a price for the D-marks now. (* above) The firm would then be protected against an adverse price change, i.e. the dollar price of Deutschemarks increasing.

The transactions labeled "90 days from now" do not cancel each other out precisely. This is because the price on the spot market and the price on the futures market might be different, at that point in time. The difference between the futures price and the spot price is known as the basis.

In order for a hedge to eliminate price risk, the futures price must move precisely parallel with the cash price -- which it rarely does. In the context of this research, the basis is the difference between the futures market exchange rate and the cash, or spot, exchange rate. In actuality, the basis tends toward zero as the delivery day for the futures contract approaches. This is reasonable because, in the end, the futures delivery becomes a spot delivery. They become nearly perfect substitutes for each other, hence they should have equal value. This principle is very important in a futures market, as it is the essence of the use of the futures for

forward pricing, or fixing costs in advance.

In the foreign currency futures market the basis primarily reflects 1) the interest rate differential among countries and 2) expectations. If stable conditions exist and there are no restrictions for trade and capital flow, forward rates will vary inversely with the interest rate differential between two countries. For example, if interest rates are 10 percent higher in Japan than in the United States, the forward price for Japanese yen should be at a 10 percent discount in terms of United States dollars. This is known as interest-rate parity: seldom is it achieved because world monetary conditions have been relatively unstable, and barriers to free trade and capital flow exist. Consequently, expectations have played a large role in the foreign exchange basis.

As table 2.2 indicates, basis movements can earn a firm either a profit or a loss: even if the firm is hedged or unhedged -- long in the cash (or spot) market or short in the cash market. (See Figure 2-4) Note that this profit or loss is either added to or subtracted from the profit a firm "locked-in" by hedging. This is because a firm will enter the futures market to guarantee itself a price, a price that will earn a profit for the firm. Basis movements can either add to or reduce this profit.

What if the price of Deutschemarks had, in fact, gone down? The

Table 2.2

Variations in Gains or Losses Resulting from Differences in Cash and Futures Price Movements[5]

Price Movements		Results			
		to one who is "long" in the Cash Market		to one who is "short" in the Cash Market	
Cash Price	Future Price	Unhedged	Hedged	Unhedged	Hedged
Falls	Falls by same amount as cash	Loss	Neither profit nor loss	Profit	Neither profit nor loss
Falls	Falls by greater amount than cash	Loss	Profit	Profit	Loss
Falls	Falls by smaller amount than cash	Loss	Loss but smaller than unhedged loss	Profit	Profit but smaller than unhedged profit
Falls	Rises	Loss	Loss but greater than unhedged loss	Profit	Profit but greater than unhedged profit
Rises	Rises by same amount as cash	Profit	Neither profit nor loss	Loss	Neither profit nor loss
Rises	Rises by greater amount than cash	Profit	Loss	Loss	Profit
Rises	Rises by smaller amount than cash	Profit	Profit but smaller than unhedged profit	Loss	Loss but smaller than unhedged loss
Rises	Falls	Profit	Profit but greater than unhedged profit	Loss	Loss but greater than unhedged loss

effect on the firm's profit is shown in (4) of table 2.1. The firm's profit will be greater than expected. If the firm had placed a hedge, it would have done so needlessly because the price of D-marks had gone down. In fact, the firm would have been better off profit-wise if it had not hedged. But -- this is an ex post realization, as the firm did not know whether the price of Deutschemarks would be higher or lower than it is now in 90 days.

Could the firm have predicted these price movements? If it could, then it could devise hedging strategies to place hedges at the most favorable time. However, it is the contention of this research that a hedging strategy is a risk reduction tool.

Trying to earn additional revenues from the movement of foreign exchange rates should be a secondary consideration.

An exporting or importing firm knows it can make money by exporting or importing goods. Such a firm should realize it faces uncertainty in the foreign exchange market and use futures markets to reduce this risk.

Hedging

The predominant role of the futures market has been, and is today, facilitating hedging. In reviewing the development of hedging, Gray and Rutledge (1971) categorized hedging into four classes. They concede that classification is difficult, but each of their

categories represent a different set of motives from the hedger's point of view.

The first class of hedging is that done to eliminate price fluctuations -- an archaic view of hedging. Early in the century Hardy and Lyon (1923) spoke of risk elimination. However, since cash and futures prices do not move strictly parallel, the risk of price fluctuations cannot be eliminated. The second class of hedging under Gray and Rutledge's classification is the reduction of risk connected with price fluctuation. Gruen (1960) pointed out that the effective usefulness of a futures contract depends upon the relationship between the futures and cash price.

A third type of hedging is hedging to profit from basis movements. The basis is the difference between the futures price of a commodity and its price on the cash market. Working (1953), using wheat price data, said that basis fluctuations are predictable. In effect, Working was saying that hedging is undertaken and inspired by the profit motive rather than solely as a means of reducing risk. Risk reduction gained through hedging is an advantage but, according to Working, it is usually not the factor that instigates the hedge. By being able to predict basis movements, agents in the market hope to profit from changes in the basis. Brogan (1977) tried to predict the Great Falls, Montana winter wheat basis on two grain exchanges, with generally negative results.

Working also talked about the ideas of selective hedging and anticipatory hedging. These types of hedging are done in response to expected prices. An example of anticipatory hedging would be a cattle feeder who long hedges grain for cattle he has yet to place in the feedlot but anticipates he will have the animals in the feedlot. Selective hedging is the placement of a hedge when the market participant expects prices to move against him.

The remaining classification of hedging is hedging that is done to maximize expected returns for a given risk (variability of returns) or minimize risk for a given expected return. This view of hedging has been studied from the viewpoint of portfolio theory by Steing (1961). Billings (1978) found that cattle feeders in Montana could have increased returns or reduced risk by judicious use of feeder and fat cattle hedges.

The International Monetary Market of the Chicago Mercantile Exchange was conceived as a futures market specializing in monetary vehicles whether they be currencies, precious metals (including gold), or other financial instruments such as United States Treasury Bills. The International Monetary Market began trading in foreign currencies on May 16, 1972. There was already a world-wide forward currency market maintained by the largest banks, but it catered primarily to multinational businesses and a few wealthy individuals. In that market dealings usually start at $1 million. On the other end,

brokers had been critical of the International Commercial Exchange because the contracts were so small that they had little appeal to larger hedgers. The International Monetary Market was aimed to split the middle.[6]

Most banks that deal in foreign exchange can enter a contract to buy or sell any amount of a currency at any date in the future, i.e., for forward delivery to its customers. Overall, the modern foreign exchange market has been beneficial in promoting world trade.[7] Higinbotham and Telser (1977) state that the benefits of an organized futures market are an increasing function of the number of potential participants.

Baron (1976) points out that forward exchange markets or their equivalents permit investors to perform their own covering of the uncertain returns from share ownership, and consequently, firms are able to plan their outputs using the forward exchange rate as a planning equivalent.

There is indeed a new literature developing which focuses on the effects of an exchange rate on futures cash flows, that is, the degree to which the present value of a firm is affected by a given exchange rate change.[8] The major conclusions are that the sector of the economy a firm operates in (exports, imports, or pure domestic) and the sources of its inputs (imports or domestics) are important in delineating a firm's true economic exposure to exchange rate fluctuations.[9]

The issue addressed in this research is the predictability of exchange rates and its implications to hedging strategies. If firms would be hedging selectively, i.e., hedging when exchange rates are expected to move against them. Conceivably, firms might also be hedging to profit from basis changes, implying that risk reduction motives are superceded by profit motives.

The issue of whether futures prices are predictable or not has been a long standing argument between academicians and traders.

The traders, broken into two basic groups, argue that futures prices are, in fact, predictable -- at least to a certain degree. These two groups agree in philosophy but disagree in practice. One group, the fundamentalists, believe that the fundamental laws of supply and demand underlying the futures market are responsible for the price formation process in the futures market. The fundamentalists then claim they are able to predict futures prices via their ability to forecast shifts in supply and demand.

The other group, the technicians, doesn't discredit the process by which the fundamentalists predict. However, they point out that this information is in past price data and that future futures prices can be predicted via past futures market price data.

The academicians argue that all new information regarding the commodity occurs randomly. If this is the case there is no way to predict a change in the price because of the random nature of new

information being released. Also, argue the academicians, this new information is quickly absorbed by the market. Since prices respond to information so quickly, there will be no possibility to observe price movements and take advantage of these price movements through any sort of mechanical trading rules. The academicians argue, in essence, if you expect the price to be higher tomorrow, it will be higher today. (Samuelson, 1965)

It is interesting to note that Carl Menger is reported to have made careful studies of the Vienna Stock Market before, in 1871, developing the concept of marginal utility and his theory of prices.[10] However, the take off point for most arguments concerning the random nature of price series usually begins with the pioneering work of the French mathematician, M. L. Bachelier. Bachelier, in his Théorie de la Speculation (1900), elegantly derived the theory of the random character of stock market prices. Basically, Bachelier's argument took this form:

$$(1) \quad P_t = P_{t-1} + \varepsilon_t$$

Equation (1) says that the price in time t is equal to the price at time t-1 plus a random element, ε_t. Bachelier also argued that $E(\varepsilon_t) = 0$. The logic behind this goes as follows. If in fact $E(\varepsilon_t) > 0$, traders would buy now, assuming they could always sell later at a higher price at a later date. However, this buying

activity at time t-1 would force the t-1 price up to the level where $E(\varepsilon_t) = 0$. A similar argument could be constructed if $E(\varepsilon_t) < 0$.

Because Bachelier's work was so advanced for its time, it took the rest of the academic world years to follow up on his outstanding work. Economists have applied his theory to price series and have had mixed results. Kendall (1963) and Alexander (1961) both concluded that price changes were random, while Carson (1960) found that prices change following a moving average process. Samuelson (1965) elegantly demonstrated that properly anticipated prices move randomly. However, Smidt (1965) and Stevenson and Bear (1970) rejected the random walk as an explanation of futures price behavior.

Holbrook Working (1958) offered another explanation of the movement of futures prices. His model tried to explain a gradual effect of information on futures prices. The random element, ε_t, in any period is affected not only by the new information but also by the series of past information, according to Working. Working's theory can be put into the framework of time series analysis according to the following finite random shock formula:[11]

$$(2) \quad Z_t = U_t + \Psi_1 U_{t-1} + \Psi_2 U_{t-2} + \ldots + \Psi_n U_{t-n}$$

where Z_t is the price change and the U_i's are random variables which explain the process of price formation through new development and new information.

To apply time series analysis it is necessary to assume that the U_i's are independently, identically distributed. With this assumption, the process becomes a linear discrete stochastic process (Nelson, 1973). Equation (2) can be approximated as an autoregressive process of order P as follows:

$$(3) \quad Z_t = \pi_1 Z_{t-1} + \pi_2 Z_{t-2} + \ldots + \pi_p Z_{t-p} + \varepsilon_t$$

where the π_i's are functions of the Ψ_i's in (2) above and the Z_{t-1}'s are previous observations.

Equation (3) is the fundamental form of an equation that will be developed in chapter three that will be used to test the efficiency of currency futures markets on the International Monetary Market. Expression (3) is a test of the efficient market theory. In the next chapter the rudimentary elements of the efficient market theory is discussed as well as the model used to test the efficiency of currency futures markets on the International Monetary Market.

Chapter 3

EFFICIENT MARKETS

Forms of the Efficient Market Hypothesis

Market prices react to supply and demand conditions. The efficient market hypothesis attempts to explain some factors affecting supply and demand. There are three forms of the efficient market hypothesis: weak form, semistrong form, and strong form. All describe the effects of information, they differ in degree of the information set.

The weak form says that markets are efficient enough to make the study of past prices a worthless way of trying to determine future prices. The information set in the weak form test is the series of past prices. The semistrong form says that as soon as information affecting the market becomes public, it is instantaneously and accurately taken into account by the market. The strong form says that these adjustments are not predictable enough to permit superior returns. The strong form test says all information, not just public information is taken into account and the market prices move accordingly. The form of the efficient market hypothesis tested in this study is the weak form test. It is appropriate here to present a general discussion of efficient markets.[12]

General Discussion of Efficient Markets

An efficient market is a market that processes information "correctly". The prices observed at any time in the market are based on "correct" evaluation of all information available at that time. In an efficient market, prices "fully reflect" available information. (Fama, 1970) Information includes not only such things as hard data, factual reports, or informed opinion, but all elements affecting a market -- such as misinterpretation, misinformation, fads, trends, and faulty expectations. (Jones, Tuttle, Heaton, 1977) The weak form test of the efficient market hypothesis assumes such factors are reflected by past prices.

To start the discussion of efficient markets, assume that all events of interest take place at discrete points in time -- t-1, t, t+1, etc. Then define the following:[13]

ϕ_{t-1} -- the set of information available at time t-1, which is relevant for determining currency futures prices at t-1.

ϕ^{m}_{t-1} -- the set of information that the market uses to determine currency futures prices at t-1. Thus, ϕ^{m}_{t-1} is a subset of ϕ_{t-1}.

$P_{j,t-1}$ -- price of currency j in dollars at time t-1; j=1,2,..., n where n is the number of currencies.

$f_{m,\lambda}(P_{1,t+\lambda},\ldots,P_{n,t+\lambda} \mid \phi^{m}_{t-1})$ -- the joint probability density function for exchange rates at time $t+\lambda$ ($\lambda \geq 0$) assessed by the market at time t-1 on the basis of the information ϕ^{m}_{t-1}.

$f_\lambda(P_{1,t+\lambda},\ldots,P_{n,t+\lambda} \mid \phi_{t-1})$ -- the "true" joint probability density function for exchange rates at time $t+\lambda$ ($\lambda \geq 0$) that is "implied by" the information ϕ_{t-1}.

The set of information ϕ_{t-1} available at time t-1 includes what might be called the "state of the world" at time t-1: e.g. current and past values of any relevant variables, like wages, prices, and "political climate", the tastes of consumers and investors, etc. Since ϕ_{t-1} included the past history of all relevant variables, ϕ_{t-1} includes ϕ_{t-n}; equivalently, ϕ_{t-n} is a subset of ϕ_{t-1} (for $n > 1$). In addition to current and past values of relevant variables, ϕ_{t-1} is also assumed to include whatever is knowable about relationships among variables. This includes relationships among current and past values of the same or different variables, and also whatever can be predicted from future "states of world" from the current state.

In short, ϕ_{t-1}, the information available at t-1, includes not only the state of the world at t-1, but also what is knowable about the process that describes the evolution of the world through time. (Fama, 1976) One of the things that is assumed to be knowable about the process is the implication of the current state of the world for the joint probability distributions of exchange rates at future times. Thus, ϕ_{t-1} is assumed to imply the joint density functions $f_\lambda(P_{1,t+\lambda}, \ldots, P_{n,t+\lambda} \mid \phi_{t-1})$; $\lambda = 0, 1, 2, \ldots$.

The process of price formation at time t-1 is then assumed to be

as follows. On the basis of the information ϕ^m_{t-1}, the market assesses a joint distribution of exchange rates for time t, $f_m(P_{1t}, \ldots, P_{nt}|\phi^m_{t-1})$ where $P_{it} = P_{1t}, P_{2t}, \ldots, P_{nt}$. From this assessment of the distribution of exchange rates at t, the market then determines appropriate current exchange rates, $P_{1,t-1}, \ldots, P_{n,t-1}$, for individual currencies. The appropriate current exchange rates are determined by some model of market equilibrium -- that is, by a model that determines what equilibrium market exchange rates should be on the basis of characteristics of the joint distribution of exchange rates at t.[14] (Fama, 1976) A market equilibrium at time t-1 is achieved when the market sets exchange rates $P_{1,t-1}, \ldots, P_{n,t-1}$ for individual currencies at which the demand for each currency is equal to the supply of the currency. In other words, a market equilibrium implies a market-clearing set of exchange rates for all currencies.

If the currency futures market is hypothesized to be efficient

(1) $\phi^m_{t-1} = \phi_{t-1}$.

That is, the information used by the market to determine futures prices is equal to all the information available.

Having correctly assessed the joint distribution of exchange rates for t, the market then uses some model of equilibrium to set exchange rates at t-1. The model says what the current exchange rate of currencies, $P_{1,t-1}, \ldots, P_{n,t-1}$, should be in the light of the correctly

assessed joint distribution of exchange rates for t.[15] (Fama, 1976)

Tests of market efficiency are concerned with whether or not the market does correctly use available information in setting prices. Most common are tests that try to determine whether prices fully reflect specific subsets of information. For example, one possible source of information about future currency futures prices is the history of past currency futures prices. A nontrivial segment of the empirical literature of efficient markets is concerned with whether current prices fully reflect any information in past prices. (Fama, 1976) This has a major empirical implication -- it rules out the possibility of trading systems based only on information in past prices that have expected profits or returns in excess of equilibrium expected profits or returns, (Fama, 1970).

Tests of Efficient Markets

The primary objective of this study is to test the efficiency of foreign currency futures markets on the International Monetary Market. To test the efficiency of a market, a general model of market equilibrium must be devised. It is against this model that efficient market tests are conducted. There are four basic types of these market models and each will be briefly presented.[16]

Expected Returns are Positive

The first model of market equilibrium says that at any time t-1 the market sets the price of any security j in such a way that the market's expected return on the security from time t-1 to time t is positive. Therefore, let

$$(2) \qquad R_{j,t} = \frac{P_{j,t} - P_{j,t-1}}{P_{i,t-1}}$$

where:

$R_{i,t}$ - the rate of return in currency futures market j during some time period t-1 to t.

$P_{i,t}$ - the futures market price of currency j at time t.

$P_{j,t-1}$ - the futures market price of currency j at time t-1.

This model of market equilibrium says that the market always sets $P_{j,t-1}$ so that the mean of the resulting distribution of R_{jt} is strictly positive. (Fama, 1976) That is,

$$(3) \qquad E_m(R_{jt}|\phi^m_{t-1}) = \frac{E_m(P_{jt}|\phi^m_{t-1} - P_{j,t-1}}{P_{j,t-1}} > 0$$

Expression (3) states that the market sets the price of security j at time t-1 such that the true expected return on security j is positive. In other words, the market has correctly assessed all available information at time t-1 to set the price of security j such that its return from time t-1 to time t is positive. Note that if the expected return on D-marks in terms of dollars is positive, then

the expected return on dollars in terms of D-marks is negative.

Filter tests are the only tests of market efficiency which test the general equilibrium market model that assumes returns are positive. (Fama, 1976)

A filter test is a type of trading rule that says once a security has started to rise it will continue to rise; once a security has started to fall it will continue to fall. The basic trading rule of a filter test is: if the price of a security moves up at least x percent, buy and hold the security until its price moves down at least x percent from a subsequent high, at which time simultaneously sell and go short. The short position is maintained until the price rises at least x percent above a subsequent low, at which time the short position is covered and a long position is established. Moves less than x percent in either direction are ignored. Such a system is called an x percent filter. (Stevenson and Bear, 1970)

Stevenson and Bear (1970) found that, in fact, filter rules could be successfully employed in corn and soybeans futures markets. Alexander (1961), and Fama and Blume (1966) conclude the filter rules cannot, for the most part, beat the simple strategy of buy and hold.

Expected Returns are Constant

Another type of test is based on a model in which the expected return is assumed to be constant through time. Specifically, this

model says that at any time t-1 the market sets the price of any security j in such a way that the market's expected return on the security from time t-1 to time t is constant. This model of market equilibrium says that the market always sets $P_{j,t-1}$ so that the mean of the resulting distribution of R_{jt} is constant. (Fama, 1976) That is,

$$(4) \qquad E_m(R_{jt}|\phi^m_{t-1}) = \frac{E_m(P_{jt}|\phi^m_{t-1}) - P_{j,t-1}}{P_{j,t-1}} = E(R_j)$$

This return, R_j, is constant through time, according to the model. Note that the model says that the return is constant, which implies that the return, R_j, could be positive, negative, or zero.

Equation (4) implies that for all ϕ_{t-1}, $E(R_{jt}|\phi_{t-1})$, the regression function of R_{jt} on ϕ_{t-1} is the constant $E(R_j)$. This means that if the return, R_{jt}, is regressed on any of the elements from the set of information available at t-1, all the coefficients except for the intercept should be indistinguishable from zero. If some of the variables have nonzero coefficients, (4) must be rejected. That is, the joint hypothesis that the market is efficient and that it sets prices so that equilibrium expected returns are constant through time is rejected. (Fama, 1976)

Stevenson and Bear (1970) tested against this type of model using serial correlation coefficients. They concluded that, in corn

and soybean futures markets, the information in past returns could be used to predict future returns. Larson (1960) also concluded that there is a discernable pattern to commodity futures prices.

Returns Conform to the Capital Asset Pricing Model

A third type of general equilibrium market model that is tested is the capital asset pricing model.

Sharpe (1964) originally proposed a model of the equilibrium pricing of portfolio assets. Lintner (1965), Mossin (1966) and Fama (1971) later extended the model. Sharpe showed that conditions exist under which the equilibrium risk-return relation for any capital asset i can be represented as:

$$(5) \quad E(\tilde{R}_i) = R_f + \left[\frac{E(\tilde{R}_w) - R_f}{\sigma(\tilde{R}_w)} \cdot \frac{\partial \sigma(\tilde{R}_w)}{\partial x_i} \right]$$

where:

$\tilde{R}_i$ - the random rate of return on asset i.

$E(\tilde{R}_i)$ - the mathematical expectation of $\tilde{R}_i$.

R_f - the pure time return on capital or the so-called riskless rate of interest.

$\tilde{R}_w$ - the random rate of return on a representative dollar of total wealth or, equivalently, the return on a portfolio containing all existing assets in the proportions, x_i, in which they are actually outstanding.

$E(\tilde{R}_w)$ - the mathematical expectation of $\tilde{R}_w$.

$\sigma(\tilde{R}_w)$ - the standard deviation of the return on total wealth -- a measure of the risk involved in holding a representative dollar of total wealth.

$\frac{\partial \sigma(\tilde{R}_w)}{\partial x_i}$ - the marginal contribution of asset i to the risk of the return on total wealth $\sigma(\tilde{R}_w)$.

Expression (5) says that, in equilibrium, the expected rate of return on any asset i will be equal to the riskless rate of interest plus a risk premium proportional to the contribution of the asset to the risk of the return on total wealth.

In general, the test conducted with the capital asset pricing model follows this type of procedure. First let R_{jt} be some return on asset j at time t and further let R_{mt} be the returns to the market at time t. The market model can then be estimated from time series data on R_{jt} and R_{mt}, using ordinary least squares. (Fama, 1976) The form of the test is:

$$(6) \quad R_{jt} = \alpha_i + \beta_j R_{mt} + \varepsilon_{jt}$$

the error term, ε_{jt}, is assumed to be normally distributed with a mean of zero and a constant variance. With an efficient market, the deviation of ε_{jt} from zero results solely from new information that becomes available from t: there is no way to use information available at t-1 as the basis of a correct nonzero assessment of the expected value of ε_{jt}. (Fama, 1976)

The first study that uses the market model as the basis of a test of market efficiency is the work on stock splits by Fama, Fisher,

Jensen, and Roll (1969). Dusak (1973) uses the market model to test market efficiency in several commodity futures markets. These studies concluded that such a relationship existed in the market.

