

Investigating the Profitability of Technical Analysis Systems on Foreign Exchange Markets

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Abstract

Research in the money markets indicates that simple technical rules, used by traders, have some predictive power over future movement of foreign exchange rates. In this study the profitability of technical analysis rules for USD/DM and USD/BP was investigated during the period 1/3/89 - 12/31/96. The sample was further divided into sub-periods based on changes in the exchange rate volatility that seemed to be related to key macro-economic fundamentals. Results indicate that these rules are profitable but there is evidence that these profits are statistically insignificant compared to a "buy and hold" strategy. However, technical analysis in the foreign exchange market can be used as an important tool in determining the trend. Thus in periods with clear trends it can be profitable.

JEL classification: F31, G15

Keywords: technical trading rules, profit-testing systems, exchange rates

I. Introduction

Exchange rate forecasting presently is a new practice to traditional portfolio investors. These investors had to investigate relative social, political, and economic variables in order to predict rates. Today while macroeconomic fundamental parameters are still generally accepted as the main force which regulate the market and determine prices, increasing numbers of analysts use technical analysis systems in order to predict returns in the foreign exchange markets. The main reason is that they find in simpler and usually do not want to spend time assessing a complexity of factors involved in supply and demand models. Technical analysis is based on the assumption that all information is included in prices and it is a lot simpler to chart and study movements of prices and returns alone.

There are many alternative models based on "economic fundamentals" that have been used to analyze movements in the spot exchange rate markets. According to the "monetary model", for example, the exchange rate determined in the capital markets reflects the relative demand for national currencies, Cuthbertson (1996). The exchange rate is determined by the expectations of the future interest rates (i) as the following equation shows:

$$S_t = \sum_{j=0}^{\infty} E_t(i_{t+j}^* - i_{t+j})$$

However, as previous studies show, exchange rate models based on fundamentals empirically perform poorly. Their failure to satisfactorily account for exchange rate behavior does not mean that they are wrong but it reflects the serious econometric problems

encountered in any attempt to make a predictive model for exchange rates. Problems, which are more often stated in relevant literature, are:

- * Monetary policy cannot be the only determinant of exchange rates. Exchange rates also depend on a complex set of macroeconomic interactions between the countries.
- * Spot rates depend not only on the current values, but also on their expected course. It is really difficult to incorporate in a model the impact of additional information on expectations.
- * The policy makers problem. That is the fact that the appointment of a new minister can have a great impact on exchange rate movements. Yet it is very difficult to incorporate this type of news in any particular model.

The application of technical analysis to foreign exchange markets is a recent development in trading and provides a wide field for investigation. The main aim in this paper is to apply technical analysis in the currency market and test its profitability over a specified period by using recent data and comparing results with previous similar studies. Although macro-economic fundamentals are not used in this analysis, indicators like interest rate differentials, inflation and growth rates may provide a useful context to understand empirical results.

The paper is organized as follows. Section one offers a survey of the literature as a basis for the analysis. The second section provides a description of the data and the methodology that will be followed in order to test the profitability of technical analysis. In the third section, estimation results are presented and compared. Risk considerations and the non-technical trading practice of "buy and hold" are added in this part. Finally, in the last section, an attempt is made to assess all findings.

II. Previous work

Studies in the 1960s and 1970s have already indicated some profitability of technical analysis [Poole (1967), Cornell and Dietrich (1978)]. Limited data periods used in some papers weakened their conclusions, while the use of fixed exchange rates in others made them out of date in periods of floating rates.

In the 1980s, research tried to draw more sound conclusions by using longer time periods [Sweeney (1986), Schulmeister (1988)]. All of these studies investigated a variety of quantitative technical analysis systems, which were applied to daily spot market data for several sub-periods. Most, like Sweeney, found that, in about one-third of the cases, profits were statistically significant. They also concluded that many technical strategies were more profitable than the "buy and hold" strategy. A major shortcoming in these studies was the fact that transaction costs were not taken into consideration.

During the 1990s, economists investigated quantitative rules of technical analysis, too, but they either used monthly data or used the future instead of the spot market [Taylor (1992), Curcio and Goodhart (1991)]. All these studies found evidence of profitability from the application of technical analysis in foreign exchange markets. Levich and Thomas (1993) and Menkhoff and Schlumberger (1995) particularly stressed the persistence of profitability. In a survey of major dealers in the foreign exchange market in London,

Taylor and Allen (1992) found that, at short horizons of one week or less, 90% of respondents reported the use of some chartist input.