Returns Conform to a Risk-Return Relationship

The fourth type of general equilibrium market model is the theory that returns conform to some risk-return relationship. Note that the capital asset pricing model also posits a risk-return relationship. However, the risk-return relationship described in the capital asset pricing model has some restrictive assumptions. The capital asset pricing model (CAPM) presents this type of a risk-return relationship:

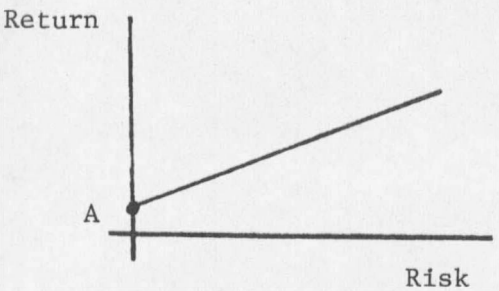


Figure 3-1 CAPM RISK-RETURN RELATIONSHIP

The relationship presented in Figure 3-1 says that in order to achieve a higher return an investor must assume more risk. Figure 3-1 also says that the return to an asset is equal to some risk free rate (point A) plus some risk premium.

The capital asset pricing model posits that the risk-return relationship is linear. Other general equilibrium market models

could hypothesize a relationship between risk and rate of return that is direct but could be quadratic, exponential, or some other nonlinear specification. Also, the assumptions of the capital asset pricing model such as[17] 1) unrestricted borrowing and lending at a risk free rate, 2) costless information and 3) costless transactions could be modified or eliminated in another general equilibrium market model.

Methodology

The Model

The general model of market equilibrium tested against here is the model that posits that expected returns are constant. The subset of ϕ_{t-1} (the information available to all market participants at time t-1) that is used in this study is the potential information about expected returns that appears in time series of past returns. If the market is efficient and equilibrium expected returns are constant through time, the past returns on security j are a source of information about $E(R_j)$. (Fama, 1976) But, if the market is efficient the past returns on security j cannot be used to estimate the deviation of R_{jt} from $E(R_{jt})$.

If an efficient market exists, there is no way to use any information available at time t-1 as the basis for a correct assessment of an expected value of R_{jt} which is different from the assumed constant equilibrium expected return. (Fama, 1976)

Therefore, for any sequence of past returns, $R_{j,t-1}$, $R_{j,t-2}$,..., the conditional expected value is

(7) $E(R_{jt}|R_{j,t-1}, R_{j,t-2}, \ldots) = E(R_j)$

Statement (7) can be tested in this manner. If the correct assessment of the expected value of R_{jt} is $E(R_j)$, then for any $R_{j,t-n}$

(8) $E(R_{jt}|R_{j,t-n}) = E(R_j)$

To test (8) an alternative hypothesis is introduced, one that proposes that the regression function is linear in $R_{j,t-n}$. This hypothesis has the general form:

(9) $E(R_{jt}|R_{j,t-n}) = \alpha_n + \beta_n R_{j,t-n}$

If the market is efficient, and if equilibrium expected returns are constant through time, this implies that the coefficients on the return on any security j are zero for all values of the lag n.

The general form of the model to be estimated is

(10) $R_{j,t} = \alpha_j + \beta_1 R_{j,t-1} + \beta_2 R_{j,t-2} + \ldots + \beta_n R_{j,t-n} + \varepsilon_{j,t}$

where:

α_j - the intercept term.
β_i - estimated regression coefficients $i = 1.,,,,n.$
$R_{j,t}$ - the return to currency j during the time period t-1 to t.
$R_{j,t-1}$ - its return from time period t-2 to t-1.
$R_{j,t-n}$ - its return from time period t-n-1 to t-n.
$\varepsilon_{i,t}$ - a random error term that is assumed to be normally distributed with a mean of zero and a constant variance.

Expression (10) will be lagged an arbitrary n time periods. If the last time period does not contribute significantly to the

estimation of $R_{j,t}$, the variable will be dropped. This process will continue until a model of some n^{th} order autoregressive process remains.

The null hypothesis to be tested is

(11) $H_o: \beta_1 = \beta_2 = \ldots = \beta_n = 0$

Also, the constant term, $\alpha_{j,t}$, will be tested to determine if it is significantly different from zero.

Two different return specifications will be tested; this is because a priori neither is a clear choice. The first defines the return to currency futures market j as

(12) $$R_{j,t} = \frac{P_{j,t} - P_{j,t-1}}{P_{j,t-1}}$$

where:

$R_{j,t}$ - the return to currency futures market j during time period t-1 to t.

$P_{j,t}$ - the futures market price of currency j at time t.

$P_{j,t-1}$ - its price at time t-1.

The second defines the rate of return to currency futures market j during the time period t-1 to t as

(13) $R_{j,t} = P_{j,t} - P_{j,t-1}$

where:

$R_{j,t}$ - the rate of return to currency futures market j during the time period t-1 to t.

$P_{j,t}$ - the futures market price of currency j at time t.

$P_{j,t-1}$ - its price at time t-1.

Note that this model measures absolute changes in the price rather than percentage changes.

If one of the return specifications can be deemed superior to the other, another model will be specified and run. This model will contain lagged returns from other currency futures markets as well as lagged values of the currency in question on the right hand side. This is a multimarket model that tests whether returns in currency market i are dependent upon returns in currency market j.

The Data

The five most actively traded currency contracts on the International Monetary Market comprise the data set for this study. These five currencies include: British pounds, Canadian dollars, Japanese yen, Swiss francs, and West German marks.

The data set covers seven years of trading on the IMM: 1972 to 1978. Each year is broken down into four contracts -- March, June, September, and December. Therefore the data set for each currency starts with the September 1972 contract and ends with the December 1978 contract. For any particular contract, there are about 62 observations. Consequently, this results in a data sample of 1,636 trading days.

The contract nearest maturity is used in the data set. For example, when the June contract closes, the September contract comprises the data set until it closes, then the December contract comprises the data set until, in turn, it closes, etc. In this manner a continuous time horizon is achieved; a futures price for each currency on every trading day from June 19, 1972 to December 18, 1978 is thus included in the data.

These futures price observations then generated returns. The difference between the futures price at time t and at time t-1 comprises a first-difference return while the percentage change of these two futures prices comprise the percentage change return. These two return specifications are computed over three different time periods, i.e., for a one day return, six day return, and a twenty day return. Note that these returns are computed over trading days.

Chapter 4

RESULTS

The general equilibrium market model that was tested was one that stated the returns over time are constant. The type of model constructed to test against the general equilibrium market model is an autocorrelation model of this form:

$$(1) \quad R_{j,t} = \alpha + \beta_1 R_{j,t-1} + \beta_2 R_{j,t-2} + \ldots + \beta_n R_{j,t-n} + \varepsilon_t$$

where

$R_{j,t}$ - the return to currency market j at time t.

$R_{j,t-i}$ - its return at time t-i, i = 1, ... , n .

α - the intercept term.

$\beta_1, \beta_2, \ldots, \beta_n$ - estimated autocorrelation coefficients.

ε_t - a random error term which is assumed to have the classic properties, i.e. $\varepsilon_t \sim n\ (0, \sigma^2)$.

Two different specifications of the independent variables were tested. After the results from each are presented, these specifications will be assessed one against the other to determine if one is superior. One, the percentage return model, defines the independent variables as a percentage return, that is

$$(2) \quad R_{j,t} = \frac{P_{j,t} - P_{j,t-1}}{P_{j,t-1}}$$

The other, the difference model, defines the independent variables as a change in the price, that is

$$(3) \quad R_{j,t} = P_{j,t} - P_{j,t-1}$$

The two specifications were lagged an arbitrary fifteen time periods. The time periods used were one day, six day, and twenty day. Each specification and time period combination was estimated for each currency. The maintained general equilibrium market hypothesis tested against is

(4) $E(R_t | R_{t-1}, \ldots R_{t-n}) = R$.

Expression (4) implies that this null hypothesis be tested for equation (1):

(5) H_o^1: $\beta_1 = \ldots = \beta_n = 0$.

If (5) is true then (1) becomes

(6) $R_{j,t} = \alpha + \varepsilon_t$,

that is, the return to currency j at time t is some constant (α) plus a random error term (ε_t). If (5) cannot be rejected, then (4) cannot be rejected. In cases where (5) is rejected, (4) is rejected.

In cases where (5) is not rejected another hypothesis will be tested. This hypothesis states that the returns to currency futures market j over time are constant and, further, these constant returns are zero. Thus, this hypothesis will then be tested:

(7) H_o^2: $\alpha = \beta_1 = \ldots = \beta_{15} = 0$

Note expression (7) is conditional upon (5) and is tested by whether the mean return is equal to zero, that is if the mean of the dependent variables is different from zero.

Expression (5) has broad implications. If it cannot be rejected then it appears that information contained in last time period's return is not much help in forecasting this time period's return. If it is rejected, then information in the last time period's return can be used to forecast this time period's return. This, then, would lead to the rejection of the joint hypothesis that the market is efficient and that it sets prices so that equilibrium returns through time are constant.

Although (5) is the null hypothesis that tests the theory of whether returns are constant, it would be beneficial to test to see where any statistical dependence might be concentrated. If (5) is rejected, it is because high order lags are different from zero or is it because low order lags are different from zero? So, for each of the currencies, time periods, and independent variable specifications, the following tests were made.

First, this hypothesis was tested:

(8) H_o: $\beta_{11} = \beta_{12} = \beta_{13} = \beta_{14} = \beta_{15} = 0$

then,

(9) H_o: $\beta_8 = \beta_9 = \ldots = \beta_{15} = 0$

then,

(10) H_o: $\beta_2 = \beta_3 = \ldots = \beta_{15} = 0$

and finally,

(11) H_o: $\beta_1 = \beta_2 = \ldots = \beta_{15} = 0$

The most extensive hypothesis is expression (10), wherein the maintained hypothesis is that none of the explanatory variables has an influence on the mean of the dependent variable. This hypothesis is tested against the alternative that the maintained hypothesis is not true; that is, that at least one of the regression coefficients is different from zero. If (11) is true then the variation of the dependent variable from observation to observation is not affected by changes in any one of the explanatory variables, but is a constant term plus a random element.

The appropriate test for evaluating (11) is

$$\frac{SSR/(k-1)}{SSE/(n-k)} \sim F_{k-1,n-k}$$

where

SSR -- the sum of squares due to regression.

k -- the number of estimated regression coefficients.

SSE -- the residual sum of squares.

n -- the number of sample observations.

$\sim F_{k-1,n-k}$ -- distributed as an F with k-1 degrees of freedom in the number and n-k degrees of freedom in the denominator.

The calculated F is compared to a critical F value. The critical value changes with the number of degrees of freedom. If the calculated F exceeds the critical value, then the null hypothesis, (11), is rejected.

Testing the expressions (8), (9), and (10), is somewhat different. In general, these tests concern the influence of additional explanatory variables on the mean of the dependent variable.

In particular, note expression (8). This expression tests two different theories. The first states

$$(12) \quad R_{j,t} = \alpha + \beta_1 R_{j,t-1} + \ldots + \beta_{10} R_{j,t-10} + \varepsilon_t$$

where the terms in (11) have the same definition as they do in (1). The second theory states

$$(13) \quad R_{j,t} = \alpha + \beta_1 R_{j,t-1} + \ldots + \beta_{15} R_{j,t-15} + \varepsilon_t$$

where the terms in (13) have the same meanings as the terms in (12). Note the difference in the two theories is that (13) includes five more independent variables. To test expression (8) is to test between the two theories. That is, do the five added regressors as a group affect the mean of the dependent variable?

To formulate the appropriate test, a new notation is introduced, using the subscript k to denote the values pertaining to the original set of explanatory variables, and the subscript Q to denote the values of the extended set of explanatory variables. If the null hypothesis is true then

$$(13) \quad \frac{(SSR_Q - SSR_K) \;/\; (Q - K)}{SSE_Q \;/\; (n - Q)} \sim F_{Q-K,n-Q}$$

where

SSR_Q -- the sum of squares due to regression of the extended set of explanatory variables.

SSR_K -- the sum of squares due to regression of the original set of explanatory variables.

Q -- the number of explanatory variables in the extended set.

K -- the number of explanatory variables in the original set.

SSE_Q -- the residual sum of squares in the extended set of explanatory variables.

n -- the number of sample observations.

$\sim F_{Q-K,n-Q}$ -- distributed as an F with K-1 degrees of freedom in the numerator and n-K degrees of freedom in the denominator.

(Kmenta, 1971)

Expression (14) can be used to test (8), (9), and (10). Again, a calculated F statistic is compared to a critical value of an F statistic to make the decision of whether or not to reject the maintained hypothesis.

Tables 4.1 and 4.2 present the test results from expression (8). This is the hypothesis that the independent variables eleven to fifteen are not significantly different from zero.

Of the thirty cases tested, the maintained hypothesis that the eleventh, twelfth, thirteenth, fourteenth, and fifteenth lag of the dependent variable have no effect on the mean of the dependent variable was only rejected once. This was the first difference return specification for the Japanese yen during a six day holding period.

TABLE 4.1

H_o: $\beta_{11} = \beta_{12} = \ldots = \beta_{15} = 0$

Return Specification -- Percentage Change

	Time Period (days)		
Currency	1	6	20
British Pounds	NO	NO	NO
Canadian Dollars	NO	NO	NO
German Marks	NO	NO	NO
Japanese Yen	NO	NO	NO
Swiss Francs	NO	NO	NO

YES -- the null is rejected

NO -- the null is not rejected

TABLE 4.2

H_o: $\beta_{11} = \beta_{12} = \ldots = \beta_{15} = 0$

Return Specification -- First Differences

	Time Period (days)		
Currency	1	6	20
British Pounds	NO	NO	NO
Canadian Dollars	NO	NO	NO
German Marks	NO	NO	NO
Japanese Yen	NO	YES	NO
Swiss Francs	NO	NO	NO

YES -- the null is rejected

NO -- the null is not rejected

At the 95 percent confidence level, the null is expected to be rejected when it is in fact true 5 percent of the time. Therefore, (8) might be true for a first difference return specification for a holding period of six days for the Japanese yen. However, sampling may have called for a rejection of this hypothesis in this one case. Therefore, it is concluded that (8) cannot be rejected.

Tables 4.3 and 4.4 show the test results of expression (9). This hypothesis states that the eighth through the fifteenth lag of the dependent variable do not, as a group, affect the mean of the dependent variable.

Of the thirty cases where (9) was tested, two were rejected. These two were: German marks, percentage return specification, one day hold and Japanese yen, first difference return specification, six day hold. The same argument used previously could be used in this case. Five percent of the time, the null will be rejected when it is, in fact, true. Therefore, two cases out of thirty is not extraordinary. However, it must be remembered that these tests are not independent. That is, if (8) is rejected, (9) will also be rejected. But, only Japanese yen six day hold with a first-difference return specification has rejected (8).

This could be nothing more than chance, especially in the light that the time periods were arbitrarily chosen. For any given sample,

TABLE 4.3

H_o: $\beta_8 = \beta_9 = \ldots = \beta_{15} = 0$

Return Specification -- Percentage Change

	Time Period (days)		
Currency	1	6	20
British Pounds	NO	NO	NO
Canadian Dollars	NO	NO	NO
German Marks	YES	NO	NO
Japanese Yen	NO	NO	NO
Swiss Francs	NO	NO	NO

YES -- the null is rejected

NO -- the null is not rejected

TABLE 4.4

H_o: $\beta_8 = \beta_9 = . . . = \beta_{15} = 0$

Return Specification -- First Difference

	Time Period (days)		
Currency	1	6	20
British Pounds	NO	NO	NO
Canadian Dollars	NO	NO	NO
German Marks	NO	NO	NO
Japanese Yen	NO	YES	NO
Swiss Francs	NO	NO	NO

YES -- the null is rejected

NO -- the null is not rejected

there exists a model that will fit it well. It could be that for the Japanese yen, the six-day first difference return model happens to fit the data. Alternatively, this could be an indication of statistical dependence in the Yen market.

Tables 4.5 and 4.6 show the test results of the null hypothesis in expression (10). Of the thirty cases, eight rejected the maintained hypothesis that the second through the fifteen lag of the dependent variable, as a group, have no effect on the mean of the dependent variable. It is interesting to note that in no case has a twenty day holding period shown any statistical dependence.

In this particular case, two six period holds, the Japanese yen and the Swiss franc (both with the first-difference return specification) rejected the null. Six one period holds rejected the null: three in the first-difference return specification (Canadian dollars, German marks, Swiss francs), and three in the percentage return specification (Canadian dollars, German marks, Japanese yen). Again, the Japanese yen six day hold with a first-difference return specification rejected the null.

The last hypothesis tested was expression (11). This maintained hypothesis theorizes that none of the lags of the dependent variable, from the first to the fifteenth, have an effect on the mean of the dependent variable. Tables 4.7 and 4.8 show the results. (Appendix II contains the numerical test results for (8), (9), (10), and (11)).

TABLE 4.5

H_o: $\beta_2 = \beta_3 = . . . = \beta_{15} = 0$

Return Specification -- Percentage Change

	Time Period (days)		
Currency	1	6	20
British Pounds	NO	NO	NO
Canadian Dollars	YES	NO	NO
German Marks	YES	NO	NO
Japanese Yen	YES	NO	NO
Swiss Francs	NO	NO	NO

YES -- the null is rejected

NO -- the null is not rejected

TABLE 4.6

$H_o: \beta_2 = \beta_3 = \ldots \beta_{15} = 0$

Return Specification -- First Differences

	Time Period (days)		
Currency	1	6	20
British Pounds	NO	NO	NO
Canadian Dollars	YES	NO	NO
German Marks	YES	NO	NO
Japanese Yen	NO	YES	NO
Swiss Francs	YES	YES	NO

YES -- the null is rejected

NO -- the null is not rejected

TABLE 4.7

H_o: $\beta_1 = \beta_2 = . . . = \beta_{15} = 0$

Return Specification -- Percentage Change

	Time Period (days)		
Currency	1	6	20
British Pounds	NO	NO	NO
Canadian Dollars	YES	NO	NO
German Marks	YES	NO	NO
Japanese Yen	YES	YES	NO
Swiss Francs	YES	NO	NO

YES -- the null is rejected

NO -- the null is not rejected

TABLE 4.8

H_o: $\beta_1 = \beta_2 = . . . = \beta_{15} = 0$

Return Specification -- First Differences

	Time Period (days)		
Currency	1	6	20
British Pounds	NO	NO	NO
Canadian Dollars	YES	NO	NO
German Marks	YES	NO	NO
Japanese Yen	YES	YES	NO
Swiss Francs	YES	YES	NO

YES -- the null is rejected

NO -- the null is not rejected

Of the thirty cases, 11 reject the null. None of these rejections were in the twenty-day holding period. Three were in the six-day holding period and eight of the ten cases in the one-day hold were rejected. They were the same for both return specifications, namely, the first-difference return and the percentage return specification. For the cases where (11) was not rejected another hypothesis was tested. This is expression (7) above. This hypothesis is tested conditionally that (11) is not rejected and it states that the returns over time are zero. The test was conducted in this manner. After (11) was not rejected, (1) became (6), with (6) stating the return to currency j is a constant plus a random term. Expression (7) tests this constant term to judge if it is significantly different from zero. Since the intercept is the estimate of the meand of the dependent variable when the independent variables have no effect upon the mean of the dependent variable, (7) tests the mean of the dependent variable to judge if it is significantly different from zero. The results are presented in tables 4.9 and 4.10. Note that in all cases where (11) was not rejected, the mean of the dependent variable was judged not significantly different from zero. Thus, in the majority of the cases, the short run returns in the currency futures markets are zero. However, there are some cases where these short run returns are not zero, i.e. there is some statistical

TABLE 4.9

H_o: $\alpha = \beta_1 = \ldots = \beta_{15} = 0$

Return Specification -- Percentage Change

	Time Period (days)		
Currency	1	6	20
British Pounds	NO	NO	NO
Canadian Dollars	*	NO	NO
German Marks	*	NO	NO
Japanese Yen	*	*	NO
Swiss Francs	*	NO	NO

* -- H_o: $\beta_1 = \beta_2 = \ldots = \beta_{15} = 0$ was rejected

YES -- the null is rejected

NO -- the null is not rejected

TABLE 4.10

H_o: $\alpha = \beta_1 = . . . = \beta_{15} = 0$

Return Specification -- First Differences

	Time Period (days)		
Currency	1	6	20
British Pounds	NO	NO	NO
Canadian Dollars	*	NO	NO
German Marks	*	NO	NO
Japanese Yen	*	*	NO
Swiss Francs	*	*	NO

* -- H_o: $\beta_1 = \beta_2 = . . . = \beta_{15} = 0$ was rejected

YES -- the null is rejected

NO -- the null is not rejected

dependence in some of the cases.

It is apparent that if any statistical dependence exists, it is not in the twenty-day holding period. None of the forty cases rejected a null that a group of variables was not different from zero. Therefore, it appears that any statistical dependence is concentrated in the one day hold and the six-day hold. Thus, it is of interest to determine the order of the autocorrelation. Tables 4.11 and 4.12 summarize the autocorrelation functions for both return specifications for the twenty day holding period.

Note two things. First, only seven of the 150 estimated coefficients were significantly different from zero (using a t-test). Further, when a fifteenth order autoregressive function is estimated, the probability that all fifteen estimated coefficients will be judged not significantly different from zero is approximately .54; if, in fact, there is no significant relationship. That is, some of the coefficients can appear to be significantly different from zero, when there is no relationship. This is assuming a 5 percent confidence level. The probability of observing no significant coefficients when there is no true dependence is given by

$$(15) \qquad 1 - (1 - c)^n$$

where c is the confidence level and n represents the number of variables. In this case c is .05 and n is 15, giving a probability

TABLE 4.11

Significance of Individual Variables
Return Specification -- Percentage Change
Holding Period -- Twenty Days

Lag	Currency: British Pounds	Canadian Dollars	German Marks	Japanese Yen	Swiss Francs
1	+	0	0	0	0
2	0	0	0	0	0
3	0	0	0	0	0
4	0	0	-	0	0
5	0	0	0	0	0
6	0	0	-	0	0
7	0	0	0	0	0
8	0	0	0	0	0
9	0	0	0	0	0
10	0	0	0	0	0
11	0	0	0	0	0
12	0	0	0	0	0
13	0	-	0	0	0
14	0	0	0	0	0
15	0	0	0	0	0

Key: 0 not significant
+ significant positive
- significant negative

TABLE 4.12

Significance of Individual Variables 5% Level
Return Specification -- First Difference
Holding Period -- Twenty Days

Lag	Currency	British Pounds	Canadian Dollars	German Marks	Japanese Yen	Swiss Francs
1		+	0	0	0	0
2		0	0	0	0	0
3		0	0	0	0	0
4		0	0	-	0	0
5		0	0	0	0	0
6		0	0	-	0	0
7		0	0	0	0	0
8		0	0	0	0	0
9		0	0	0	0	0
10		0	0	0	0	0
11		0	0	0	0	0
12		0	0	0	0	0
13		0	0	0	0	0
14		0	0	0	0	0
15		0	0	0	0	0

Key: 0 not significant
+ significant positive
- significant negative

of .54. In fact, of the ten equations estimated for a twenty day holding period, five of them had every estimated coefficient not different from zero, complying with expectations.

Tables 4.13 and 4.14 show the results of the six day holding period. Two of the estimated equations have no significant coefficients. Of the remaining eight equations, four have lags significant that are third order or higher. Of these four, two have only the third lag significant and two have the third and fourth lag significant. In the context of this study, this says the return from the eighteenth trading day ago to the twelfth trading day ago will help the trader forecast the return from today to six trading days from now. This seems a bit implausible since the information from this time period should have been adapted into the price by the market. It makes more sense, in terms of information, to talk about returns that occurred only one period ago.

The remaining four, however, show a significant coefficient on the first variable. This might lead to the conclusion that this model might be used to reap gains from this seemingly inefficient market.

Tables 4.15 and 4.16 have five estimated equations that have the first order lag significant. (The numerical results of 4.11 - 4.16 appear in Appendix II.)

TABLE 4.13

Significance of Individual Variables
Return Specification -- Percentage Change
Holding Period -- Six Days

Lag	Currency: British Pounds	Canadian Dollars	German Marks	Japanese Yen	Swiss Francs
1	0	0	+	+	0
2	0	0	+	0	0
3	+	0	0	0	-
4	0	0	0	0	+
5	0	0	0	0	0
6	0	0	0	0	0
7	0	0	0	0	0
8	0	0	0	0	0
9	0	0	0	0	0
10	0	0	0	0	0
11	0	0	0	0	0
12	0	0	0	0	0
13	0	0	0	0	0
14	0	0	0	0	0
15	0	0	0	0	0

Key: 0 not significant
+ significant positive
- significant negative

TABLE 4.14

Significance of Individual Variables 5% Level
Return Specification -- First Differences
Holding Period -- Six Days

Lag	Currency: British Pounds	Canadian Dollars	German Marks	Japanese Yen	Swiss Francs
1	0	0	+	+	0
2	0	0	0	0	0
3	+	0	0	0	-
4	0	0	0	0	+
5	0	0	0	0	0
6	0	0	0	0	0
7	0	0	0	0	0
8	0	0	0	0	0
9	0	0	0	0	0
10	0	0	0	0	0
11	0	0	0	0	0
12	0	0	0	-	0
13	0	0	0	0	0
14	0	0	0	0	0
15	0	0	0	0	0

Key: 0 not significant
+ significant positive
- significant negative

TABLE 4.15

Significance of Individual Variables
Return Specification -- Percentage Change
Holding Period -- One Day

Lag	Currency: British Pounds	Canadian Dollars	German Marks	Japanese Yen	Swiss Francs
1	0	0	0	-	+
2	0	-	0	-	0
3	0	+	0	-	0
4	0	0	0	0	0
5	0	0	0	+	0
6	0	0	0	+	0
7	0	+	0	0	+
8	0	0	0	0	0
9	0	0	+	+	0
10	+	0	+	+	+
11	0	0	0	0	0
12	0	0	0	0	0
13	0	0	0	0	0
14	0	0	0	0	0
15	0	0	0	0	0

Key: 0 not significant
+ significant positive
- significant negative

TABLE 4.16

Significance of Individual Variables 5% Level
Return Specification -- First Differences
Holding Period -- One Day

Lag	Currency: British Pounds	Canaidan Dollars	German Marks	Japanese Yen	Swiss Francs
1	0	0	+	-	+
2	0	-	+	0	0
3	0	+	0	-	+
4	0	0	0	0	-
5	0	+	0	0	-
6	0	0	0	0	0
7	0	+	0	0	+
8	0	0	0	0	0
9	0	0	+	+	+
10	+	0	+	+	0
11	0	0	0	0	-
12	0	0	0	0	0
13	0	0	0	0	0
14	0	0	0	0	0
15	0	0	0	0	0

Key: 0 not significant
+ significant positive
- significant negative

This could be explained in part by the discussion concerning (15). However, since the first order lag would be the lag that theoretically would contain the most information, these results might point to some market inefficiency. In the one day hold models, every estimated equation had at least one coefficient significantly different from zero. Consequently, it appears that there is some dependence in the one-day hold models.

Comparing the Specification Models

Throughout these results, two models of return specifications have been presented. However, if only one of the return specifications is correct, then faulty estimates may have been made. Therefore, it is best to determine if one of the models is superior to the other.

In order to do this two different null hypotheses must be tested. The first is

$$(16)\quad H_o^1: \quad \frac{P_{j,t} - P_{j,t-1}}{P_{j,t-1}} = \varepsilon_{j,t}$$

where

$P_{j,t}$ -- the price in currency market j at time t.

$P_{j,t-1}$ -- its price at time t-1.

$\varepsilon_{j,t}$ -- a random error term assumed to have the classic ordinary least squares properties.

Note that (16) says that returns in currency futures market j are just due to a random error term, which according to tests of (5) and (7) appears plausible.

If (16) is true, then it implies

(17) $P_{j,t} - P_{j,t-1} = P_{j,t-1}\epsilon_{j,t}$

The right-hand term in (17) can be defined as a new error term, $U_{j,t}$, that is assumed to be normally distributed with mean zero and variance $\sigma^2 P^2_{j,t-1}$. Thus (17) becomes

(18) $P_{j,t} - P_{j,t-1} = U_{j,t}$

The variance of the error term in (18) will be proportional to the square of the last period's price. That is, if the percentage return specification is correct and a first difference return specification is estimated, a heteroskedastic error term is introduced.

To test (16) the squared residuals from the first-order first-difference regression were regressed on the squared price one period ago. Therefore this equation was estimated

(19) $\hat{U}^2_{j,t} = \hat{\alpha} + \hat{\beta}\ (P^2_{j,t-1}) + v_t$

The estimated coefficient of the term P^2_{t-1} is the key to determining if the error term in (18) is heteroskedastic. Note, from (18),

(20) $E(U_{j,t})^2 = \sigma^2 P^2_{j,t-1}$

and from (19)

(21) $E(\hat{U}_{j,t})^2 = \hat{\alpha} + \hat{\beta}\ (P^2_{j,t-1})$

Thus, the coefficient $\hat{\beta}$ in (19) is an estimate of σ^2 in (20). The maintained hypothesis (16) states that this coefficient should be positive in sign. If β is significantly greater than zero, then the error term in (18) is heteroskedastic and the first difference model with homoskedastic error must be rejected. Intuitively, a positive value for β lends credence to the null hypothesis of a percentage change return specification. Two hypotheses from (19) are tested

(22) H_o: $\alpha = 0$

and

(23) H_o: $\beta = 0$

Expression (23) was tested against the alternative that the estimated coefficient in (21) is greater than zero. The results of (22) are in table 4.17 and the results of (23) are in table 4.18. The numerical results are in Appendix II.

The other null hypothesis that is tested is

(24) H_o^2: $P_{j,t} - P_{j,t-1} = \varepsilon_{j,t}$

where

$P_{j,t}$ -- the price in currency market j at time t.

$P_{j,t-1}$ -- its price at time t-1.

$\varepsilon_{j,t}$ -- a random error term assumed to have the classical properties.

TABLE 4.17

Testing the Intercept

$\hat{U}^{2}_{j,t} = \alpha + \beta(P^{2}_{j,t-1}) + \nu_{j,t}$				$\hat{U}^{2*}_{j,t} = \alpha + \beta(P_{j,t-1})^{-2} + \nu^{*}_{j,t}$		
	$H_o: \alpha = 0$			$H_o: \alpha = 0$		
	Holding Period			Holding Period		
	1	6	20	1	6	20
BP	Yes	No	No	No	No	Yes
CD	Yes	No	No	Yes	No	No
DM	Yes	Yes	No	Yes	Yes	Yes
JY	Yes	Yes	Yes	Yes	Yes	Yes
SF	Yes	Yes	Yes	Yes	Yes	Yes

Yes -- The null is rejected

No --- The null is not rejected

TABLE 4.18

Choosing the Return Specification

	(A) $\hat{U}^2_{j,t} = \alpha + \beta(P^2_{j,t-1}) + \nu_{j,t}$ $H_o: \beta = 0$ $H_a: \beta > 0$			(B) $\hat{U}^{2*}_{j,t} = \alpha + \beta(P_{j,t-1})^{-2} + \nu^*_{j,t}$ $H_o: \beta = 0$ $H_a: \beta > 0$		
	Holding Period			Holding Period		
	1	6	20	1	6	20
BP	No	No	Yes	Yes	No	No
CD	Yes	No	No	Yes	No	No
DM	Yes	Yes	Yes	No	No	No
JY	Yes	Yes	Yes	No	No	No
SF	Yes	Yes	Yes	No	No	No

Yes -- The null is rejected in favor of the alternative hypothesis

No -- The null is not rejected

The argument of H_o^2 is exactly reversed of the argument presented by H_o^1. Also, (24) states that returns in currency market j are due to a random element. From tests of (5) and (7), this appears plausible. If (24) is true, then it implies

$$(25) \quad \frac{P_{j,t} - P_{j,t-1}}{P_{j,t-1}} = \frac{\varepsilon_{j,t}}{P_{j,t-1}}$$

The right hand term in (25) can be defined as a new error term, $U^*_{j,t}$, that is assumed to be normally distributed with mean zero and variance $\frac{\sigma^2}{P^2_{j,t-1}}$. Expression (25) then becomes

$$(26) \quad \frac{P_{j,t} - P_{j,t-1}}{P_{j,t-1}} = U^*_{j,t}$$

The variance of the error term varies inversely with the square of the last period's price. If the first-difference specification is the correct specification, but the percentage change return specification is estimated, a heteroskedastic error term is introduced.

To test (24) the squared residuals from the percentage change regression were regressed on the inverse of the squared price one period ago. Therefore this equation was estimated

$$(27) \quad \hat{U}^{*2}_{j,t} = \hat{\alpha} + \hat{\beta} \, (P_{j,t-1})^{-2} + v^*_t$$

The estimated coefficient of the term $(P_{j,t-1})^{-2}$ is the key to determining if the error term in (26) is heteroskedastic. Note, from (26)

$$(28) \quad E(U^*_{j,t})^2 = \frac{\sigma^2}{P^2_{j,t-1}}$$

and from (27)

$$(29) \quad E(\hat{U}^*_{j,t})^2 = \hat{\alpha} + \hat{\beta} (P_{j,t-1})^{-2}$$

Thus, the coefficient $\hat{\beta}$ in (27) is an estimate of σ^2 in (28). The maintained hypothesis (24) states that this coefficient should be positive in sign. If β is significantly greater than zero, then the error term in (26) is heteroskedastic and the percentage change model with homoskedastic error must be rejected. Intuitively, a positive value for β lends credence to the null hypothesis of a first difference return specification. Two hypotheses from (27) are tested

$$(30) \quad H_o: \ \alpha = 0$$

and

$$(31) \quad H_o: \ \beta = 0$$

Expression (31) was tested against the alternative hypothesis that the estimated coefficient in (29) is greater than zero. The results of (30) are in table 4.17 and the results of (31) are in table 4.18. The numerical results are in Appendix II.

Table 4.18 shows some interesting results. It appears that the

error term resulting from a first-difference specification in heteroskedastic. This is shown by the number of yeses in (A). These yeses say that the first difference returns specification results in a heteroskedastic error term. Further, in all but two cases of (B) in table 4.18, the null hypothesis was not rejected. This suggests that the percentage change return specification is not heteroskedastic. Therefore, the specification of a first difference return will be rejected in favor of a percentage change return specification. Note, though, these two different return specifications generated basically the same results (see tables 4.1 to 4.16).

Developing a Prediction Model

Tables 4.11 through 4.16 suggest that most of the statistical dependence on past returns occurred in the first lag i.e., the return from one period ago. A more powerful test should be made to determine the magnitude of this dependence.

Therefore, this equation was estimated for all currencies for all time periods:

$$(32) \quad R_{j,t} = \alpha_j + \beta_j R_{j,t-1} + \epsilon_{j,t}$$

where

$R_{j,t}$ -- the percentage change return in currency market j during the time period t-1 to t.

$R_{j,t-1}$ -- its return from time period t-2 to t-1.

α_j -- the intercept in currency market j.

β_j -- autoregression coefficient to be estimated.

$\varepsilon_{j,t}$ -- a random error term assumed to have the classical properties.

The results from (32) are presented in tables 4.19, 4.20, and 4.21. Only one of the coefficients in the twenty day hold was significant, the first order coefficient on British pounds. The six day hold had significance in two of the first order lags and the one day hold had three. These are the most interesting theoretically because all the information contained in all past prices is considered to be contained in the most recent time period.

From Tables 4.19, 4.20, and 4.21 as well as tables 4.11 - 4.16, it appears there is some statistical dependence in past returns in the currency futures market. Whether or not this dependence can be used to produce future returns resulting in a positive gain is examined in Chapter Five.

TABLE 4.19

First Order Lag -- Percentage Change Returns
Twenty Day Hold

	Currency				
	British Pound	Canadian Dollar	German Mark	Japanese Yen	Swiss Franc
$\hat{\alpha}$	.0011	-.0014	.0016	.0048	.0062
$(S_{\hat{\alpha}})$	(.0027)	(.0015)	(.0036)	(.0036)	(.0046)
t	.4074	-.9333	.4444	1.333	1.3478
$\hat{\beta}$	.3128	-.0490	.0266	.0451	.0463
$(S_{\hat{\beta}})$	(.1224)	(.1285)	(.1290)	(.1302)	(.1297)
t	2.556*	-.3813	.2062	.3464	.3570
R^2	.0982	.0024	.0007	.0020	.0021
N	62	62	62	62	62

* Significant at the .05 level
** Significant at the .02 level
*** Significant at the .01 level

TABLE 4.20

First Order Lag -- Percentage Change Returns
Six Day Hold

	Currency				
	British Pound	Canadian Dollar	German Mark	Japanese Yen	Swiss Franc
$\hat{\alpha}$	.0005	-.00048	.00108	.00118	.00221
$(S_{\hat{\alpha}})$	(.0007)	(.00036)	(.00097)	(.00081)	(.00123)
t	.7143	-1.3333	1.1134	1.4568	1.7967
$\hat{\beta}$	.0164	.05877	.1837	.2905	.05763
$(S_{\hat{\beta}})$	(.0637)	(.06402)	(.06298)	(.06127)	(.06393)
t	.2575	.9181	2.917**	4.740***	.9015
R^2	.00027	.0056	.0337	.08433	.0033
N	246	246	246	246	246

* Significant at the .05 level
** Significant at the .02 level
*** Significant at the .01 level

TABLE 4.21

First Order Lag -- Percentage Change Returns
One Day Hold

	Currency				
	British Pound	Canadian Dollar	German Mark	Japanese Yen	Swiss Franc
$\hat{\alpha}$	.00008	-.00008	.00020	.00033	.00031
$(S_{\hat{\beta}})$	(.00012)	(.00005)	(.00014)	(.00019)	(.00016)
t	.6631	-1.4881	1.4286	1.7368	1.9375
$\hat{\beta}$	.02899	-.01892	.05287	-.2451	.1327
$(S_{\hat{\beta}})$	(.02513)	(.02506)	(.02510)	(.02431)	(.01249)
t	1.154	-.7549	2.106*	-10.08***	5.332***
R^2	.0008	.0004	.0028	.05998	.01754
N	1595	1595	1595	1595	1595

* Significant at the .05 level
** Significant at the .02 level
*** Significant at the .01 level

Chapter Five

EXTENSION OF THE RESULTS

In the preceding chapter, some statistical dependence was found in the returns of currency futures markets. The purpose of this chapter is to determine if this dependence can be used to predict returns that will yield a positive profit. Also, a multimarket model will be estimated. This model will include not only lagged values of the dependent variable but also lagged returns from other currencies as independent variables. The currencies to be tested are: British pounds (20 day hold), German marks (six day and one day hold), Japanese yen (six day and one day hold), and Swiss francs (one day hold). The prediction model used is a first order autoregressive equation. Therefore this model is estimated for all currencies and all holding periods:

$$(1) \quad R_{j,t} = \alpha_j + \beta_j R_{j,t-1} + \varepsilon_{j,t}$$

where

$R_{j,t}$ -- the percentage change return in currency figures market j during the time period t-1 to t.

$R_{j,t-1}$ -- its return from t-2 to t-1.

α_j -- the intercept term for currency j.

β_j -- the estimated autocorrelation coefficient.

$\varepsilon_{j,t}$ -- a random error term assumed to have the classic properties.

Equation (1) was estimated for all currencies and all holding periods. The results are presented in tables 4.19, 4.20, and 4.21.

The currencies named above have a coefficient that is significantly different from zero. Table 5.1 presents these currencies. Since none of the intercept terms were significant, the prediction model becomes

$$(2) \quad \hat{R}_{j,t+1} = \hat{\beta}_j R_{j,t}$$

where

$\hat{R}_{j,t+1}$ -- the predicted return in currency futures market j during the time period t to t+1.

$R_{j,t}$ -- the return in currency futures market j during the time period t-1 to t.

$\hat{\beta}_j$ -- the estimated first order autoregression coefficient for currency j.

Expression (2) predicts the return during the time period t to t+1 is equal to the return in time period t-1 to t multiplied by an estimated coefficient. For a participant in the futures market the prediction model can be used to predict a return during the time period t to t+1 that will yield a gross gain of some amount of money. In order to do this the return of the previous time period must be of a certain magnitude in order to predict this gross gain. Tables 5.2 to 5.7 show what return must be observed last time period in order to predict a gross gain of a certain amount of dollars. Tables 5.2a to 5.7a show what the probability is of observing this return. The method in which these probabilities are calculated is as follows. The returns to the currency futures

Table 5.1

Prediction Model Coefficients

	British Pounds 20 day	German Marks one day	German Marks six day	Japanese Yen one day	Japanese Yen one day	Swiss Francs one day
$\hat{\alpha}$	.0011	.00020	.00108	.00033	.00118	.00031
$S_{\hat{\alpha}}$	(.0027)	(.00014)	(.00097)	(.00019)	(.00081)	(.00016)
t	.4074	1.4286	1.1134	1.7368	1.4568	1.9375
$\hat{\beta}_1$	.3128	.05287	.1837	-.2451	.2905	.1327
$S_{\hat{\beta}_1}$	(.1224)	(.02510)	(.06298)	(.02431)	(.06127)	(.01249)
t	2.556*	2.106*	2.917**	-10.08***	4.740***	5.332***
R^2	.0982	.0028	.0337	.05998	.08433	.01754
N	62	1595	246	1595	246	1595

* -- Significant at the .05 level

** - Significant at the .02 level

*** - Significant at the .01 level

Table 5.2

Prediction Values for British Pounds -- Twenty Day Hold

If the Price of BP is:	The value of R_t to give an $X return would have to be:					
	$50	$100	$150	$200	$250	$500
1.80	.0036	.0071	.0107	.0142	.0178	.0355
1.81	.0035	.0071	.0106	.0141	.0177	.0353
1.82	.0035	.0070	.0105	.0141	.0176	.0351
1.83	.0035	.0070	.0105	.0140	.0176	.0349
1.84	.0035	.0069	.0104	.0139	.0176	.0347
1.85	.0035	.0069	.0104	.0138	.0173	.0346
1.86	.0034	.0069	.0103	.0138	.0172	.0344
1.87	.0034	.0068	.0103	.0137	.0171	.0342
1.88	.0034	.0068	.0102	.0136	.0170	.0340
1.89	.0034	.0068	.0101	.0135	.0169	.0338
1.90	.0034	.0067	.0101	.0135	.0168	.0337
1.91	.0033	.0067	.0100	.0134	.0167	.0335
1.92	.0033	.0067	.0100	.0133	.0167	.0333
1.93	.0033	.0066	.0099	.0133	.0166	.0331
1.94	.0033	.0066	.0099	.0132	.0165	.0330
1.95	.0033	.0066	.0098	.0131	.0164	.0328
1.96	.0033	.0065	.0098	.0130	.0163	.0326
1.97	.0032	.0065	.0097	.0130	.0162	.0325
1.98	.0032	.0065	.0097	.0129	.0161	.0323
1.99	.0032	.0064	.0096	.0129	.0161	.0321
2.00	.0032	.0064	.0096	.0128	.0160	.0320
2.01	.0032	.0064	.0095	.0127	.0159	.0318
2.02	.0032	.0063	.0095	.0127	.0158	.0317
2.03	.0031	.0063	.0094	.0126	.0157	.0315
2.04	.0031	.0063	.0094	.0125	.0157	.0313
2.05	.0031	.0062	.0094	.0125	.0156	.0312
2.06	.0031	.0062	.0093	.0124	.0155	.0310
2.07	.0031	.0062	.0093	.0124	.0154	.0309
2.08	.0031	.0061	.0092	.0123	.0154	.0307
2.09	.0031	.0061	.0092	.0122	.0153	.0306
2.10	.0030	.0061	.0091	.0122	.0152	.0304

Mean BP price during the sample period: $2.02
Range of BP prices during the sample period: $1.54 - $2.51

Table 5.2a

Probability of Prediction Values for British Pounds -- Twenty Day Hold

If the Price of BP is:	The Probability of Observing the Value of R_t to give an $X return is					
	$50	$100	$150	$200	$250	$500
1.80	.4356	.3746	.3149	.2612	.2113	.0549
1.81	.4374	.3746	.3165	.2627	.2126	.0559
1.82	.4374	.3763	.3181	.2627	.2139	.0569
1.83	.4374	.3763	.3181	.2641	.2139	.0580
1.84	.4374	.3780	.3197	.2656	.2166	.0590
1.85	.4374	.3780	.3197	.2671	.2179	.0596
1.86	.4391	.3780	.3213	.2671	.2193	.0606
1.87	.4391	.3797	.3213	.2686	.2206	.0617
1.88	.4391	.3797	.3230	.2701	.2219	.0628
1.89	.4391	.3797	.3246	.2716	.2233	.0639
1.90	.4391	.3814	.3246	.2716	.2246	.0645
1.91	.4409	.3814	.3262	.2731	.2259	.0656
1.92	.4409	.3814	.3262	.2746	.2259	.0668
1.93	.4409	.3831	.3278	.2746	.2273	.0680
1.94	.4409	.3831	.3278	.2761	.2287	.0686
1.95	.4409	.3831	.3294	.2776	.2300	.0698
1.96	.4409	.3848	.3294	.2791	.2314	.0710
1.97	.4427	.3848	.3311	.2791	.2328	.0716
1.98	.4427	.3848	.3311	.2806	.2342	.0728
1.99	.4427	.3866	.3327	.2806	.2342	.0741
2.00	.4427	.3866	.3327	.2821	.2355	.0747
2.01	.4427	.3866	.3344	.2836	.2369	.0760
2.02	.4427	.3883	.3344	.2836	.2383	.0767
2.03	.4445	.3883	.3360	.2852	.2397	.0780
2.04	.4445	.3883	.3360	.2867	.2397	.0793
2.05	.4445	.3900	.3360	.2867	.2411	.0800
2.06	.4445	.3900	.3376	.2882	.2425	.0813
2.07	.4445	.3900	.3376	.2882	.2439	.0820
2.08	.4445	.3917	.3393	.2898	.2439	.0834
2.09	.4445	.3917	.3393	.2913	.2454	.0840
2.10	.4463	.3917	.3409	.2913	.2468	.0854