Levich and Thomas (1993) implemented a new testing procedure based on a bootstrap methodology. Their results suggest that simple technical trading rules very often led to unusual profits, but, during the last five years of their investigation period, profits declined. Some possible explanations of the persistence of trading profits were the central banks' intervention which tends to counterbalance exchange rate movements and also excessive private speculation that causes prices to follow, at least temporarily, a "speculative bubble path" away from their fundamental equilibrium prices. Frankel and Rose (1994) assessed the predictive performance of exchange rate models based upon fundamentals and the results were that no model based on standard fundamentals like money supply, real income, interest rates, inflation rates, and current account balances would ever succeed. Nelly and Weller (1997) found how central banks could affect exchange rates and make technical analysis profitable by using non-traditional approaches. The most important, and relevant to this paper, previous studies are summarized in table 1.

III. Data and Methodology

Data series for this paper consists of daily spot exchange rates for USD/DM and USD/BP and for the period 01/03/1989 to 12/31/1996. Short-term, monthly Eurodollars, Euro-mark, and Eurosterling interest rates are also used. The technical analysis software used is "Windows on WallStreet (version 2.1.2)". Data analysis is carried in two steps. First, the profitability of specific technical systems is calculated for the whole period as well as for two sub-periods 01/03/89-12/31/92, 01/01/93-12/31/96 . Then, these profits are compared to "buy and hold" trading strategy.

The present analysis will attempt to add to previous studies the following elements. Firstly it will use more variants of technical analysis systems. Secondly it will compare technical speculation strategies with a "buy and hold" strategy that is based on interest rate differentials. Risk and transaction costs will also be taken into consideration and long as well as short position will be investigated.

Technical analysis trading systems that will be considered are:

1. Moving Average Crossover System (Exponential long-term and short-term MA)¹
2. Momentum²
3. Moving Average Convergence - Divergence (MACD)³

In order to avoid random results, 25 variants of the moving average crossover, 12 variants of the momentum rules, and 13 variants of MACD system will be examined. The selection is such that more sensitive and more sluggish variants are covered. Standard moving average crossover systems using exponential moving averages are chosen because these are more sensitive to the prevailing trend since they weigh data in favor of the most recent periods. These systems have the advantage of smoothing data twice, and so reduce the possibility of a whipsaw; in addition, they provide warnings of trend changes fairly quickly, after they have taken place.

The most widely-known method of momentum interpretation is used. According to this method, one should determine overbought and oversold levels that will be boundaries for buy and sell signals together with the signal line 100. The overbought and oversold levels depend on the volatility of the price being monitored and the time period over which the momentum index has been calculated.

MACD oscillator is based on the point spread difference between two exponential moving averages of the closing price. The two exponential MA generally used have 12 and 26 periods. The difference between these exponential MA is then smoothed by a 9-period exponential MA. While following standard testing procedure, additional MA numbers of periods are investigated in this paper⁴.

In order to measure the profit differential between technical systems and the “buy and hold” strategy, monthly profitability is calculated, assuming that the evaluation period has roughly that length (Menkhoff & Schlumberger, 1995). Profits for the latter are calculated as shown below:

$$[\text{Profits from buy and hold}] = \sum_{k=1}^n \left\{ (e_{t_1} - e_{t_0}) + \left[e_{t_1} \cdot \frac{1}{12} \cdot (i^* - i) \right] \right\}$$

where:

e_{t_0} = exchange rate at the first day of the month

e_{t_1} = exchange rate at the last day of the month

i = eurodollar interest rate

i^* = interest rate of foreign currency

n = number of months

Measured profits must be carefully adjusted for risk in order to be economic profits. Some of the papers mentioned in the first section do not adjust for risk and others can be criticized for making adjustments that are perhaps inadequate and misleading. The Sharpe ratio for risk adjustments fits institutional circumstances, where results are evaluated over a long-term period. However, this does not usually reflect real situations, because foreign exchange dealers are interested for short time intervals against “buy and hold”. As a result of the above considerations, in order to represent a real model, a risk adjustment in the form of a t-test, known as the “Gaub test” was used. This test provides the advantage that it does not presume a normal distribution of the summands.