Table 5.3

Prediction Values for German Marks -- One Day Hold

If the Price of DM is:	The Value of R_t to Give an $X Return would have to be:					
	$50	$100	$150	$200	$250	$500
.30	.0252	.0504	.0757	.1009	.1261	.2522
.31	.0244	.0488	.0732	.0976	.1220	.2441
.32	.0236	.0473	.0709	.0946	.1182	.2364
.33	.0229	.0459	.0688	.0917	.1146	.2293
.34	.0223	.0445	.0668	.0890	.1113	.2225
.35	.0216	.0432	.0648	.0865	.1081	.2162
.36	.0210	.0420	.0630	.0841	.1051	.2102
.37	.0204	.0409	.0613	.0818	.1022	.2045
.38	.0199	.0398	.0597	.0796	.0995	.1991
.39	.0194	.0388	.0582	.0776	.0970	.1940
.40	.0189	.0378	.0567	.0757	.0946	.1891
.41	.0185	.0369	.0554	.0738	.0923	.1845
.42	.0180	.0360	.0540	.0721	.0901	.1801
.43	.0176	.0352	.0528	.0704	.0880	.1759
.44	.0172	.0344	.0516	.0688	.0860	.1719
.45	.0168	.0336	.0504	.0673	.0841	.1681
.46	.0164	.0329	.0493	.0658	.0822	.1645
.47	.0161	.0322	.0483	.0644	.0805	.1610
.48	.0158	.0315	.0473	.0630	.0788	.1576
.49	.0154	.0309	.0463	.0618	.0772	.1544
.50	.0151	.0303	.0454	.0605	.0757	.1513
.51	.0148	.0297	.0445	.0593	.0742	.1483
.52	.0145	.0291	.0436	.0582	.0727	.1455
.53	.0143	.0285	.0428	.0571	.0714	.1427
.54	.0140	.0280	.0420	.0560	.0701	.1401
.55	.0138	.0275	.0413	.0550	.0688	.1376
.56	.0135	.0270	.0405	.0540	.0676	.1351
.57	.0133	.0265	.0398	.0531	.0664	.1327
.58	.0130	.0261	.0391	.0522	.0652	.1304
.59	.0128	.0256	.0385	.0513	.0641	.1282
.60	.0126	.0252	.0378	.0504	.0630	.1261

Mean DM price during the sample period: $.41
Range of DM prices during the sample period: $.31 - $.58

Table 5.3a

Probability of Prediction Values for German Marks -- One Day Hold

If the Price of DM is:	The Probability of Observing the Value of R_t to give an $X Return is:					
	$50	$100	$150	$200	$250	$500
.30	.000004	*	*	*	*	*
.31	.000007	*	*	*	*	*
.32	.000013	*	*	*	*	*
.33	.000023	*	*	*	*	*
.34	.000036	*	*	*	*	*
.35	.000060	*	*	*	*	*
.36	.000093	*	*	*	*	*
.37	.000141	*	*	*	*	*
.38	.0002	*	*	*	*	*
.39	.0003	*	*	*	*	*
.40	.0004	*	*	*	*	*
.41	.0005	*	*	*	*	*
.42	.0007	*	*	*	*	*
.43	.0009	*	*	*	*	*
.44	.0011	*	*	*	*	*
.45	.0014	*	*	*	*	*
.46	.0018	*	*	*	*	*
.47	.0021	*	*	*	*	*
.48	.0025	*	*	*	*	*
.49	.0031	*	*	*	*	*
.50	.0036	*	*	*	*	*
.51	.0042	*	*	*	*	*
.52	.0049	*	*	*	*	*
.53	.0055	*	*	*	*	*
.54	.0064	*	*	*	*	*
.55	.0070	*	*	*	*	*
.56	.0081	*	*	*	*	*
.57	.0090	*	*	*	*	*
.58	.0103	*	*	*	*	*
.59	.0114	*	*	*	*	*
.60	.0125	.000004	*	*	*	*

*Value is more than 4.5 standard deviations from the mean.

Table 5.4

Prediction Values for German Marks -- Six Day Hold

If the Price of DM is:	The Value of R_t to give an $X Return would have to be:					
	$50	$100	$150	$200	$250	$500
.30	.0073	.0145	.0218	.0290	.0363	.0726
.31	.0070	.0140	.0211	.0281	.0351	.0702
.32	.0068	.0136	.0204	.0272	.0340	.0680
.33	.0066	.0132	.0198	.0264	.0330	.0660
.34	.0064	.0128	.0192	.0256	.0320	.0640
.35	.0062	.0124	.0187	.0249	.0311	.0622
.36	.0060	.0121	.0181	.0242	.0302	.0605
.37	.0059	.0118	.0177	.0235	.0294	.0589
.38	.0057	.0115	.0172	.0229	.0287	.0573
.39	.0056	.0112	.0167	.0223	.0279	.0558
.40	.0054	.0109	.0163	.0218	.0272	.0544
.41	.0053	.0106	.0159	.0212	.0266	.0531
.42	.0052	.0104	.0156	.0207	.0259	.0518
.43	.0051	.0101	.0152	.0203	.0253	.0506
.44	.0049	.0099	.0148	.0198	.0247	.0495
.45	.0048	.0097	.0145	.0194	.0242	.0484
.46	.0047	.0095	.0142	.0189	.0237	.0473
.47	.0046	.0093	.0139	.0185	.0232	.0463
.48	.0045	.0091	.0136	.0181	.0227	.0454
.49	.0044	.0089	.0133	.0178	.0222	.0444
.50	.0044	.0087	.0131	.0174	.0218	.0435
.51	.0043	.0085	.0128	.0171	.0213	.0427
.52	.0042	.0084	.0126	.0167	.0209	.0419
.53	.0041	.0082	.0123	.0164	.0205	.0411
.54	.0040	.0081	.0121	.0161	.0202	.0403
.55	.0040	.0079	.0119	.0158	.0198	.0396
.56	.0039	.0078	.0117	.0156	.0194	.0389
.57	.0038	.0076	.0115	.0153	.0191	.0382
.58	.0038	.0075	.0113	.0150	.0188	.0375
.59	.0037	.0074	.0111	.0148	.0185	.0369
.60	.0036	.0073	.0109	.0145	.0181	.0363

Mean DM price during the sample period: $.41
Range of DM prices during the sample period: $.31 - $.58

Table 5.4a

Probability of Prediction Values for German Marks -- Six Day Hold

If the Price of DM is:	The Probability of Observing the Value of R_t to give an $X Return is:					
	$50	$100	$150	$200	$250	$500
.30	.3188	.1748	.0798	.0307	.0096	*
.31	.3258	.1832	.0867	.0349	.0118	*
.32	.3304	.1901	.0941	.0396	.0141	.00001
.33	.3351	.1972	.1007	.0443	.0166	.00001
.34	.3398	.2045	.1077	.0493	.0195	.00002
.35	.3446	.2119	.1138	.0541	.0224	.00003
.36	.3493	.2175	.1215	.0592	.0257	.00005
.37	.3517	.2232	.1267	.0647	.0289	.00007
.38	.3565	.2291	.1336	.0698	.0320	.0001
.39	.3589	.2350	.1406	.0751	.0359	.0002
.40	.3638	.2410	.1465	.0798	.0396	.0002
.41	.3662	.2470	.1525	.0857	.0431	.0003
.42	.3686	.2511	.1571	.0909	.0474	.0004
.43	.3711	.2573	.1634	.0952	.0513	.0005
.44	.3760	.2615	.1698	.1007	.0555	.0007
.45	.3784	.2657	.1748	.1054	.0592	.0009
.46	.3809	.2700	.1798	.1114	.0631	.0011
.47	.3833	.2743	.1849	.1163	.0672	.0014
.48	.3858	.2786	.1901	.1215	.0715	.0017
.49	.3883	.2829	.1954	.1254	.0760	.0021
.50	.3883	.2873	.1990	.1308	.0798	.0025
.51	.3907	.2917	.2045	.1350	.0847	.0029
.52	.3932	.2939	.2081	.1406	.0888	.0034
.53	.3957	.2984	.2137	.1450	.0930	.0040
.54	.3982	.3006	.2175	.1495	.0962	.0047
.55	.3982	.3051	.2213	.1540	.1007	.0053
.56	.4007	.3074	.2252	.1571	.1054	.0060
.57	.4032	.3120	.2291	.1618	.1089	.0069
.58	.4032	.3142	.2330	.1666	.1126	.0078
.59	.4057	.3165	.2370	.1698	.1163	.0086
.60	.4082	.3188	.2410	.1748	.1215	.0096

*Value is more than 4.5 Standard Deviations from the Mean

Table 5.5

Prediction Values for Japanese Yen -- One Day Hold

If the Price of JY is:	The Value of R_t to give an $X Return would have to be:					
	$50	$100	$150	$200	$250	$500
.0030	-.00544	-.01088	-.01632	-.02176	-.02720	-.05440
.0031	-.00526	-.01053	-.01579	-.02106	-.02632	-.05264
.0032	-.00510	-.01020	-.01530	-.02040	-.02550	-.05100
.0033	-.00495	-.00989	-.01484	-.01978	-.02473	-.04945
.0034	-.00480	-.00960	-.01440	-.01920	-.02400	-.04800
.0035	-.00466	-.00933	-.01399	-.01865	-.02331	-.04663
.0036	-.00453	-.00907	-.01360	-.01813	-.02267	-.04533
.0037	-.00441	-.00882	-.01323	-.01764	-.02205	-.04411
.0038	-.00429	-.00859	-.01288	-.01718	-.02147	-.04295
.0039	-.00418	-.00837	-.01255	-.01674	-.02093	-.04185
.0040	-.00408	-.00816	-.01224	-.01632	-.02040	-.04080
.0041	-.00398	-.00796	-.01194	-.01592	-.01990	-.03980
.0042	-.00389	-.00777	-.01166	-.01554	-.01943	-.03886
.0043	-.00380	-.00759	-.01139	-.01518	-.01898	-.03795
.0044	-.00371	-.00742	-.01113	-.01484	-.01855	-.03709
.0045	-.00363	-.00725	-.01088	-.01451	-.01813	-.03627
.0046	-.00355	-.00710	-.01064	-.01419	-.01774	-.03548
.0047	-.00347	-.00694	-.01042	-.01389	-.01736	-.03472
.0048	-.00340	-.00680	-.01020	-.01360	-.01700	-.03400
.0049	-.00333	-.00666	-.00999	-.01332	-.01665	-.03331
.0050	-.00326	-.00653	-.00979	-.01306	-.01632	-.03264
.0051	-.00320	-.00640	-.00960	-.01280	-.01600	-.03200
.0052	-.00314	-.00628	-.00942	-.01255	-.01569	-.03138
.0053	-.00308	-.00616	-.00924	-.01232	-.01540	-.03079
.0054	-.00302	-.00604	-.00907	-.01209	-.01511	-.03022
.0055	-.00297	-.00593	-.00890	-.01187	-.01484	-.02967
.0056	-.00291	-.00583	-.00874	-.01166	-.01457	-.02914
.0057	-.00286	-.00573	-.00859	-.01145	-.01432	-.02863
.0058	-.00281	-.00563	-.00844	-.01126	-.01407	-.02814
.0059	-.00277	-.00553	-.00830	-.01106	-.01383	-.02766
.0060	-.00272	-.00544	-.00816	-.01088	-.01360	-.02720

Mean JY price during the sample period: $.0037
Range of JY prices during the sample period: $.0033 - $.0056

Table 5.5a

Probability of Prediction Values for Japanese Yen -- One Day Hold

If the Price of JY is:	The Probability of Observing the Value of R_t to Give an $X Return is:					
	$50	$100	$150	$200	$250	$500
.0030	.2445	.0832	.0190	.0028	.0003	*
.0031	.2518	.0903	.0223	.0037	.0004	*
.0032	.2583	.0973	.0258	.0047	.0006	*
.0033	.2645	.1042	.0296	.0059	.0008	*
.0034	.2708	.1111	.0335	.0073	.0011	*
.0035	.2767	.1177	.0376	.0088	.0015	*
.0036	.2823	.1244	.0418	.0106	.0020	*
.0037	.2874	.1310	.0462	.0124	.0025	*
.0038	.2927	.1373	.0507	.0144	.0032	*
.0039	.2975	.1436	.0552	.0166	.0035	*
.0040	.3019	.1497	.0598	.0190	.0047	*
.0041	.3064	.1557	.0644	.0215	.0057	*
.0042	.3104	.1615	.0691	.0241	.0067	*
.0043	.3144	.1672	.0737	.0268	.0079	*
.0044	.3185	.1727	.0785	.0296	.0092	*
.0045	.3222	.1783	.0832	.0325	.0106	*
.0046	.3258	.1833	.0880	.0356	.0120	*
.0047	.3295	.1887	.0926	.0387	.0136	.00001
.0048	.3327	.1936	.0973	.0418	.0153	.00001
.0049	.3360	.1985	.1020	.0451	.0171	.00001
.0050	.3392	.2031	.1066	.0484	.0190	.00001
.0051	.3420	.2078	.1111	.0518	.0209	.00002
.0052	.3448	.2122	.1155	.0552	.0230	.00003
.0053	.3476	.2167	.1200	.0606	.0251	.00005
.0054	.3505	.2212	.1244	.0621	.0273	.00006
.0055	.3528	.2254	.1288	.0656	.0296	.00008
.0056	.3557	.2292	.1332	.0691	.0319	.0001
.0057	.3580	.2331	.1373	.0727	.0343	.0001
.0058	.3604	.2370	.1415	.0761	.0368	.0002
.0059	.3623	.2409	.1456	.0798	.0393	.0002
.0060	.3647	.2445	.1497	.0832	.0418	.0003

*Value is more than 4.5 Standard Deviations from the Mean.

Table 5.6

Prediction Values for Japanese Yen -- Six Day Hold

If the Price of JY is:	The Value of R_t to Give an $X Return Would Have to be:					
	$50	$100	$150	$200	$250	$500
.0030	.00459	.00918	.01377	.01836	.02295	.04590
.0031	.00444	.00888	.01333	.01777	.02221	.04442
.0032	.00430	.00861	.01291	.01721	.02151	.04303
.0033	.00417	.00835	.01252	.01669	.02025	.04173
.0034	.00405	.00810	.01215	.01620	.02002	.04050
.0035	.00393	.00787	.01180	.01574	.01967	.03934
.0036	.00382	.00765	.01147	.01530	.01912	.03825
.0037	.00372	.00744	.01116	.01489	.01861	.03721
.0038	.00362	.00725	.01087	.01449	.01812	.03624
.0039	.00353	.00706	.01059	.01412	.01765	.03531
.0040	.00344	.00688	.01033	.01377	.01721	.03443
.0041	.00336	.00672	.01008	.01343	.01679	.03358
.0042	.00328	.00656	.00984	.01311	.01639	.03278
.0043	.00320	.00640	.00961	.01281	.01601	.03202
.0044	.00313	.00626	.00939	.01252	.01565	.03129
.0045	.00306	.00612	.00918	.01224	.01530	.03060
.0046	.00299	.00599	.00898	.01197	.01497	.02993
.0047	.00293	.00586	.00879	.01173	.01465	.02930
.0048	.00287	.00574	.00861	.01147	.01434	.02860
.0049	.00281	.00562	.00843	.01124	.01405	.02810
.0050	.00275	.00551	.00826	.01102	.01377	.02754
.0051	.00270	.00540	.00810	.01080	.01350	.02700
.0052	.00265	.00530	.00794	.01059	.01324	.02648
.0053	.00260	.00520	.00779	.01039	.01299	.02598
.0054	.00255	.00510	.00765	.01020	.01275	.02550
.0055	.00250	.00501	.00751	.01001	.01252	.02504
.0056	.00246	.00492	.00738	.00984	.01229	.02459
.0057	.00242	.00483	.00725	.00966	.01208	.02416
.0058	.00237	.00475	.00712	.00950	.01187	.02374
.0059	.00233	.00467	.00700	.00934	.01167	.02334
.0060	.00229	.00459	.00688	.00918	.01147	.02295

Mean JY price during the sample period: $.0037
Range of JY prices during the sample period: $.0033 - $.0056

Table 5.6a

Probability of Prediction Values for Japanese Yen -- Six Day Hold

If the Price of JY is:	The Probability of Observing the Value of R_t to give an $X Return is:					
	$50	$100	$150	$200	$250	$500
.0030	.36461	.24437	.14953	.08309	.04175	.00027
.0031	.36887	.25153	.15738	.09010	.04697	.00040
.0032	.37286	.25807	.16513	.09716	.05238	.00059
.0033	.37658	.26444	.17254	.10407	.06336	.00082
.0034	.38002	.27065	.17976	.11091	.06555	.00113
.0035	.38347	.27642	.18676	.11761	.06898	.00150
.0036	.38664	.28200	.19352	.12428	.07466	.00196
.0037	.39953	.28737	.20000	.13073	.08024	.00251
.0038	.39243	.29227	.20618	.13725	.08589	.00314
.0039	.39504	.29721	.21225	.14347	.09158	.00387
.0040	.39765	.30193	.21798	.14953	.09716	.00472
.0041	.39998	.30615	.22357	.15557	.10272	.00566
.0042	.40231	.31040	.22902	.16141	.10822	.00672
.0043	.40465	.31467	.23431	.16701	.11364	.00787
.0044	.40670	.31843	.23943	.17254	.11895	.00915
.0045	.40875	.32221	.24437	.17798	.12428	.01051
.0046	.41080	.32573	.24913	.18334	.12946	.01200
.0047	.41256	.32927	.25370	.18839	.13462	.01356
.0048	.41432	.33255	.25807	.19352	.13975	.01525
.0049	.41609	.33584	.26247	.19831	.14467	.01704
.0050	.41785	.33888	.26667	.20297	.14953	.01890
.0051	.41933	.34192	.27065	.20769	.15432	.02087
.0052	.42080	.34469	.27466	.21225	.15902	.02291
.0053	.42227	.34747	.27844	.21665	.16363	.02504
.0054	.42375	.35026	.28200	.22088	.16814	.02724
.0055	.42523	.35278	.28557	.22515	.17254	.02949
.0056	.42641	.35530	.28891	.22902	.17700	.03184
.0057	.42759	.35783	.29227	.23315	.18114	.03423
.0058	.42907	.36009	.29565	.23686	.18535	.03670
.0059	.43026	.36235	.29878	.24060	.18941	.03919
.0060	.43144	.36461	.30193	.24437	.19353	.04175

Table 5.7

Prediction Values for Swiss Francs -- One Day Hold

If the Price of SF is:	The Value of R_t to Give an $X Return Would Have to be:					
	$50	$100	$150	$200	$250	$500
.35	.0086	.0172	.0258	.0344	.0431	.0861
.36	.0084	.0167	.0251	.0335	.0419	.0837
.37	.0081	.0163	.0244	.0326	.0407	.0815
.38	.0079	.0159	.0238	.0317	.0397	.0793
.39	.0077	.0155	.0232	.0309	.0386	.0773
.40	.0075	.0151	.0226	.0301	.0377	.0754
.41	.0074	.0147	.0221	.0294	.0368	.0735
.42	.0072	.0144	.0215	.0287	.0359	.0718
.43	.0070	.0140	.0210	.0280	.0351	.0701
.44	.0069	.0137	.0206	.0274	.0343	.0685
.45	.0067	.0134	.0201	.0268	.0335	.0670
.46	.0066	.0131	.0197	.0262	.0328	.0655
.47	.0064	.0128	.0192	.0257	.0321	.0641
.48	.0063	.0126	.0188	.0251	.0314	.0628
.49	.0062	.0123	.0185	.0246	.0308	.0615
.50	.0060	.0121	.0181	.0241	.0301	.0603
.51	.0059	.0118	.0177	.0236	.0296	.0591
.52	.0058	.0116	.0174	.0232	.0290	.0580
.53	.0057	.0114	.0171	.0227	.0284	.0569
.54	.0056	.0112	.0167	.0223	.0279	.0558
.55	.0055	.0110	.0164	.0219	.0274	.0548
.56	.0054	.0108	.0161	.0215	.0269	.0538
.57	.0053	.0106	.0159	.0212	.0264	.0539
.58	.0052	.0104	.0156	.0208	.0260	.0520
.59	.0051	.0102	.0153	.0204	.0255	.0511
.60	.0050	.0100	.0151	.0201	.0251	.0502
.61	.0049	.0099	.0148	.0198	.0247	.0494
.62	.0049	.0097	.0146	.0194	.0243	.0486
.63	.0048	.0096	.0144	.0191	.0239	.0478
.64	.0047	.0094	.0141	.0188	.0235	.0471
.65	.0046	.0093	.0139	.0185	.0232	.0464

Table 5.7a

Probability of Prediction Values for Swiss Francs -- One Day Hold

If the Price of SF is:	The Probability of Observing the Value of R_t to Give an $X Return is:					
	$50	$100	$150	$200	$250	$500
.35	.0927	.0040	.00004	*	*	*
.36	.0979	.0051	.00006	*	*	*
.37	.1061	.0060	.00009	*	*	*
.38	.1119	.0072	.0001	*	*	*
.39	.1179	.0085	.0002	*	*	*
.40	.1241	.0100	.0003	*	*	*
.41	.1272	.0118	.0003	*	*	*
.42	.1338	.0133	.0005	.000005	*	*
.43	.1405	.0155	.0006	.00001	*	*
.44	.1440	.0174	.0008	.00001	*	*
.45	.1511	.0195	.0010	.00002	*	*
.46	.1547	.0218	.0012	.00003	*	*
.47	.1622	.0244	.0016	.00004	*	*
.48	.1660	.0262	.0019	.00006	*	*
.49	.1699	.0291	.0022	.00008	*	*
.50	.1778	.0312	.0027	.0001	*	*
.51	.1818	.0346	.0032	.0001	*	*
.52	.1859	.0370	.0037	.0002	.000004	*
.53	.1900	.0396	.0042	.0002	.00001	*
.54	.1943	.0423	.0051	.0003	.00001	*
.55	.1985	.0451	.0058	.0004	.00002	*
.56	.2028	.0481	.0066	.0005	.00002	*
.57	.2072	.0513	.0072	.0005	.00002	*
.58	.2116	.0546	.0081	.0007	.00003	*
.59	.2161	.0581	.0092	.0008	.00004	*
.60	.2207	.0618	.0100	.0010	.00006	*
.61	.2253	.0637	.0113	.0011	.00007	*
.62	.2253	.0676	.0123	.0014	.00009	*
.63	.2299	.0697	.0133	.0016	.0001	*
.64	.2346	.0739	.0150	.0019	.0001	*
.65	.2394	.0761	.0162	.0022	.0002	*

* Value is more than 4.5 Standard Deviations from the Mean.

markets are assumed to be normally distributed in the long run. The unconditional mean of this distribution is given by

$$(3) \quad E(R_i) = \alpha_i + \beta_i E(R_i)$$

which is equal to

$$(4) \quad E(R_i) = \frac{\alpha_i}{1 - \beta_i}$$

where

$E(R_i)$ -- the expected return in currency futures market i.

α_i -- the intercept term of currency i.

β_i -- the regression coefficient of currency i.

Therefore, if α is zero the mean of the long run distribution is zero. Note from tables 4.19, 4.20, and 4.21 the intercept term, α is never significantly different from zero. Thus, the mean of the long run distribution of returns in the currency futures markets examined in this study is not different from zero. The variance of this distribution is given by

$$(5) \quad V(R_i) = \beta_i^2 V(R_i) + V(\varepsilon_i)$$

which is equal to

$$(6) \quad V(R_i) = \frac{V(\varepsilon_i)}{1 - \beta_i^2}$$

where

$V(R_i)$ -- the variance of the return in currency futures market i.

$V(\varepsilon_i)$ -- the square of the standard error of the estimate for currency i.

β_i^2 -- the square of the regression coefficient for currency i.

After the mean and variance of the long run distribution is calculated the probability of observing a particular return is calculated in this manner. First,

$$(7) \quad \frac{R_i^* - E(R_i)}{V(R_i)^{1/2}} = Z$$

where

R_i^* -- the return in currency futures market i necessary to predict an \$x return.

$E(R_i)$ -- the expected long run return in currency futures market i: which, based upon the results of tables 4.19, 4.20, and 4.21, is not different from zero.

$V(R_i)^{1/2}$ -- the standard deviation of the return to currency futures market i.

Z -- a measure of how many standard deviations from the mean R_i^* lies.

Note that the distribution of long run returns has now been transformed into a standard normal distribution having a mean of zero and a unit variance. After a Z is computed for an R_i^* the probability of observing a value that exceeds this Z value is shown by Figure 5-1.

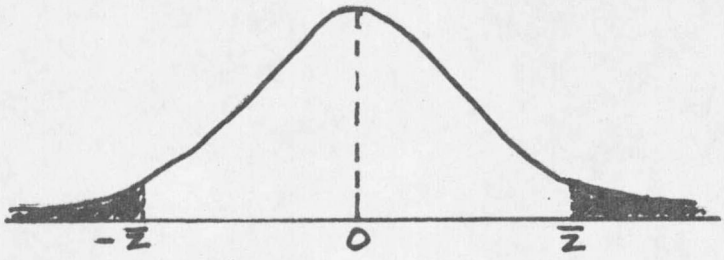


Figure 5-1. Standard Normal Distribution

The probability of observing a Z less than some $-\overline{Z}$ or of observing a Z greater than some $\overline{Z}$ is shown by the shaded area in Figure 5-1.

Note that this prediction model can be used by the participant to open either a long or short position. If the previous return was negative and of a certain magnitude, a negative return is predicted for the next time period. The participant would then sell short. If the previous return was positive and of a certain magnitude, a positive return is predicted for the next time period. The participant would then buy, i.e. open a long position. The above strategy holds for a positive value of the estimated coefficient: a negative value of the estimated coefficient would use a strategy opposite of the positive coefficient strategy.

The decision rule used to invest is: If the price of the currency is between any two values on the tables and if the previous time period's return exceeds the return necessary to predict a gross

gain of a certain amount, a position will be opened. For example, if the price of British pounds is between $2.00 and $2.01 the investor will open a long position if the previous period's return was greater than .0032 and will open a short position if the previous period's return was less than -.0032. It is possible to construct many different strategies from the table based upon how much of a gross gain the investor wants and the value of the return necessary to open a position. In the following example, two different strategies will be used. The first will open a position if the previous period's return falls within the values corresponding to the gross gain column of $50 or if the previous period's return exceeds the largest value. The position is assumed to be closed out at the start of the next time period. The second will open a position based upon the values in the $100 column and close it in the same manner at the $50 gain strategy. Note that these strategies are similar to filter rules in that a minimum price movement must occur before a position is opened. However, these strategies assume that the position is closed the next trading day regardless of how the price moves; whereas a filter rule specifies the price must move a specified amount before the position is closed. Both strategies will be compared to a buy and hold and a sell and hold strategy for control purposes. The data used is March 1979 futures prices in the

various currencies from December 19, 1978 to March 19, 1979: a time period that lies outside of the sample time period used for the estimation of regression coefficients. The results are presented in tables 5.8 to 5.13. Table 5.14 shows the composite results of the various strategies.

During the time period the prediction models were tested, it appears that prices in these markets were falling. This is shown by the success of the sell-and-hold strategy and by the failure of the buy-and-hold strategy. The sell-and-hold strategy netted the greatest return, the buy-and-hold strategy netted the smallest return, and the two prediction strategies were in between. The commission charge ($50 a round turn), or transactions cost, was sufficient to make the $50 gain strategy a negative net strategy. It must be noted that these transactions costs could be reduced if the contract position was held longer than the assumed one time period. However, as previously stated, there are many different strategies that could be constructed: with the two tested being conservative strategies with respect to exposure.

The opportunity cost of capital figure did not affect the outcomes of the $50 gain and $100 gain strategies as much as the transactions costs did. The buy-and-hold and sell-and-hold strategies were affected more by the opportunity costs of capital than by

Table 5.8

British Pounds -- Twenty Day Hold

Strategy	Number of Trades	Shorts	Longs	Trades Resulting in Gains	Trades Resulting in Losses	Dollar Amount Gained	Dollar Amount Lost	Commission	Opp. Cost of Capital	Net result of Strategy
Buy and Hold	1	0	1	0	0	300.00	-0-	50	35.63	214.37
Sell and Hold	1	1	0	0	1	-0-	300.00	50	35.63	(385.63)
$50 Gain	1	1	0	0	1	-0-	62.50	50	7.92	(120.52
$100 Gain	1	1	0	0	1	-0-	62.50	50	7.92	(120.52)

Table 5.9

German Marks -- One Day Hold

Strategy	Number of Trades	Shorts	Longs	Trades Resulting in Gains	Trades Resulting in Losses	Dollar Amount Gained	Dollar Amount Lost	Commission	Opp. Cost of Capital	Net result of Strategy
Buy and Hold	1	0	1	0	1	-0-	2362.50	50	47.50	(2460.00)
Sell and Hold	1	1	0	1	0	2362.50	-0-	50	47.50	2265.00
$50 Gain	2	1	1	2	0	437.50	-0-	100	.53	336.97
$100 Gain	0	0	0	0	0	-0-	-0-	0	-0-	-0-

Table 5.10

German Marks -- Six Day Hold

Strategy	Number of Trades	Shorts	Longs	Trades Resulting in Gains	Trades Resulting in Losses	Dollar Amount Gained	Dollar Amount Lost	Commission	Opp. Cost of Capital	Net result of Strategy
Buy and Hold	1	0	1	0	1	-0-	2362.50	50	47.50	(2460.00)
Sell and Hold	1	1	0	1	0	2362.50	-0-	50	47.50	2265.00
$50 Gain	8	5	3	2	6	2912.50	4300.00	400	25.23	(1812.73)
$100 Gain	7	5	2	2	5	2912.50	2987.50	350	22.17	(447.17)

Table 5.11

Japanese Yen -- One Day Hold

Strategy	Number of Trades	Shorts	Longs	Trades Resulting in Gains	Trades Resulting in Losses	Dollar Amount Gained	Dollar Amount Lost	Commission	Opp. Cost of Capital	Net result of Strategy
Buy and Hold	1	0	1	0	1	-0-	6062.50	50	47.50	(6160.00)
Sell and Hold	1	1	0	1	0	6062.50	-0-	50	47.50	5965.00
$50 Gain	27	8	19	11	15	3200.00	3687.50	1350	14.25	(1851.75)
$100 Gain	11	3	8	6	5	2487.50	1475.00	550	5.81	456.69

Table 5.12

Japanese Yen -- Six Day Hold

Strategy	Number of Trades	Shorts	Longs	Trades Resulting in Gains	Trades Resulting in Losses	Dollar Amount Gained	Dollar Amount Lost	Commission	Opp. Cost of Capital	Net result of Strategy
Buy and Hold	1	0	1	0	1	-0-	6062.50	50	47.50	(6160.00)
Sell and Hold	1	1	0	1	0	6062.50	-0-	50	47.50	5965.00
$50 Gain	10	8	2	6	3	5537.50	2450.00	500	31.67	(2555.83)
$100 Gain	8	6	2	4	3	3250.00	2450.00	500	25.33	274.67

Table 5.13

Swiss Francs -- One Day Hold

Strategy	Number of Trades	Shorts	Longs	Trades Resulting in Gains	Trades Resulting in Losses	Dollar Amount Gained	Dollar Amount Lost	Commission	Opp. Cost of Capital	Net result of Strategy
Buy and Hold	1	0	1	0	1	-0-	4387.50	50	71.25	(4508.75)
Sell and Hold	1	1	0	1	0	4387.50	-0-	50	71.25	4266.25
$50 Gain	20	12	8	9	9	3087.50	3537.00	1000	15.83	(1465.53)
$100 Gain	8	5	3	6	2	1312.50	325.00	400	6.33	581.17

Table 5.14

Summary of Strategies

Strategy	Number of Trades	Shorts	Longs	Trades Resulting in Gains	Trades Resulting in Losses	Dollar Amount Gained	Dollar Amount Lost	Commission	Opp. Cost of Capital	Net result of Strategy
Buy and Hold	6	0	6	1	5	300.00	21237.50	300	296.88	(21534.38)
Sell and Hold	6	6	0	5	1	21237.50	300.00	300	296.88	20340.62
$50 Gain	68	35	33	30	34	16562.00	14037.30	3400	95.43	(1970.63)
$100 Gain	35	20	15	18	16	9962.50	7300.00	1750	67.56	844.94

transactions costs. This can be explained by the nature of the two groups of strategies; with one group trading very often and the other group being exposed by a long period of time.

The opportunity cost of capital was computed in this manner: The required margins used were the margin requirements set by the Chicago Mercantile Exchange. This figure varies for different currencies, (contract sizes in parentheses): British pounds (25,000 BP) and Canadian dollars (100,000 CD), $1500; German marks (125,000 DM) and Japanese yen (12,500,000 JY), $2000; and Swiss francs (125,000 SF), $3000. The required margin was multiplied by an assumed interest rate of 9-1/2 percent -- giving an annual interest figure. This yearly interest was then allocated to the amount of time the margin was committed. For example, a buy-and-hold strategy during the prediction period would use the margin money for three months. Therefore, the interest foregone by investing in the futures market is given by the margin times the interest rate times the amount of time the margin was committed.

The margin requirements set by the Chicago Mercantile Exchange are the minimum amount that can be charged by a brokerage house. An individual speculator would have to pay a much higher margin -- $5000 versus the $1500 a large firm would have to pay in the British pound market, for example. A large firm trading many contracts has

another option available to it. The purpose of margin is to act as a performance bond. It is permissable to deposit Treasury Bills instead of cash. The interest paid on these Treasury Bills accrues to the original holder of the T-Bill -- the firm in this case. In this instance, the opportunity cost of capital figure is negligible because the firm is posting no cash for margin but instead an interest-bearing note. The opportunity cost of capital figure becomes meaningful if the firm can post no Treasury Bills and has to pay cash for margin. Also, from an individual speculator's point of view the opportunity cost of his margin is higher than shown in the tables; simply because a broker generally requires more margin from individual speculators than from firms.

The Multimarket Model

One other extension of the model which was not fully developed in this paper was the idea of multimarket models. In the previous models, the theory stated that all worldly events were accounted for by the market and the price of the currencies reflected these events. That is, inflation in West Germany would already be accounted for in the price of Japanese yen. The multimarket model tries to estimate the percentage change in the price of currency j from lagged values of the percentage change in the price of currency j and from lagged percentage changes in the price of other currencies.

Since events in the world offset all currencies these events are no longer assigned to be picked up by the error term but by other regressors.

This model was then estimated for each currency:

$$(3) \quad R_{j,t} = \alpha_j + \sum_{j=1}^{5} R_{j,t-1} + \eta_{j,t-1}$$

This model was run for all three holding periods, with the results in tables 5.15, 5.16, and 5.17 with the ratio of the independent variable to its standard error in parentheses.

Note that the estimates, unlike the previously estimated coefficients in the single market test, are efficient. The efficiency of the estimators in the single market equations is "questionable" because each equation was estimated separately and independently. This is because the mutual correlation of the disturbance terms is disregarded. It is reasonable to expect that the disturbance terms could be correlated because of the following: There are events taking place in the world of economy that could affect the prices, and thereby the returns, of the currencies in question and since these events could affect all the currencies simultaneously the disturbance terms across equating could be correlated. This problem could be eliminated by estimating these equations simultaneously. Also, the "questionableness" of the efficiency of these estimators is reduced if the sample size is "large". A special case of

Table 5.16

Estimated Multimarket Model
Holding Period -- Six Days
N = 260

Dependent (Mean)	Intercept	British Pounds	Canadian Dollars	German Marks	Japanese Yen	Swiss Francs	R^2
British Pounds (.000300)	-.0001306	-.04728	-.2657	.1006	.1045	.01667	.05572
	(-.0123)	(-.7158)	(1.937)	(1.197)	(1.499)	(.2602)	
Canadian Dollars (-.0004919)	-.0004278	-.0006874	.06519	-.001456	.01998	-,02891	.01086
	(-.0403)	(-.02253)	(1.029)	(-.3747)	(.6204)	(-.0768)	
German Marks (.001140)	.0005766	-.02405	-.2790	.1117	.2144	-.01060	.06832
	(.0542)	(-.2935)	(-1.640)	(1.071)	(2.478)**	(-.1334)	
Japanese Yen (.001469)	.0009908	.1390	-.1118	-.08034	.2756	.03372	.1033
	(.0932)	(2.002)*	(-.7760)	(-.9090)	(3.761)**	(.5008)	
Swiss Franks (.002136)	.001734	.1095	-.2506	.1442	(.2862)	-.1544	.05993
	(.1625)	(1.067)	(-1.177)	(1.104)	(2.643)***	(-.1552)	

* Significant at the .05 level
** Significant at the .02 level
*** Significant at the .01 level

Joint Test $F_{25,230} = \underline{9.6044}$

$F_{25,230}$ Critical = 1.52

Table 5.15

Estimated Multimarket Model
Holding Period -- One Day
N = 1609

Dependent (Mean)	Intercept	British Pounds	Canadian Dollars	German Marks	Japanese Yen	Swiss Francs	R^2
British Pounds (.0005606)	.00005336	.03644	-.05565	.01709	-.01215	-.01011	.002498
	(.0250)	(1.343	(-.9930)	(.5410)	(-.7688)	(-.3799)	
Canadian Dollars (-.0000821)	-.00008765	.002899	-.01606	.01192	.004310	.001304	.002124
	(-.0412)	(.2398)	(-.6434)	(.8474)	(.6122)	(.1100)	
German Marks (.0002181)	.0002032	.07001	.09658	-.01255	.02706	.04275	.01066
	(.0953)	(2.230)*	(1.490)	(-.3435)	(1.480)	(1.389)	
Japanese Yen (.0003871)	.0003093	.05556	-.03118	.1187	-.2754	.07097	.07838
	(.1448)	(1.307)	(-.3551)	(2.399)**	(-11.12)***	(1.702)	
Swiss Francs (.0003603)	.0003149	.08288	.08753	.1488	.05721	,007431	.03854
	(.1476)	(2.315)*	(1.184)	(3.573)***	(2,744)***	(.2117)	

* Significant at the .05 level
** Significant at the .02 level
*** Significant at the .01 level

Joint Test $F_{25,1579} = \underline{65.94}$

$F_{25,1579}$ Critical = 1.52

Table 5.17

Estimated Multimarket Model
Holding Period - Twenty Days
N = 76

Dependent (Mean)	Intercept	British Pounds	Canadian Dollars	German Marks	Japanese Yen	Swiss Francs	R^2
British Pounds (.001446)	.001322	.3510	-.1877	-.08403	.0007676	-.002049	.1222
	(.0308)	(2.732)***	(-.8368)	(-.5454)	(.006810)	(-.1513)	
Canadian Dollars (-.001613)	-.001859	-.1303	-.08593	-.03375	.01055	-.002816	.05334
	(-.0536)	(-1.911)	(-.7220)	(.4128)	(.1763)	(-.3918)	
German Marks (.003972)	.004602	.3511	-.07375	.03152	.0005474	-.1293	.04923
	(.1320)	(1.768)	(-.2127)	(.1324)	(.003142)	(-.6179)	
Japanese Yen (.004545)	.004865	.4661	-.003377	-.3614	-.05514	.1491	.1045
	(.1397)	(2.534(**	(-.01051)	(-1.638)	(-.3416)	(.7685)	
Swiss Francs (.007563)	.007786	.4209	.2103	-.4375	-.08063	.2611	.06644
	(.2229)	(1.806)	(.5167)	(-1.565)	(-.3942)	(1.062)	

* Significant at the .05 level
** Significant at the .02 level
*** Significant at the .01 level

Joint Test $F_{25,46} = 1.9936$

$F_{25,46}$ Critical = 1.79

simultaneous equation estimation arises when all of the independent variables are the same in each question. This is the case with (3). In this special case the estimates from a simultaneous estimation are the same as the ordinary least squares estimates from estimating each equation separately and independently.

The results in the multimarket tests were similar to those in the single market tests. The same pattern of time period significance was observed with six variables being significant in the one day hold, four in the six day hold, and two in the twenty day hold. The R^2 was "low" in these tests, with one being over .125.

It is interesting to contrast two of the currencies in the multimarket tests. The Canadian dollar did not have a single significant variable when it was an independent variable trying to explain the variance of some other currency. Further, no other currency, in any of the time periods, could explain any variance in the returns to Canadian Dollars. The Japanese yen was significant a total of five times as an independent variable -- half of the total number of significant variables. In three other cases, other currencies were able to explain some of the variance in Japanese yen. This has the possible implication of using the Japanese yen to predict other currency movements.

Chapter 6

SUMMARY, CONCLUSIONS, AND HEDGING IMPLICATIONS

Summary

A firm in the United States that does business internationally must realize the exchange rates between the dollar and other currencies are constantly changing. This has at least one clear implication -- the results realized from forward contracts to purchase goods or services from foreign countries may differ from their intended purpose. This is illustrated in Chapter 2. The reason the realized result of the forward contract differed from the intended result of the forward contract was a change in the exchange rate. The process by which the exchange rate is determined and how it changes is then described in Chapter 2.

The firm can reduce the risk of adverse price fluctuations via a market where future foreign exchange rates are bought and sold -- a futures market. The futures market in international currencies is the International Monetary Market of the Chicago Mercantile Exchange. As in other futures markets, a firm can "lock-in" a price (an exchange rate) by purchasing the exchange rate today. This process is known as a long hedge. The extent to which the hedge can reduce risk depends upon the variation in the basis versus variation in the spot price of the currency.

Suppose a firm places a hedge and the price (exchange rate) did not move such that the firm was protected by the hedge, but in fact would have been better of financially if it had not placed the hedge. Could the firm have predicted this price movement? This, then, is the objective of the study. Can the firm predict short run exchange rate movements so as to place hedges at the most favorable time?

Being able to place hedges at the most favorable time is predicted upon the ability to forecast short run exchange rate movements. As in the case of most auction markets, the futures market in foreign currencies is thought to be an efficient market. In short, this is "generally" understood to mean that "all available" information concerning a price in the future is "fully reflected" in the price quoted at any time for the price in the future. The statement that the current price of a futures contract "fully reflects" all market information implies successive price changes, or successive returns, are independent. Many different opinions on why a firm should hedge as well as the predictability of futures market prices were examined.

Tests of efficient markets concern themselves with testing how information affects the market. This test of information is broken down into three types: weak-form tests, semi-strong form tests, and strong form tests. The test used in this study is the weak form test -- where the information set is the series of past prices.

The weak form test says that markets are efficient enough to make the research of past prices a worthless way of trying to determine future prices.

Further, tests of market efficiency are concerned with a general equilibrium market model. It is against this model that alternative models of the market are tested.

The general equilibrium market model can take many specific forms, however, there are four general specifications of the general equilibrium market models. All of these concern themselves with the returns to a market. The first form says that the returns in the market are some constant rate, the second states that returns are zero, the third says returns conform to the Sharpe-Litner model, and the fourth says the returns conform to some other risk-return relationship. The general equilibrium market model tested against in this study is the one that says returns in the market are constant.

There are many different alternative models that could be constructed to test the maintained model that returns are constant. The model used is an autoregressive model that is tested for three different time periods - one day, six day, and twenty day. That is the returns over one day are calculated and regressed on previous returns over one day. Similar runs were made for six day and twenty day holding periods.

The results of the various runs are presented in Chapter 4. Also, two different model specifications were tested and the results of each model are presented. Both models showed the same basic results, but the percentage change return model was deemed superior to the first-difference model.

Conclusions

The results of the models tested showed two things. First, there was more statistical dependence in the shorter time period than in the longer time periods. The return from last time period explained more of the variance in this time period if the time period was short. Twenty day time periods, with one exception, did not show much statistical relationship. There was more in the six day periods and there was the most in the one day time periods. Secondly, the higher the order of the lag the less it explained the additional variance of the dependent variable. The lags from many time periods ago were not significant, in general. However, lags that were first or second order appeared significant. These lags did explain some of the variance in the dependent variable. However, the R^2 in the various runs was never higher than .33 and in most cases the R^2 ranged from .02 to .20. Even though some of these lags had significant t-values they did not explain much of the variance of the dependent variable.

The fact that some statistical dependence exists contradicts the theory that there should be no statistical dependence. The value of this dependence to a market participant was the subject of Chapter 5. In this chapter some prediction models were used to try to exploit the statistical dependence. The results of this were negative. The statistical dependence could not be used to contruct prediction models that would yield significant returns. Also, a multimarket model was specified and tested. The results of this model were consistant with the single market model results in that there was more statistical dependence in the one day hold that in the six day hold and more in the six day hold than in the twenty day hold.

It must be kept in mind that many different strategies could be constructed from the prediction models and even more could be constructed from the data used in this study. After trying many different prediction models, al least one would be found that would yield significant profits.

In some sense, the general model of market equilibrium that states returns through time are zero in the currency futures market must be rejected. This model implies that no strategy could consistently yield positive returns. However, the $100 gain prediction model did just that. But, in another sense, the general model of

market equilbrium that states returns through time are zero in the currency futures market must not be rejected.

In the strict sense, the $100 gain model did not yield positive returns across every currency tested in this study. Also, the $50 gain strategy did not yield consistent gains across currencies and looking at the sum total of the $50 gain strategy it netted a negative amount.

In order to not reject the maintained hypothesis that returns are zero in the currency futures market, models of many variations must be tested. In order to reject this model, a strategy must be found that will consistently yield positive returns. In this study, neither of these conditions were met. Certainly an infinite number of strategies were not tested, and, of the ones tested, there was not one that consistently yielded positive returns. The concrete conclusion is that some statistical dependence was found in the series of past returns in the various currency futures markets tested. This statistical dependence was found using autocorrelation coefficients, that is, laggec values of some variable. In this case the lagged variable was the percentage change in the price of a currency futures market from time t-1 to time t. The majority of the dependence was found in the first or second lag and in the one day holding period. Whether or not this statistical dependence can be exploited into

positive returns is the unresolved question arising from this research.

Implications to Hedging Strategies

Gruen (1960) pointed out that if a futues market is to be useful there must be a relationship between the futures price and cash price. In order to determine if a hedge can be useful, the degree of basis change must be compared to the degree of cash price change. Usually, this is done in this method:

(A) Measure the variability of the price of the cash commodity over a period of time;

(B) Measure the variability of the basis over the same period of time; and

(C) If the variability of the basis is less than the variability of the cash price, an effective hedge can be placed in that commodity.

Tables 6.1 - 6.5 present these calculations for twenty-six contracts in five currencies. These calculations were made during the last three months of the contract. The contracts marked by an asterisk (*) have basis variability greater than spot price variability. The cases numbered thirteen, or ten percent of the total cases. In these instances, a hedge would not have reduced the risk of price variability because the basis variability was greater. Note, however,

Table 6.1

British Pounds -- Standard Deviation of Basis and Spot Prices

Contract	Basis	Spot	N
Sept 1972	.0105	.0349	64
Dec 1972	.0060	.0367	62
Mar 1973	.0128	.0542	61
June 1973	.0089	.0412	63
Sept 1973	.0073	.0550	63
Dec 1973	.0091	.0434	64
Mar 1974	.0161	.0487	61
June 1974	.0184	.0338	63
Sept 1974	.0374	.0523	63
Dec 1974	.0066	.0094	63
Mar 1975	.0185	.0320	62
June 1975	.0115	.0414	63
Sept 1975	.0083	.0548	63
Dec 1975	.0065	.0200	64
Mar 1976	.0256	.0390	61
June 1976	.0081	.0555	63
Sept 1976	.0112	.0123	63
Dec 1976	.0145	.0371	63
Mar 1977	.0132	.0138	62
*June 1977	.0072	.0038	63
Sept 1977	.0060	.0113	68
Dec 1977	.0034	.0364	63
Mar 1978	.0044	.0224	57
June 1978	.0042	.0308	69
Sept 1978	.0039	.0379	63
Dec 1978	.0074	.0349	62

* Basis standard deviation exceeds spot standard deviation

Table 6,2

Canadian Dollars -- Standard Deviation of Basis and Spot Prices

Contract	Basis	Spot	N
Sept 1972	.0007	.0024	64
Dec 1972	.0005	.0067	62
Mar 1973	.0013	.0042	61
*June 1973	.0106	.0103	63
Sept 1973	.0138	.0151	63
Dec 1973	.0023	.0047	64
Mar 1974	.0018	.0107	61
June 1974	.0017	.0055	63
Sept 1974	.0018	.0064	63
Dec 1974	.0022	.0035	63
Mar 1975	.0018	.0051	62
June 1975	.0023	.0109	63
Sept 1975	.0012	.0040	63
Dec 1975	.0024	.0064	64
Mar 1976	.0030	.0110	61
*June 1976	.0038	.0036	63
Sept 1976	.0025	.0075	63
Dec 1976	.0052	.0210	63
Mar 1977	.0028	.0146	62
June 1977	.0024	.0036	63
Sept 1977	.0018	.0068	68
Dec 1977	.0008	.0013	63
Mar 1978	.0009	.0082	57
June 1978	.0013	.0088	69
Sept 1978	.0040	.0108	63
Dec 1978	.0009	.0049	62

* Basis standard deviation exceeds spot standard deviation

Table 6.3

German Marks -- Standard Deviation of Basis and Spot Prices

Contract	Basis	Spot	N
Sept 1972	.0012	.0018	64
*Dec 1972	.0010	.0009	62
Mar 1973	.0030	.0190	61
June 1973	.0028	.0118	63
Sept 1973	.0038	.0132	63
Dec 1973	.0022	.0163	64
Mar 1974	.0016	.0096	61
June 1974	.0020	.0082	63
Sept 1974	.0016	.0074	63
Dec 1974	.0012	.0104	63
Mar 1975	.0014	.0084	62
June 1975	.0010	.0045	63
Sept 1975	.0027	.0149	63
Dec 1975	.0013	.0049	64
Mar 1976	.0009	.0039	61
June 1976	.0126	.0131	63
Sept 1976	.0004	.0043	63
Dec 1976	.0007	.0047	63
Mar 1977	.0004	.0039	62
June 1977	.0004	.0029	63
Sept 1977	.0367	.0379	68
Dec 1977	.0014	.0119	63
Mar 1978	.0025	.0101	57
June 1978	.0038	.0098	69
Sept 1978	.0028	.0099	63
Dec 1978	.0046	.0162	62

* Basis standard deviation exceeds spot standard deviation

Table 6.4

Japanese Yen -- Standard Deviation of Basis and Spot Prices

Contract	Basis	Spot	N
*Sept 1972	.000047	.000012	64
*Dec 1972	.000041	.000005	62
Mar 1973	.000041	.000239	61
*June 1973	.000037	.000017	63
*Sept 1973	.000078	.000013	63
Dec 1973	.000032	.000091	64
Mar 1974	.000069	.000095	61
*June 1974	.000074	.000031	63
Sept 1974	.000010	.000086	63
Dec 1974	.000011	.000016	63
Mar 1975	.000017	.000071	62
June 1975	.000007	.000019	63
Sept 1975	,000005	.000017	63
*Dec 1975	.000021	.000020	64
Mar 1976	.000009	.000023	61
*June 1976	.000017	.000011	63
Sept 1976	.000005	.000046	63
Dec 1976	.000004	.000044	63
Mar 1977	.000006	.000056	62
June 1977	.000013	.000034	63
Sept 1977	.000014	.000035	68
Dec 1977	.000014	.000138	63
Mar 1978	.000018	.000038	57
June 1978	.000025	.000093	69
Sept 1978	.000051	.000194	63
Dec 1978	.000387	.000407	62

* Basis standard deviation exceeds spot standard deviation

Table 6.5

Swiss Francs -- Standard Deviation of Basis and Spot Prices

Contract	Basis	Spot	N
Sept 1972	.00076	.00113	64
*Dec 1972	.00091	.00070	62
Mar 1973	.06451	.06936	61
June 1973	.00154	.00748	63
Sept 1973	.00367	.01194	63
Dec 1973	.00158	.00871	64
Mar 1974	.00169	.01047	61
June 1974	.00156	.00734	63
Sept 1974	.00135	.00352	63
Dec 1974	.00267	.01549	63
Mar 1975	.00281	.00875	62
June 1975	.00093	.00556	63
Sept 1975	.00083	.01111	63
*Dec 1975	.05306	.05276	64
Mar 1976	.00238	.00319	61
June 1976	.00123	.00582	63
Sept 1976	.00180	.00214	63
Dec 1976	.00139	.00241	63
Mar 1977	.00124	.00627	62
June 1977	.00265	.00393	63
Sept 1977	.00099	.00581	68
Dec 1977	.00194	.01792	63
Mar 1978	.00404	.01824	57
June 1978	.00318	.01820	69
Sept 1978	.00618	.03271	63
Dec 1978	.00812	.00349	62

* Basis standard deviation exceeds spot standard deviation

that most of these instances occur during the early years of the IMM when volume was very low. This low volume resulted in a very stable futures price -- hence, a small variance.

Another implication to hedging in the currency futures market also has to do with the basis.

Table 6.6 shows the average basis near the end of a currency contract. Assume that a firm, such as National Blivit Company, has agreed to import some goods sometime in the delivery month but before the expiration date of the contract. If the firm has decided to hedge the currency, the price the firm has "locked in" is the futures price on the day the hedge was placed minus the expected basis. If, at any time the firm can contract a price in the cash market that is "better" than the "lockin-in" price, the firm could close its future position and take a cash position. For example, assume that National Blivit Company is going to import some goods from West Germany sometime during the first week of June. At the time the agreement was made, assume that the June futures price is .5400. The expected basis is .0005; therefore the firm has "locked-in" a price of .5395. Note that in this example the "lock-in" price is a price the firm can buy D-marks. If the firm sees the cash and futures price for D-marks fall below this "locked-in" price, it could close its futures position. If the cash price rises again to

Table 6.6

Average Basis During Delivery Month -- 1972-1978

Currency	Month			
	March	June	September	December
British Pound	-.0052	-.0023	.0034	-.0011
Canadian Dollar	-.00003	-.0040	.0001	-.0002
German Mark	.00002	.0005	-.0001	-.00001
Japanese Yen	.00004	-.000001	.0000	.0000
Swiss Franc	.0007	.0004	.00004	.0003

some level the firm sets, a futues position can again be opened. However, when the firm has closed its futures position, it again becomes a speculator in the currency market. Also, the firm might watch the forward contract market if the firm is more conservative. If the price in the forward market reaches a "favorable" level, then the firm can close its futues position and buy its exchange rate on the forward market. However, this leads to less flexibility for the firm than by dealing in the futues market and watching basis movements, which is a more risk-taking position. The important thing is that once a hdge is placed it should not be completely ignored. That is, conditions change in the market that would make it undesirable to be hedged. For example, if prices are falling, the firm that has a long position in the futures market might be better off unhedged. But, this again introduces some sort of speculation or risk taking. An importing firm can successfully reduce the risk of adverse price movements via the futures market. When a firm sees a price for a foreign currency in the futures market that allows the firm a profit on the international transaction, the firm can hedge that price. When the firm starts lifting and placing hedges to take advantage of price movements, it must realize that it is taking more risk and speculating on future price movements.

Suggestions for Further Research

The object of this study was to determine if futures prices in currency futures markets are predictable. The conclusion was that, in general, they were not. The implications to hedgers are: (1) trying to place hedges based upon the ability to predict futures prices will not work, and (2) successful hedges can still be placed even though futues prices are not predictable.

This research used the information set of past prices to try to predict future prices in the futures market. Perhaps other information sets could be tested. For example, in this study such economic variables as relative inflation rates, trade balances, and rates of money supply changes were assumed to be reflected in the futures price. Perhaps these economic variables could be tested as independent variables that determine futures prices. Further, this study looked at relatively short run futures price changes. A longer time horizon could be tested, for example, the length of the contract for one year or longer.

A model using lagged returns of several currencies to predict returns of a specific currency could be developed. Clearly, many different types of models could be tested using different data sets, independent variables, assumptions and functional forms.

Certainly, one point above could be expanded. This is the fact that successful hedges can still be placed despite the fact that

futures market prices are, in general, unpredictable. Basis movements in currency futures markets could be modeled. From basis movements heding strategies can be constructed and simulated. Further, the concept of using a combination of futures markets and forward markets in a hedging strategy could be examined.

APPENDIX I

Table I-1
Summary of Contract Specifications

Specification	Currency				
	British Pounds	Canadian Dollars	German Marks	Japanese Yen	Swiss Francs
Ticker Symbol	BP	CD	DM	JY	SF
Contract Size	25,000 BP	100,000 CD	125,000 DM	12,500,000 JY	125,000 SF
Approx. U.S. Dollars	$51,500[a]	$86,000[a]	$65,000[a]	$57,000[a]	$73,000[a]
Minimum Fluctuation	.0005 ($12.50)	.0001 ($10)	.0001 ($12.50)	.000001 ($12.50)	.0001 ($12.50)
Daily Limit (Normal)	.0500 ($1,250)	.0075 ($750)	.0060 ($750)	.000060 ($750)	.0060 ($750)
Commissions	*	*	*	*	*
Margins	*	*	*	*	*

All currency contracts' delivery months are: March, June, September, December

[a] As of May 30, 1979

* Consult your broker

Source: International Monetary Market Yearbook 1977-1978.

Table I-2
Volume of British Pound Futures Market

	Number of Contracts Traded						
Month	1978	1977	1976	1975	1974	1973	1972
Janauary	15,576	2,239	599	1,218	3,900	5,441	---
February	11,360	2,155	434	313	978	2,728	---
March	17,360	2,561	2,143	508	698	1,087	---
April	22,667	1,658	2,679	789	391	981	---
May	22,983	1,283	2,187	1,094	476	2,143	1,271
June	21,956	1,851	2,686	2,456	775	6,385	1,655
July	---	3,598	1,279	1,778	442	1,774	2,710
August	---	6,059	984	1,690	970	490	1,104
September	---	7,997	4,986	1,864	1,692	579	1,876
October	---	17,712	6,063	1,274	362	1,026	1,948
November	---	17,808	5,513	660	1,158	368	911
December	---	13,870	3,912	1,371	2,191	8,410	3,312
TOTAL	111,902	78,701	33,465	15,015	14,033	31,412	14,787

Source: International Monetary Market Yearbook 1977-1978

Table I-3
Volume of Canadian Dollar Futures Market

	Number of Contracts Traded						
Month	1978	1977	1976	1975	1974	1973	1972
Janauary	7,791	11,769	297	1,568	831	8,529	---
February	7,083	18,946	248	16	314	2,565	---
March	8,984	34,170	381	10	238	1,155	---
April	17,470	10,584	492	113	202	832	---
May	14,511	3,248	1,499	106	123	2,621	7,074
June	---	13,424	1,001	93	539	5,398	9,672
July	---	8,528	607	73	75	4,707	3,334
August	---	11,447	837	42	49	1,322	4,450
September	---	6,449	1,032	77	188	688	1,306
October	---	19,466	1,243	92	250	11	919
November	---	9,167	3,333	186	172	26	3,462
December	---	13,941	7,098	301	718	1,327	8,587
TOTAL	55,839	161,139	17,068	2,677	3,699	29,161	38,804

Source: International Monetary Market Yearbook 1977-1978.

Table I-4
Volume of German Mark Futures Market

	Number of Contracts Traded						
Month	1978	1977	1976	1975	1974	1973	1972
Janauary	12,864	9,646	2,921	7,470	12,839	4,680	---
February	14,410	7,167	3,522	3,628	676	2,488	---
March	22,901	6,764	4,481	5,306	1,010	3,195	---
April	28,721	9,008	2,317	4,172	1,547	1,494	---
May	32,464	8,691	3,070	3,143	2,892	2,258	2,906
June	24,707	6,551	2,451	2,425	2,667	1,055	3,785
July	---	18,441	1,495	4,292	2,398	989	1,237
August	---	11,416	3,373	3,527	3,808	2,149	2,299
September	---	8,097	4,269	4,335	2,300	5,234	1,004
October	---	14,922	8,304	5,265	3,323	1,384	1,114
November	---	16,434	3,705	5,382	2,804	24,388	1,094
December	---	17,231	4,979	5,848	13,183	27,810	5,879
TOTAL	136,067	134,368	44,887	54,793	49,447	77,264	19,318

Source: International Monetary Market Yearbook 1977-1978.

Table I-5
Volume of Japanese Yen Futures Market

	Number of Contracts Traded						
Month	1978	1977	1976	1975	1974	1973	1972
Janauary	11,634	216	14	629	1,951	17,196	---
February	18,751	443	198	153	172	8,410	---
March	35,098	3,107	38	174	173	20,487	---
April	22,242	4,149	165	82	238	9,463	---
May	25,479	1,142	22	27	84	5,377	486
June	38,290	5,006	75	40	842	21,767	1,273
July	---	4,757	109	12	668	6,499	147
August	---	3,378	158	70	491	12,035	3,900
September	---	5,470	157	258	900	3,993	1,813
October	---	28,387	138	228	80	15,050	4,063
November	---	13,921	157	28	353	3,422	9,571
December	---	12,285	218	89	1,287	1,954	22,736
TOTAL	151,494	82,261	1,449	1,790	7,239	125,653	42,989

Source: International Monetary Market Yearbook 1977-1978.

Table I-6
Volume of Swiss Francs

	Number of Contracts Traded						
Month	1978	1977	1976	1975	1974	1973	1972
Janauary	18,992	3,301	2,972	8,474	3,309	4,152	---
February	23,486	4,864	2,223	3,482	2,181	949	---
March	23,985	8,733	3,467	5,686	3,018	3,729	---
April	22,242	8,057	2,377	5,462	3,661	762	---
May	27,776	4,160	4,099	7,443	5,978	2,920	984
June	24,603	4,457	5,607	3,656	3,686	1,686	2,641
July	---	5,845	3,519	9,086	4,133	767	2,010
August	---	8,939	2,411	6,254	1,881	1,080	1,275
September	---	9,629	2,582	6,617	1,537	315	4,409
October	---	14,992	3,514	6,758	2,373	1,444	1,572
November	---	13,215	2,104	3,179	3,664	3,316	1,458
December	---	20,776	2,371	3,836	7,084	893	3,372
TOTAL	141,084	106,968	37,246	69,933	42,505	22,013	17,721

Source: International Monetary Market Yearbook 1977-1978.

Table I-7
Volume of All Futures Markets -- CME and AMM

Month	Number of Contracts Traded						
	1978	1977	1976	1975	1974	1973	1972
January	583,327	461,105	521,782	446,630	454,319	561,918	---
February	699,337	391,485	409,231	348,098	384,202	539,925	---
March	---	545,667	461,650	379,634	448,720	642,770	---
April	---	652,306	536,745	445,883	442,672	447,543	---
May	---	617,824	481,508	523,336	500,440	435,446	357,953
June	---	585,198	526,983	573,178	379,724	407,001	413,907
July	---	482,667	470,518	550,351	464,971	457,249	336,416
August	---	502,380	400,270	477,258	397,494	564,167	391,084
September	---	426,765	413,438	525,828	330,591	337,165	384,118
October	---	453,310	505,354	563,267	458,355	463,294	371,008
November	---	470,600	429,055	439,046	360,269	405,720	360,464
December	---	472,257	400,761	486,252	355,855	361,094	457,176
TOTAL	1,282,664	6,061,565	5,557,295	5,758,761	4,977,612	5,623,292	3,072,116

Source: Chicago Mercantile Exchange Yearbook 1977-1978.

Table I-8
Volume of All Futures Markets -- IMM

	Number of Contracts Traded						
Month	1978	1977	1976	1975	1974	1973	1972
January	298,311	85,302	53,804	89,161	63,820	42,914	---
February	246,453	89,529	46,446	39,377	7,871	18,656	---
March	327,468	164,016	44,492	46,329	9,679	29,981	---
April	324,223	124,103	41,478	43,951	12,919	16,308	---
May	316,571	94,566	44,190	50,477	15,399	18,684	12,799
June	351,437	99,225	48,207	40,259	18,948	43,817	19,124
July	---	108,831	45,831	56,561	14,475	15,515	9,553
August	---	117,458	43,751	58,150	17,149	18,848	13,421
September	---	128,849	60,465	62,025	22,018	13,968	10,417
October	---	289,565	57,015	56,798	42,257	30,654	9,750
November	---	272,698	82,212	51,656	28,869	57,378	21,020
December	---	242,540	76,029	48,451	62,864	129,651	48,844
TOTAL	1,909,463	1,816,682	664,370	643,195	316,268	436,374	144,928

Source: International Monetary Market Yearbook 1977-1978.

Table I-9
IMM Volum As A Percent of CME and AMM Volume

Year	Percent
1978	N.A.
1977	.2997
1976	.1160
1975	.1117
1974	.0635
1973	.0776
1972	.0472

APPENDIX II

Table II-1

Return Specification -- Percentage Change

H_o: $\beta_{11} = \beta_{12} = \ldots = \beta_{15} = 0$

	Holding Period					
	1-Day		6-Day		20-Day	
Currency	F Calc.	F Crit.	F Calc.	F. Crit.	F Calc.	F Crit.
British Pounds	.67	2.21	.34	2.21	.39	2.45
Canadian Dollars	.53	2.21	1.05	2.21	1.22	2.45
German Marks	.48	2.21	.22	2.21	.41	2.45
Japanese Yen	.30	2.21	1.40	2.21	.86	2.45
Swiss Francs	.52	2.21	.29	2.21	.21	2.45

Table II-2
Return Specification -- First Difference
H_o: $\beta_{11} = \beta_{12} = \ldots = \beta_{15} = 0$

	Holding Period					
	1-Day		6-Day		20-Day	
Currency	F Calc.	F Crit.	F Calc.	F. Crit.	F Calc.	F Crit.
British Pounds	1.02	2.21	.45	2.21	.43	2.45
Canadian Dollars	.49	2.21	1.16	2.21	1.22	2.45
German Marks	.20	2.21	.16	2.21	.31	2.45
Japanese Yen	.40	2.21	2.88*	2.21	.98	2.45
Swiss Francs	1.58	2.21	.60	2.21	.11	2.45

* Reject H_o

Table II-3
Return Specification -- Percentage Change
H_o: $\beta_8 = \beta_9 = \ldots = \beta_{15} = 0$

	Holding Period					
	1-Day		6-Day		20-Day	
Currency	F Calc.	F Crit.	F Calc.	F. Crit.	F Calc.	F Crit.
British Pounds	1.33	1.94	.32	1.94	.87	2.18
Canadian Dollars	.52	1.94	.79	1.94	1.23	2.18
German Marks	2.35*	1.94	.23	1.94	.42	2.18
Japanese Yen	1.57	1.94	1.32	1.94	.55	2.18
Swiss Francs	1.05	1.94	.31	1.94	.22	2.18

* Reject H_o

Table II-4
Return Specification -- First Difference
H_o: $\beta_8 = \beta_9 = \ldots = \beta_{15} = 0$

	Holding Period					
	1-Day		6-Day		20-Day	
Currency	F Calc.	F Crit.	F Calc.	F. Crit.	F Calc.	F Crit.
British Pounds	1.66	1.94	.39	1.94	.89	2.18
Canadian Dollars	.47	1.94	.93	1.94	1.20	2.18
German Marks	1.85	1.94	.41	1.94	.35	2.18
Japanese Yen	1.87	1.94	2.45*	1.94	.63	2.18
Swiss Francs	1.89	1.94	.97	1.94	.19	2.18

* Reject H_o

Table II-5
Return Specification -- Percentage Change
H_o: $\beta_2 = \beta_3 = \ldots = \beta_{15} = 0$

	Holding Period					
	1-Day		6-Day		20-Day	
Currency	F Calc.	F Crit.	F Calc.	F. Crit.	F Calc.	F Crit.
British Pounds	.88	1.67	1.16	1.67	.64	1.92
Canadian Dollars	2.15*	1.67	.91	1.67	.97	1.92
German Marks	2.31*	1.67	.58	1.67	1.62	1.92
Japanese Yen	2.06*	1.67	.81	1.67	.58	1.92
Swiss Francs	1.62	1.67	1.25	1.67	.57	1.92

* Reject H_o

Table II-6
Return Specification -- First Difference
H_o: $\beta_2 = \beta_3 = \ldots = \beta_{15} = 0$

	Holding Period					
	1-Day		6-Day		20-Day	
Currency	F Calc.	F Crit.	F Calc.	F. Crit.	F Calc.	F Crit.
British Pounds	1.08	1.67	1.09	1.67	.77	1.92
Canadian Dollars	2.06*	1.67	.96	1.67	.99	1.92
German Marks	1.93*	1.67	.51	1.67	1.26	1.92
Japanese Yen	1.65	1.67	1.98*	1.67	.84	1.92
Swiss Francs	3.03*	1.67	3.10*	1.67	.57	1.92

* Reject H_o

Table II-7
Return Specification -- Percentage Change
H_o: $\beta_1 = \beta_2 = \ldots = \beta_{15} = 0$

	Holding Period					
	1-Day		6-Day		20-Day	
Currency	F Calc.	F Crit.	F Calc.	F. Crit.	F Calc.	F Crit.
British Pounds	.91	1.67	1.98	1.67	1.34	1.92
Canadian Dollars	2.05*	1.67	.90	1.67	.91	1.92
German Marks	2.48*	1.67	1.10	1.67	1.51	1.92
Japanese Yen	8.76*	1.67	2.24*	1.67	.55	1.92
Swiss Francs	3.51*	1.67	1.22	1.67	.54	1.92

* Reject H_o

Table II-8
Return Specification -- First Difference
H_o: $\beta_1 = \beta_2 = \ldots = \beta_{15} = 0$

	Holding Period					
	1-Day		6-Day		20-Day	
Currency	F Calc.	F Crit.	F Calc.	F. Crit.	F Calc.	F Crit.
British Pounds	1.06	1.67	1.03	1.67	1.09	1.92
Canadian Dollars	1.95*	1.67	.97	1.67	.93	1.92
German Marks	2.33*	1.67	.87	1.67	1.19	1.92
Japanese Yen	6.78*	1.67	2.36*	1.67	.81	1.92
Swiss Francs	5.81*	1.67	2.90*	1.67	.54	1.92

* Reject H_o

Table II-9

H_o: $\alpha = \beta_1 = \ldots = \beta_{15} = 0$

Return Specification -- Percentage Change

Currency	1	6	20
British Pounds			
Mean	.00009116	.0005687	.001402
(S.D.)	(.004818)	(.01220)	(.02204)
t	.0189	.0466	.0636
Canadian Dollars			
Mean		-.0005077	-.001366
(S.D.)		(.005594	.01193
t		-.0908	-.1145
German Marks			
Mean		.001311	.001613
(S.D.)		(.01546)	(.02813)
t		.0848	.0573
Japanese Yen			
Mean			.005071
(S.D.)			(.02830)
t			.1792
Swiss Franc			
Mean		.002341	.006481
(S.D.)		(.01927)	(.03584)
t		.1215	.1808

Table II-10

H_o: $\alpha = \beta_1 = \ldots = \beta_{15} = 0$

Return Specification -- First Differences

Currency	1	6	20
British Pounds			
Mean	.0001485	.0009508	.001831
(S.D.)	(.009878)	(.02508)	(.04505)
t	.0150	.0379	.0406
Canadian Dollars			
Mean		-.0004931	-.001305
(S.D.)		(.005423)	(.01159)
t		-.0909	-.1126
German Marks			
Mean		.0004829	.0006532
(S.D.)		(.006674)	(.01228)
t		.0724	.0532
Japanese Yen			
Mean			.00001935
(S.D.)			(.0001212)
t			.1597
Swiss Franc			
Mean			.002647
(S.D.)			(.01727)
t			.0533

Table II-11.a

ESTIMATED AUTOCORRELATION FUNCTION RETURN SPECIFICATION --
PERCENTAGE CHANGE HOLDING PERIOD -- TWENTY DAYS

British Pounds

LAG	1	2	3	4	5
$\hat{\beta}$	.3721	-.05622	-.1256	-.07248	.09373
$S_{\hat{\beta}}$	.1457	.1586	.1621	.1639	.1661
t	2.555**	-.3569	-.7750	.4423	.5644

LAG	6	7	8	9	10
$\hat{\beta}$	-.1690	.06039	.1935	-.2731	.2602
$S_{\hat{\beta}}$	.1636	.1658	.1681	.1681	.1666
t	-1.033	.3692	1.151	-1.625	1.561

LAG	11	12	13	14	15
$\hat{\beta}$	.08280	-.06249	.01935	.04419	-.1834
$S_{\hat{\beta}}$	.1694	.1699	.1704	.1649	.1413
t	.4886	-.3678	.1136	.2679	-1.298

* Significant at the .05 level
** Significant at the .02 level
*** Significant at the .01 level

N = 62

R^2 = .2453

Mean of the Dependent Variable: .001402

Intercept: .0005518

Table II-11.b

ESTIMATED AUTOCORRELATION FUNCTION RETURN SPECIFICATION -- PERCENTAGE CHANGE HOLDING PERIOD -- TWENTY DAYS

Canadian Dollars

LAG	1	2	3	4	5
$\hat{\beta}$	.09749	.01640	.1267	.1548	.05800
$S_{\hat{\beta}}$	.1468	.1451	.1396	.1460	.1522
t	-.6643	-.1130	.9080	1.060	.3810

LAG	6	7	8	9	10
$\hat{\beta}$	-.08601	-.08560	.01751	-.1760	.2312
$S_{\hat{\beta}}$	.1531	.1554	.1571	.1691	.1634
t	-.5619	-.5510	.1114	-1.087	1.411

LAG	11	12	13	14	15
$\hat{\beta}$	.02373	-.05701	-.3194	-.2250	.01447
$S_{\hat{\beta}}$	.1647	.1683	.1629	.1770	.1788
t	-.1440	-.3388	-1.967*	-1.272	.08096

* Significant at the .05 level
** Significant at the .02 level
*** Significant at the .01 level

N = 62

R^2 = .2297

Mean of the Dependent Variable: -.001932

Intercept: -.001932

Table II-11.c

ESTIMATED AUTOCORRELATION FUNCTION RETURN SPECIFICATION --
PERCENTAGE CHANGE HOLDING PERIOD -- TWENTY DAYS

German Marks

LAG	1	2	3	4	5
$\hat{\beta}$	.003773	.03057	.1312	-.4006	-.04442
$S_{\hat{\beta}}$	.1483	.1549	.1420	.1414	.1597
t	.02558	.1973	.9244	-2.833***	-.2781

LAG	6	7	8	9	10
$\hat{\beta}$	-.4139	.2717	-.05252	1.1513	-.1528
$S_{\hat{\beta}}$	.1582	.1654	.1733	.1701	.1516
t	-2.616***	1.642	-.3030	.8898	-1.008

LAG	11	12	13	14	15
$\hat{\beta}$	.03858	-.1340	.09976	.07452	.02672
$S_{\hat{\beta}}$	.1533	.1472	.1444	.1405	.1334
t	.2516	-.9108	.6907	.5304	-.2004

* Significant at the .05 level
** Significant at the .02 level
*** Significant at the .01 level

N = 62

R^2 = .3302

Mean of the Dependent Variable: .001613

Intercept: .002855

Table II-11.d

ESTIMATED AUTOCORRELATION FUNCTION RETURN SPECIFICATION --
PERCENTAGE CHANGE HOLDING PERIOD -- TWENTY DAYS

JAPANESE YEN

LAG	1	2	3	4	5
$\hat{\beta}$	-.04332	.05234	-.1139	-.1381	-.1503
$S_{\hat{\beta}}$	.1501	(.1570	.1602	.1681	.1729
t	-.2886	.3334	-.7109	-.8533	-.8694

LAG	6	7	8	9	10
$\hat{\beta}$	-.03263	.08979	.08578	.04328	.07307
$S_{\hat{\beta}}$	.1774	.1752	.1480	.1643	.1557
t	-.1840	.5126	.5795	.2634	.4693

LAG	11	12	13	14	15
$\hat{\beta}$	.06696	.1580	.09425	.2651	.09718
$S_{\hat{\beta}}$	.1547	.1527	.1537	.1624	.1662
t	.4327	1.035	.6131	1.632	.5847

* Significant at the .05 level
** Significant at the .02 level
*** Significant at the .01 level

N = 62

R^2 = .1516

Mean of the Dependent Variable: .005071

Intercept: .003550

Table II-11.e

ESTIMATED AUTOCORRELATION FUNCTION RETURN SPECIFICATION -- PERCENTAGE CHANGE HOLDING PERIOD -- TWENTY DAYS

SWISS FRANCS

LAG	1	2	3	4	5
$\hat{\beta}$	.07246	.1527	-.1085	-.1710	.03627
$S_{\hat{\beta}}$	.1463	.1615	.1646	.1663	.1919
t	.4954	.9451	-.6590	-1.028	.1890

LAG	6	7	8	9	10
$\hat{\beta}$	-.09183	.1394	.02448	- .1112	-.05993
$S_{\hat{\beta}}$	.1896	.1934	.2101	.2221	.1982
t	-.4843	.7211	.1165	- .5009	-.3024

LAG	11	12	13	14	15
$\hat{\beta}$	-.1703	.03033	.01300	.01198	0.1021
$S_{\hat{\beta}}$	.1998	.1933	.1904	.1853	.1820
t	-.8526	.1596	.06829	.06468	-.5608

* Significant at the .05 level
** Significant at the .02 level
*** Significant at the .01 level

N = 62

R^2 = .1490

Mean of the Dependent Variable: .006481

Intercept: .009250

Table II-12.a

ESTIMATED AUTOCORRELATION FUNCTION RETURN SPECIFICATION --
FIRST DIFFERENCE HOLDING PERIOD --TWENTY DAYS

British Pounds

LAG	1	2	3	4	5
$\hat{\beta}$	.3687	-.04164	-.1218	.03905	.1413
$S_{\hat{\beta}}$	.1453	.1575	.1609	.1617	.1634
t	2.538**	-.2644	-.7573	.2414	.8649

LAG	6	7	8	9	10
$\hat{\beta}$	-.2467	.04146	.2111	-.2872	.2417
$S_{\hat{\beta}}$	.1620	.1666	.1680	.1659	.1620
t	-1.523	.2489	1.256	-1.731	1.492

LAG	11	12	13	14	15
$\hat{\beta}$	.09093	-.04441	-.02162	.08186	-.1780
$S_{\hat{\beta}}$	.1641	.1647	.1651	.1575	.1309
t	.5540	-.2697	-.1310	.5198	-1.360

* Significant at the .05 level
** Significant at the .02 level
*** Significant at the .01 level

N = 62

R^2 = .2626

Mean of the Dependent Variable: .001831

Intercept: .0003256

Table II-12.b

ESTIMATED AUTOCORRELATION FUNCTION RETURN SPECIFICATION --
FIRST DIFFERENCE HOLDING PERIOD --TWENTY DAYS

Canadian Dollars

LAG	1	2	3	4	5
$\hat{\beta}$	-.09899	-.008083	.1448	.1560	.01842
$S_{\hat{\beta}}$	.1466	.1451	.1401	.1463	.1517
t	-.6751	-05569	1.033	1.066	.1214

LAG	6	7	8	9	10
$\hat{\beta}$	-.09752	-.08818	.04213	-.1641	.2078
$S_{\hat{\beta}}$	.1521	.1545	.1555	.1599	.1609
t	-.6410	-.5708	.2709	-1.027	1.291

LAG	11	12	13	14	15
$\hat{\beta}$	-.04822	-.07354	-.2981	-.2167	.01376
$S_{\hat{\beta}}$	.1611	.1639	.1586	.1711	.1728
t	-.2993	-.4487	-1.880	-1.266	.07963

* Significant at the .05 level
** Significant at the .02 level
*** Significant at the .01 level

N = 62

R^2 = .2334

Mean of the Dependent Variable: -.001305

Intercept: -.001902

Table II-12.c

ESTIMATED AUTOCORRELATION FUNCTION RETURN SPECIFICATION --
FIRST DIFFERENCE HOLDING PERIOD --TWENTY DAYS

German Marks

LAG	1	2	3	4	5
$\hat{\beta}$	-.07183	.06911	.1468	-.3713	-.08708
$S_{\hat{\beta}}$	.1478	.1556	.1488	.1486	.1679
t	-.4859	.4442	.9863	-2.499**	-.5185

LAG	6	7	8	9	10
$\hat{\beta}$	-.3756	.2707	-.03980	.1859	-.1588
$S_{\hat{\beta}}$	.1666	.1721	.1838	.1852	.1672
t	-2.254**	1.573	-.2165	1.004	-.9496

LAG	11	12	13	14	15
$\hat{\beta}$	.04640	-.1351	.09056	.07889	-.008324
$S_{\hat{\beta}}$	.1706	.1631	.1593	.1558	.1511
t	.2719	-.8283	.5685	.5062	-.05509

* Significant at the .05 level
** Significant at the .02 level
*** Significant at the .01 level

N = 62

R^2 = .2796

Mean of the Dependent Variable: .0006532

Intercept: .001002

Table II-12.d

ESTIMATED AUTOCORRELATION FUNCTION RETURN SPECIFICATION --
FIRST DIFFERENCE HOLDING PERIOD --TWENTY DAYS

Japanese Yen

LAG	1	2	3	4	5
$\hat{\beta}$	-.1416	.01842	-.1668	-.01252	-.3239
$S_{\hat{\beta}}$	.1537	.1663	.1671	.1689	.1837
t	-.9216	.1107	-.9984	-.07410	-1.764

LAG	6	7	8	9	10
$\hat{\beta}$	.1089	.1530	-.06219	.1999	.008746
$S_{\hat{\beta}}$	.1959	.1936	.1791	.2073	.1992
t	.5561	.7903	-.3473	.9646	.04391

LAG	11	12	13	14	15
$\hat{\beta}$	.08606	.2300	.2160	.1491	.2516
$S_{\hat{\beta}}$	.1986	.2023	.2014	.2091	.2065
t	.4334	1.136	1.073	.7128	1.218

* Significant at the .05 level
** Significant at the .02 level
*** Significant at the .01 level

N = 62

R^2 = .2100

Mean of the Dependent Variable: .00001935

Intercept: .00001386

Table II-12.e

ESTIMATED AUTOCORRELATION FUNCTION RETURN SPECIFICATION --
FIRST DIFFERENCE HOLDING PERIOD --TWENTY DAYS

Swiss Francs

LAG	1	2	3	4	5
$\hat{\beta}$	.02503	.1812	-.2752	-.1077	.09169
$S_{\hat{\beta}}$	.1465	.1669	.1752	.1805	.2138
t	.1609	1.086	-1.571	-.5968	.4289

LAG	6	7	8	9	10
$\hat{\beta}$	.09757	.1768	-.01541	-.1518	-.1015
$S_{\hat{\beta}}$	.2120	.2158	.2543	.2760	.2526
t	.4603	.8195	-.06060	-.5498	-.4018

LAG	11	12	13	14	15
$\hat{\beta}$	-.1379	-.002717	.01680	-.06273	-.08518
$S_{\hat{\beta}}$	.2578	.2508	.2483	.2458	.2464
t	-.5351	-.01084	.06766	-.2552	-.3457

* Significant at the .05 level
** Significant at the .02 level
*** Significant at the .01 level

N = 62

R^2 = .1490

Mean of the Dependent Variable: .002647

Intercept: .003669

Table II-13.a

ESTIMATED AUTOCORRELATION FUNCTION RETURN SPECIFICATION -- PERCENTAGE CHANGE HOLDING PERIOD -- SIX DAYS

BRITISH POUNDS

LAG	1	2	3	4	5
$\hat{\beta}$	-.002496	.06909	.1577	.04902	.03286
$S_{\hat{\beta}}$	.06577	.06574	.06594	.06751	.07057
t	-.03795	1.051	2.392**	.7261	.4656

LAG	6	7	8	9	10
$\hat{\beta}$	.05321	-.1348	-.04636	.04215	-.01574
$S_{\hat{\beta}}$	.07125	.07179	.07224	.07198	.07195
t	.7467	-1.877	-.6418	.5856	-.2187

LAG	11	12	13	14	15
$\hat{\beta}$	.01162	-.06406	-.05547	.04234	.001352
$S_{\hat{\beta}}$	.07208	.07199	.07116	.06989	.06898
t	.1612	-.8899	-.7795	.6058	.01960

* Significant at the .05 level
** Significant at the .02 level
*** Significant at the .01 level

N = 246

R^2 = .06627

Mean of the Dependent Variable: .0005687

Intercept: .0005094

Table II-13.b

ESTIMATED AUTOCORRELATION FUNCTION RETURN SPECIFICATION -- PERCENTAGE CHANGE HOLDING PERIOD -- SIX DAYS

CANADIAN DOLLARS

LAG	1	2	3	4	5
$\hat{\beta}$	.06361	.07048	-.07007	.001540	-.09817
$S_{\hat{\beta}}$	.06587	.06600	.06595	.06612	.06628
t	.9658	1.068	-1.062	.02329	-1.481

LAG	6	7	8	9	10
$\hat{\beta}$	.07666	-.01778	- .002633	-.0003867	.06929
$S_{\hat{\beta}}$	.06811	.06830	.06838	.06838	.06844
t	1.126	-.2603	-.03850	-.005655	1.012

LAG	11	12	13	14	15
$\hat{\beta}$	.09932	-.01757	.09078	-.01578	.05652
$S_{\hat{\beta}}$	.06838	.06885	.06884	.06880	.06884
t	1.453	-.2552	1.319	-.2294	.8210

* Significant at the .05 level
** Significant at the .02 level
*** Significant at the .01 level

N = 246

R^2 = .05554

Mean of the Dependent Variable: -.0005077

Intercept: -.0003493

Table II-13.c

ESTIMATED AUTOCORRELATION FUNCTION RETURN SPECIFICATION -- PERCENTAGE CHANGE HOLDING PERIOD -- SIX DAYS

GERMAN MARKS

LAG	1	2	3	4	5
$\hat{\beta}$	.1641	.1497	-.02501	-.03812	-.07418
$S_{\hat{\beta}}$	.06595	.06689	.06754	.06794	.07204
t	2.488**	2.239*	-.3703	-.5612	-1.030

LAG	6	7	8	9	10
$\hat{\beta}$	.03647	-.005604	-.03272	.02497	-.05017
$S_{\hat{\beta}}$	.07348	.07413	.07400	.07399	.07409
t	.4964	-.07560	-.4421	.3375	-.6772

LAG	11	12	13	14	15
$\hat{\beta}$	.03033	.01795	-.07545	-.004640	.02362
$S_{\hat{\beta}}$	.07406	.07438	.07471	.07363	.07377
t	.4095	.2413	-1.010	-.06301	.3202

* Significant at the .05 level
** Significant at the .02 level
*** Significant at the .01 level

N = 246

R^2 = .06692

Mean of the Dependent Variable: .001311

Intercept: .001143

Table II-13.d

ESTIMATED AUTOCORRELATION FUNCTION RETURN SPECIFICATION -- PERCENTAGE CHANGE HOLDING PERIOD -- SIX DAYS

JAPANESE YEN

LAG	1	2	3	4	5
$\hat{\beta}$	.3017	.001476	.009426	-.02043	.03062
$S_{\hat{\beta}}$	.06558	.06830	.06824	.06861	.07005
t	4.600***	.02162	.1381	-.2978	.4372

LAG	6	7	8	9	10
$\hat{\beta}$	-.004178	-.03371	-.09814	.1064	-.005758
$S_{\hat{\beta}}$	.07028	.07047	.07014	.07034	.07077
t	-.05944	-.4784	-1.399	1.513	-.08136

LAG	11	12	13	14	15
$\hat{\beta}$	.004908	-.1344	.01584	.1049	-.09624
$S_{\hat{\beta}}$	.07075	.07070	.07163	.07194	.06895
t	.06938	-1.901	.2211	1.459	-1.396

* Significant at the .05 level
** Significant at the .02 level
*** Significant at the .01 level

N = 246

R^2 = .1275

Mean of the Dependent Variable: .001638

Intercept: .001371

Table II-13.e

ESTIMATED AUTOCORRELATION FUNCTION RETURN SPECIFICATION --
PERCENTAGE CHANGE HOLDING PERIOD -- SIX DAYS

SWISS FRANCS

LAG	1	2	3	4	5
$\hat{\beta}$	.08612	.1248	-.1317	.6143	-.05302
$S_{\hat{\beta}}$	.06598	.06623	.06673	.06843	.07133
t	1.305	1.884	-1.973*	2.401**	-.7433

LAG	6	7	8	9	10
$\hat{\beta}$	- .09081	.02062	-.01914	.06228	-.02850
$S_{\hat{\beta}}$	.07160	.07186	.07214	.07339	.07429
t	-1.268	.2870	-.2652	.8486	-.3838

LAG	11	12	13	14	15
$\hat{\beta}$	- .03278	-.07919	.01103	.008026	-.009522
$S_{\hat{\beta}}$	.07428	.07499	.07578	.07557	.07506
t	-.4413	-1.056	.1455	.1062	-.1269

* Significant at the .05 level
** Significant at the .02 level
*** Significant at the .01 level

N = 246

R^2 = .07356

Mean of the Dependent Variable: .002341

Intercept: .002281

Table II-14.a

ESTIMATED AUTOCORRELATION FUNCTION RETURN SPECIFICATION --
FIRST DIFFERENCE HOLDING PERIOD -- SIX DAYS

BRITISH POUNDS

LAG	1	2	3	4	5
$\hat{\beta}$	.01133	.07004	.1388	.07587	.01959
$S_{\hat{\beta}}$	.06566	.06555	.06578	.06699	.07017
t	.1725	1.069	2.110*	1.133	.2791

LAG	6	7	8	9	10
$\hat{\beta}$	.05129	- .1351	-.05468	.04127	-.007251
$S_{\hat{\beta}}$	.07082	.07126	.07168	.07143	.07139
t	.7242	-1.896	-.7629	.5778	-.1016

LAG	11	12	13	14	15
$\hat{\beta}$	.03337	- .06503	-.06939	.03778	-.003848
$S_{\hat{\beta}}$	.07139	.07121	.07072	.06923	.06768
t	.4673	-.9133	-.9813	.5457	-.05686

* Significant at the .05 level
** Significant at the .02 level
*** Significant at the .01 level

N = 246

R^2 = .06322

Mean of the Dependent Variable: .0009508

Intercept: .0008618

Table II-14.b

ESTIMATED AUTOCORRELATION FUNCTION RETURN SPECIFICATION --
FIRST DIFFERENCE HOLDING PERIOD -- SIX DAYS

CANADIAN DOLLARS

LAG	1	2	3	4	5
$\hat{\beta}$	.06903	.07361	-.07013	-.01162	-.08411
$S_{\hat{\beta}}$	.06589	.06604	.06588	.06604	.06615
t	1.048	1.115	-1.065	-.1759	1.272

LAG	6	7	8	9	10
$\hat{\beta}$	.08771	- .02115	- .004724	-.002651	.08458
$S_{\hat{\beta}}$	.06741	.06766	.06773	.06772	.06766
t	1.301	- .3126	- .06974	-.03914	1.250

LAG	11	12	13	14	15
$\hat{\beta}$	.09362	- .01865	.1097	.01707	.04798
$S_{\hat{\beta}}$	.06772	.06811	.06807	.06816	.06815
t	1.383	- .2738	1.6111	- .2504	.7040

* Significant at the .05 level
** Significant at the .02 level
*** Significant at the .01 level

N = 246

R^2 = .05976

Mean of the Dependent Variable: -.0004931

Intercept: -.0003262

Table II-14.c

ESTIMATED AUTOCORRELATION FUNCTION RETURN SPECIFICATION --
FIRST DIFFERENCE HOLDING PERIOD -- SIX DAYS

GERMAN MARKS

LAG	1	2	3	4	5
$\hat{\beta}$	.1508	.08794	-.02448	-.03616	-.09668
$S_{\hat{\beta}}$	.06598	.06681	.06702	.06756	.07467
t	2.286***	1.316	-.3653	-.5352	-1.295

LAG	6	7	8	9	10
$\hat{\beta}$	.03717	-.01448	-.004388	.06940	- .1066
$S_{\hat{\beta}}$	.07715	.07823	.07814	.07807	.07832
t	.4817	-.1851	-.05616	.8889	-1.361

LAG	11	12	13	14	15
$\hat{\beta}$	.02874	.007846	-.06416	-.005969	- .001314
$S_{\hat{\beta}}$	.07850	.07916	.07954	.07897	.07958
t	.3661	.09911	-.8066	-.07558	- .01651

* Significant at the .05 level
** Significant at the .02 level
*** Significant at the .01 level

N = 246

R^2 = .05391

Mean of the Dependent Variable: .0004829

Intercept: .0004781

Table II-14.d

ESTIMATED AUTOCORRELATION FUNCTION RETURN SPECIFICATION --
FIRST DIFFERENCE HOLDING PERIOD -- SIX DAYS

JAPANESE YEN

LAG	1	2	3	4	5
$\hat{\beta}$	.1581	.05310	-.01595	.04032	.06879
$S_{\hat{\beta}}$	.06625	.06720	.06697	.06666	.06897
t	2.387**	.7901	-.2382	.6049	.9975

LAG	6	7	8	9	10
$\hat{\beta}$	- .01230	-.9435	-.06073	.1094	.09207
$S_{\hat{\beta}}$	.06934	.06966	.06985	.06995	.07095
t	-.1779	-1.354	-.8695	1.564	1.298

LAG	11	12	13	14	15
$\hat{\beta}$	-.04981	- .2473	.09904	.05685	.01138
$S_{\hat{\beta}}$	.07128	.07082	.07309	.07348	.07231
t	-.6987	-3.492***	1.355	.7736	.1574

* Significant at the .05 level
** Significant at the .02 level
*** Significant at the .01 level

N = 246

R^2 = .1343

Mean of the Dependent Variable: .000008943

Intercept: .000006916

Table II-14.e

ESTIMATED AUTOCORRELATION FUNCTION RETURN SPECIFICATION --
FIRST DIFFERENCE HOLDING PERIOD -- SIX DAYS

Swiss Francs

LAG	1	2	3	4	5
$\hat{\beta}$	.06010	.1121	-.2134	.3107	-.03641
$S_{\hat{\beta}}$	.06617	.06629	.06675	.07074	.07778
t	.9083	1.691	-3.196***	4.392***	-.4681

LAG	6	7	8	9	10
$\hat{\beta}$	-.1359	.01865	-.06901	.1133	-.1073
$S_{\hat{\beta}}$	.07778	.07837	.07906	.08109	.08368
t	-1.747	.2379	-.8730	1.397	-1.282

LAG	11	12	13	14	15
$\hat{\beta}$	-.04942	-.1260	-.006069	.01024	-.03642
$S_{\hat{\beta}}$	.08403	.08578	.08736	.08755	.08694
t	-.5881	-1.469	-.06947	.1169	-.4189

* Significant at the .05 level
** Significant at the .02 level
*** Significant at the .01 level

N = 246

R^2 = .1589

Mean of the Dependent Variable: .0008512

Intercept: .001003

Table II-15.a

ESTIMATED AUTOCORRELATION FUNCTION RETURN SPECIFICATION --
PERCENTAGE CHANGE HOLDING PERIOD -- ONE DAY

British Pounds

LAG	1	2	3	4	5
$\hat{\beta}$	.02496	.0009458	-.01800	-.02442	.01107
$S_{\hat{\beta}}$	.02524	.02524	.02523	.02524	.02524
t	.9891	.03747	-.7135	-.9676	.4385

LAG	6	7	8	9	10
$\hat{\beta}$	-.009425	-.0009739	.01460	.02023	.06169
$S_{\hat{\beta}}$	.02521	.02520	.02519	.02518	.02518
t	0.3739	-.03864	.5795	.8032	2.450**

LAG	11	12	13	14	15
$\hat{\beta}$	.02616	-.001719	.01379	.01747	.03066
$S_{\hat{\beta}}$	.02522	.02522	.02521	.02521	.02519
t	1.037	0.06818	.5470	.6931	1.217

* Significant at the .05 level
** Significant at the .02 level
*** Significant at the .01 level

N = 1595

R^2 = .008605

Mean of the Dependent Variable: .00009116

Intercept: 00008406

Table II-15.b

ESTIMATED AUTOCORRELATION FUNCTION RETURN SPECIFICATION --
PERCENTAGE CHANGE HOLDING PERIOD -- ONE DAY

Canadian Dollars

LAG	1	2	3	4	5
$\hat{\beta}$	-.02156	-.06255	.05504	.03904	.04801
$S_{\hat{\beta}}$	.02517	.02518	.02522	.02525	.02526
t	-.8566	-2.485**	2.183*	1.546	1.900

LAG	6	7	8	9	10
$\hat{\beta}$	-.01300	.07549	.02364	.02121	-.0008888
$S_{\hat{\beta}}$	.02529	.02529	.02533	.02526	-.02527
t	0.5139	2.985***	.9332	.8395	-.03518

LAG	11	12	13	14	15
$\hat{\beta}$	.006251	-.006467	.02829	-.008724	-.02501
$S_{\hat{\beta}}$	.02526	.02522	.02521	.02516	.02515
t	.2475	-.2565	1.122	-.3468	-.9947

* Significant at the .05 level
** Significant at the .02 level
*** Significant at the .01 level

N = 1595

R^2 = .01906

Mean of the Dependent Variable: -.00008163

Intercept: -.00006950

Table II-15.c

ESTIMATED AUTOCORRELATION FUNCTION RETURN SPECIFICATION --
PERCENTAGE CHANGE HOLDING PERIOD -- ONE DAY

German Marks

LAG	1	2	3	4	5
$\hat{\beta}$	.03815	.04746	-.001732	.004408	-.01535
$S_{\hat{\beta}}$	.02524	.02525	.02527	.02527	.02527
t	1.511	1.879	-.06853	.1744	-.6074

LAG	6	7	8	9	10
$\hat{\beta}$	.04109	.04334	.04093	.05125	.07226
$S_{\hat{\beta}}$	.02522	.02521	.02521	.02521	.02522
t	1.629	1.719	1.624	2.033*	2.865***

LAG	11	12	13	14	15
$\hat{\beta}$	.0009880	-.007457	.03207	0.2044	-.003362
$S_{\hat{\beta}}$	.02529	.02530	.02530	.02528	.02527
t	.03906	-.2948	1.268	.8083	-.1330

* Significant at the .05 level
** Significant at the .02 level
*** Significant at the .01 level

N = 1595
R^2 = .02276
Mean of the Dependent Variable: .0002138
Intercept: .0001414

Table II-15.d

ESTIMATED AUTOCORRELATION FUNCTION RETURN SPECIFICATION --
PERCENTAGE CHANGE HOLDING PERIOD -- ONE DAY

Japanese Yen

LAG	1	2	3	4	5
$\hat{\beta}$	-.2682	-.06388	-.05507	-.01167	.05160
$S_{\hat{\beta}}$	.02518	.02607	.02611	.02614	.02612
t	-10.65***	-2.450**	-2.109*	-.4466	1.975*

LAG	6	7	8	9	10
$\hat{\beta}$	.07082	.03690	.04635	.07354	.06088
$S_{\hat{\beta}}$	.02612	.02611	.02610	.02610	.02608
t	2.711	1.413	1.776	2.817	2.335

LAG	11	12	13	14	15
$\hat{\beta}$	.02202	.007766	-.01883	-.002724	-.007656
$S_{\hat{\beta}}$	.02609	.02609	.02608	.02604	.02519
t	.8440	.2977	-.7221	-.1046	-.3040

* Significant at the .05 level
** Significant at the .02 level
*** Significant at the .01 level

N = 1595

R^2 = .07686

Mean of the Dependent Variable: .0002649

Intercept: .0002768

Table II-15.e

ESTIMATED AUTOCORRELATION FUNCTION RETURN SPECIFICATION --
PERCENTAGE CHANGE HOLDING PERIOD -- ONE DAY

Swiss Francs

LAG	1	2	3	4	5
$\hat{\beta}$	.1250	.02569	.04375	-.02717	-.03521
$S_{\hat{\beta}}$	.02522	.02541	.02544	.02547	.02546
t	4.956***	1.011	1.720	-1.067	-1.383

LAG	6	7	8	9	10
$\hat{\beta}$	.004400	.06428	.01034	.03071	.05052
$S_{\hat{\beta}}$	.02545	.02544	.02549	.02544	.02545
t	.1729	2.526**	.4054	1.207	1.985*

LAG	11	12	13	14	15
$\hat{\beta}$	-.02733	-.0007392	.02052	.01386	.01384
$S_{\hat{\beta}}$	.02549	.02548	.02547	.02548	.02528
t	-1.072	-.02901	.8058	.5439	.5473

* Significant at the .05 level
** Significant at the .02 level
*** Significant at the .01 level

N = 1595

R^2 = .03228

Mean of the Dependent Variable: .0003569

Intercept: .0002504

Table II-16.a

ESTIMATED AUTOCORRELATION FUNCTION RETURN SPECIFICATION --
FIRST DIFFERENCE HOLDING PERIOD -- ONE DAY

British Pounds

LAG	1	2	3	4	5
$\hat{\beta}$	.02014	.001016	-.008683	-.02345	.01798
$S_{\hat{\beta}}$	.02523	.02523	.02521	.02521	.02521
t	.7982	.04025	-.3445	0.9302	.7132

LAG	6	7	8	9	10
$\hat{\beta}$	-.01396	-.0006660	.01194	.01716	.06705
$S_{\hat{\beta}}$	.02517	.02516	.02514	.02513	.02512
t	0.5546	-.02647	.4749	.6828	2.669***

LAG	11	12	13	14	15
$\hat{\beta}$	.01688	-.01275	.03664	.01972	.03108
$S_{\hat{\beta}}$	.02516	.02515	.02514	.02515	.02512
t	.6709	-.5071	1.457	.7843	1.237

* Significant at the .05 level
** Significant at the .02 level
*** Significant at the .01 level

N = 1595

R^2 = .009995

Mean of the Dependent Variable: .0001485

Intercept: .0001411

Table II-16.b

ESTIMATED AUTOCORRELATION FUNCTION RETURN SPECIFICATION --
FIRST DIFFERENCE HOLDING PERIOD -- ONE DAY

Canadian Dollars

LAG	1	2	3	4	5
$\hat{\beta}$	-.02118	-.05235	.04964	.03975	.05095
$S_{\hat{\beta}}$	.02517	.02517	.02520	.02523	.02523
t	-.8416	-2.080*	1.970*	1.576	2.019*

LAG	6	7	8	9	10
$\hat{\beta}$	-.01223	.08046	.02410	.01670	-.001292
$S_{\hat{\beta}}$	.02527	.02527	.02532	.02523	.02524
t	-.4842	3.185***	.9518	.6619	-.05120

LAG	11	12	13	14	15
$\hat{\beta}$	.007479	-.004993	.02698	-.008129	-.02464
$S_{\hat{\beta}}$	.02522	.02518	.02516	.02513	.02512
t	.2966	-.1983	1.072	-.3235	-.9809

* Significant at the .05 level
** Significant at the .02 level
*** Significant at the .01 level

N = 1595

R^2 = .01822

Mean of the Dependent Variable: -.00007774

Intercept: -.00006517

Table II-16.c

ESTIMATED AUTOCORRELATION FUNCTION RETURN SPECIFICATION --
FIRST DIFFERENCE HOLDING PERIOD -- ONE DAY

German Marks

LAG	1	2	3	4	5
$\hat{\beta}$	.05727	.05945	-.004515	-.01579	-.02086
$S_{\hat{\beta}}$	.02528	.02532	.02536	.02536	.02537
t	2.265***	2.348**	-.1780	-.6226	-.8222

LAG	6	7	8	9	10
$\hat{\beta}$	.04213	.02487	.04642	.05402	.05322
$S_{\hat{\beta}}$	.02535	.02534	.02532	.02534	.02536
t	1.662	.9815	1.833	2.132*	2.099*

LAG	11	12	13	14	15
$\hat{\beta}$	-.0003811	-.01292	.01424	.01637	-.007537
$S_{\hat{\beta}}$	.02541	.02541	.02542	.02538	.02534
t	-.01500	-.5083	.5600	.6450	-.2975

* Significant at the .05 level
** Significant at the .02 level
*** Significant at the .01 level

N = 1595

R^2 = .02162

Mean of the Dependent Variable: .00008295

Intercept: .00006002

Table II-16.d

ESTIMATED AUTOCORRELATION FUNCTION RETURN SPECIFICATION --
FIRST DIFFERENCE HOLDING PERIOD -- ONE DAY

Japanese Yen

LAG	1	2	3	4	5
$\hat{\beta}$	-.2307	-.03925	-.05939	-.04071	-.006017
$S_{\hat{\beta}}$	.02523	.02588	.02509	.02594	.02596
t	-9.142***	-1.517	-2.293***	-1.569	-.2318

LAG	6	7	8	9	10
$\hat{\beta}$	.009415	-.01047	.009420	.05431	.08866
$S_{\hat{\beta}}$	.02587	.02583	.02584	.02593	.02597
t	.3639	-.4054	.3646	2.094*	3.414***

LAG	11	12	13	14	15
$\hat{\beta}$	.01807	.006619	.005444	.03565	.01896
$S_{\hat{\beta}}$	.02610	.02615	.02610	.02609	.02546
t	.6924	.2531	.2086	1.366	.7448

* Significant at the .05 level
** Significant at the .02 level
*** Significant at the .01 level

N = 1595

R^2 = .06077

Mean of the Dependent Variable: .0000006897

Intercept: .0000007643

Table II-16.e

ESTIMATED AUTOCORRELATION FUNCTION RETURN SPECIFICATION --
FIRST DIFFERENCE HOLDING PERIOD -- ONE DAY

Swiss Francs

LAG	1	2	3	4	5
$\hat{\beta}$	.1577	.04224	.06823	-.06116	-.05556
$S_{\hat{\beta}}$	.02527	.02557	.02564	.02570	.02569
t	6.242***	1.652	2.661***	-2.379**	-2.162*

LAG	6	7	8	9	10
$\hat{\beta}$	-.007206	.05708	-.007828	.05487	.04309
$S_{\hat{\beta}}$	.02571	.02569	.02573	.02569	.02573
t	-.2803	2.222*	-.3043	2.136*	1.675

LAG	11	12	13	14	15
$\hat{\beta}$	-.06447	-.02734	-.005390	.03124	-.008366
$S_{\hat{\beta}}$	.02575	.02575	.02572	.02573	.02542
t	-2.504**	1.061	-.2096	1.214	-.3291

* Significant at the .05 level
** Significant at the .02 level
*** Significant at the .01 level

N = 1595

R^2 = .05235

Mean of the Dependent Variable: .0001374

Intercept: .0001024

Table II-17

Testing the Intercept

$H_o: \alpha = 0$

$\hat{U}_{j,t} = \alpha + \beta(P^2_{j,t-1}) + v_{j,t}$

$H_o: \alpha = 0$

$\hat{U}^{*2}_{j,t} = \alpha + \beta(P_{j,t-1})^{-2} + v^*_{j,t}$

Currency	Hold	$H_o: \alpha = 0$ $\hat{U}_{j,t} = \alpha + \beta(P^2_{j,t-1}) + v_{j,t}$			$H_o: \alpha = 0$ $\hat{U}^{*2}_{j,t} = \alpha + \beta(P_{j,t-1})^{-2} + v^*_{j,t}$		
		1	6	20	1	6	20
BP							
	$\hat{\alpha}$:	.00007864	.0004633	-.0003496	.000005595	.00004792	.0006456
	$S_{\hat{\alpha}}$:	(.000025394)	(.000308866)	(.001168110)	(.000006296)	(.000073988)	(.0002797)
	t:	3.0968*	1.5000	-.2993	.8886	.6477	2.3082*
CD							
	$\hat{\alpha}$:	.00001698	.00003005	-.000001475	-.00001358	-.000007631	.0001662
	$S_{\hat{\alpha}}$:	(.000002937)	(.000076446)	(.000323144)	(.0000029)	(.00006835)	(.000293179)
	t:	5.7814*	.3931	-.0046	-4.6833*	-.1116	.5669
DM							
	$\hat{\alpha}$:	-.00001066	-.0001193	-.0002128	.0000653	.0004105	.001996
	$S_{\hat{\alpha}}$:	(.000001664)	(.000039985)	(.000158944)	(.000008147)	(.00018379)	(.000961349)
	t:	-6.4063*	-2.9836*	-1.3388	8.0152*	2.2335*	2.0762*
JY							
	$\hat{\alpha}$:	-.000000001803	-.000000007284	-.00000003557	.0001896	.0005586	.003668
	$S_{\hat{\alpha}}$:	(.000000001)	(.000000001)	(.00000008)	(.000015073)	(.000023109)	(.000128034)
	t:	-2.5463*	-5.2264*	-4.3315*	12.5788*	24.1724*	28.6486*
SF							
	$\hat{\alpha}$:	-.00001607	-.0002277	-.0006774	.00007709	.0006745	.003126
	$S_{\hat{\alpha}}$:	(.000001604)	(.000038764)	(.000193661)	(.111116156)	(.000191201)	(.0009151)
	t:	-10.0203*	-5.8740*	-3.4979*	12.5227*	3.5277*	3.4160*

* Reject H_o

Table II-18

Choosing the Return Specification

$\hat{U}^2_{j,t} = \alpha + \beta(P^2_{j,t-1}) + v_{j,t}$

H_o: $\beta = 0$

H_a: $\beta > 0$

$\hat{U}^{2*}_{j,t} = \alpha + \beta(P_{j,t-1})^{-2} + v^*_{j,t}$

H_o: $\beta = 0$

H_a: $\beta > 0$

Currency	Hold 1	6	20	1	6	20
BP						
$\hat{\beta}$:	.000004215	.00003502	.005341	.00007265	.0004082	-.0008372
$S_{\hat{\beta}}$:	(.000005493)	(.00006784)	(.0002717)	(.00002502)	(.0002902)	(.001056)
t:	.7673*	.5162*	1.966	2.904	1.407*	-.7925*
CD						
$\hat{\beta}$:	.00001239	-.00000938	.0001411	.00001717	.00003639	-.00002481
$S_{\hat{\beta}}$:	(.000003077)	(.0000799)	(.0003398)	(.000002719)	(.00006391)	(.0002722)
t:	4.354	-.01174*	.4151*	6.314	.5694*	-.0191*
DM						
$\hat{\beta}$:	.00009671	.0009426	.002052	-.000005426	-.00002891	-.0002166
$S_{\hat{\beta}}$:	(.000009452)	(.0002258)	(.0008680)	(.000001264)	(.00002992)	(.0001634)
t:	10.25	4.175	2.364	-4.294*	-.9963*	-1.326*
JY						
$\hat{\beta}$:	.0001944	.0007117	.003536	-.000000001719	-.000000005245	-.00000003761
$S_{\hat{\beta}}$:	(.00004807)	(.00009386)	(.0005519)	(.0000000009243)	(.000000001409)	(.000000007621)
t:	4.054	7.583	6.407	-1.860*	-3.722*	-4.935*
SF						
$\hat{\beta}$:	.000155	.001854	.005498	-.000004864	-.00004356	-.0002889
$S_{\hat{\beta}}$:	(.000008829)	(.0002099)	(.001007)	(.000000777)	(.0000255)	(.0001353)
t:	17.55	8.833	5.461	-6.261*	-1.709*	-2.136*

* Reject H_o

FOOTNOTES

[1]Fama, Eugene, "Efficient Capital Markets: A review of Theory and Empirical Work," Journal of Finance, May 1970, pp. 469-482.

[2]Exchange Rate Practices of IMF Members (as of June 30, 1975)

Exchange Rate Regime	Number of Countries	Percentate of World Trade
Floating	18[a]	69.6
Pegged	104	30.4
Total	122	100.0

[a]Includes seven European nations participating in a joint float.

Source: Ingram, James C., International Economic Problems, John Wiley and Sons, New York, New York, 1978, p. 90.

[3]Ingram, James C., International Economic Problems, John Wiley and Sons, New York, New York, 1978, p. 90.

[4]Federal Republic of Germany (Bundes Republik Deutschland) i.e. West Germany, hereafter Germany or West Germany.

[5]Teweles, Richard J.; Harlow, Charles J.; and Stone, Herbert L., The Commodity Futures Game, Who Wins? Who Loses?, McGraw-Hill Book Company, New York, New York, 1974, p. 39.

[6]"Commodity Traders Play with Currency." Business Week, April 12, 1972.

[7]"Understanding Futures in Foreign Exchange," Public Relations Department, International Monetary Market of the Chicago Mercantile Exchange, Inc., Chicago, IL, 1974.

[8]Dufey, G., "Corporate Finance and Exchange Rate Variations," Financial Management, Vol. 1, No. 2, (Summer, 1972).

[9]Shapiro, A. C., "Exchange Rate Changes, Inflation, and the Value of the Multinational Corporation," Journal of Finance, Vol. 30, No. 2, (May, 1975).

[10]Granger, C. W. J., and Morgenstern, O., "Spectral Analysis of New York Stock Market Prices," KyKlos, Vol. 16, (1963).

[11]Brogan, A., "Simulation of Moving Average Hedging Strategies for Winter Wheat," Unpublished M.S. Thesis, Montana State Univeristy, Bozeman, MT, June, 1977, p. 12.

[12]This discussion presented can be found in greater detail in Fama, E.F., Foundations of Finance, Basic Books, Inc., New York, New York, 1976, pp. 133-137.

[13]Fama, E.F., Foundations of Finance, Basic Books, Inc., New York, New York, 1976.

[14]Fama, op. cit., 1976.

[15]Fama, op. cit., 1976.

[16]A more detailed presentation is made in Fama, E.F., Foundations of Finance, Basic Books, Inc., New York, New York, 1976, pp. 137-166 and pp. 320-382.

[17]For a more detailed list, see Boudreaux, Kenneth J., and Long, Hugh W., The Basic Theory of Corporate Finance, Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1977, p. 56.

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