Calculations are based on the mean of differences of profits over n months. The basic formula of this form of t-test is the following⁵:

$$t = \frac{\bar{z}}{\sqrt{\left(\frac{1}{n-1}\right) \cdot \sum_{k=1}^n (z_k - \bar{z})^2}} \cdot \sqrt{n}$$

where:

z_k	= (Profits from technical rules)-(Profits from "buy and hold")
n	= sample observations
\bar{z}	= mean of variable z_k

Because technical analysis trading systems are usually impeded by an overwhelming number of restraints and protective filters which, in turn, take the realism out of the testing, no filters were used in the systems tested. The tests of profitability are based on the consideration of transaction costs as well as of long and short positions. Interbank transaction costs for the period of study were 0.03% for buying and 0.03% for selling currencies. It should also be noted that if you have a trading system that trades only one side of the market, then this long/short option will not affect the side that is not defined. Indexes that are calculated on each testing report are summarized in table 2.

System Ranking is a process which by trial-and-error attempts and lets you get a sorted list of how each trading system performs on the selected security. In addition it provides the ability to rank two or more indicators for a single security. Average trade gain is used because the goal is to find the system that performs best on average. The Net Profit is smaller because one exceptional trade could have caused a large profit or loss. The number of trades is important because this shows you whether results are sustainable over numerous trades or just a couple of trades. This is an extremely powerful feature which will quickly show the analyst which Trading Systems work on his or her securities and which ones do not.

IV. Empirical Results

Part 1 Exchange rates within the macro-economic context

The economies of USA, Great Britain and Germany and their changing role within a world money and capital market determine the macroeconomic context of this analysis. During the 90's USA and Europe to a higher degree still relied heavily on Keynesian type of deficits in order to come out of the 1989-1993 recession, a phase of the traditional economic cycle.

By 1991 the USA economy was developing at comparatively higher growth rates while its inflation and interest rates were also decreasing. The dollar had become a safety currency for European currencies that suffered serious losses, especially around the period of the summer of 1991 Persian Gulf war.

The 1989 to 1993 period was a period of large interest rate differentials in favor of the US economy that strengthened the USD and increased the volatility of European exchange rates such as the BP and the DM against the dollar. The BP was in more serious problem than the DM since interest rates were comparatively the highest among these three economies.

The weakness of the BP increased its sensitivity to speculative attacks, like the Soros September 1992 massive sale of pounds, forced a serious devaluation of the British currency and led GB outside the Exchange Rate Mechanism (ERM). The variation of the USD/BP had reached higher levels than the ERM bands. It is these high levels of volatil-

ity that usually make trading in the exchange rate market profitable and give a sound basis for Technical Analysis Systems to perform well.

After 1993 the European economy was in a tract of recovery with Germany leading the way. Interest rate differentials against the US rate decreased considerably and economic growth brought about lower rates of unemployment. By 1994 the US-German interest rate differential had reached zero while GB followed with small positive differentials trying to get out of the 1989-1993 phase of recession.

A result of this new macroeconomic environment was that the volatility of BP and DM exchange rates against the USD were considerably lower than the 1989-1993 period. Lower exchange rate volatility usually cut away profitability rates and makes Technical Analysis Systems perform poorly.

Part 2 Testing profitability of technical rules

The two distinct periods from the macroeconomic point of view led us to divide the whole period into two sub-periods too and thus investigate the profitability of technical analysis for each period separately.

In considering the USD/DM exchange rate over the whole period, all technical rules used were profitable. More specifically, all variants of the MACD system were profitable while, from the momentum rules only, one had losses. In table 3 one can see that, for the second period, there is a slight drop in profitability which could be explained by similar low levels of inflation and decreases of interest rate differentials between the two economies.

For the USD/BP rate, over the whole period and for fifty technical rules, 43 were profitable and 7 unprofitable. This time series shows big losses for the second sub-period, a fact that leads us to consider more carefully the persistent profitability of technical analysis. Profitability of technical analysis over the first period can be easily explained as a result of the slow but wide movements of the exchange rates due to persistent high interest rate differentials (figure 3). As a result the number of trades is small and commission costs are limited.

On the other hand, over the second period, the volatility of the exchange rate over a specified small channel did not give the opportunity to easily recognize profits. Delays, commissions, and whipsaws are the main reasons of high losses over this second period.

More analytical results are presented in table 4, which ranks each trading system according to its profitability. Average trade gains, net profit, and number of trades are used as basic criteria for ranking.

Analyzing the USD/DM rate, one could state that, in general, moving average cross-over systems and some of the MACD type have the highest percentage of profitable trades. These systems have also low transaction costs. However, they do not include a big number of consecutive-win trades. They include a small number of consecutive losses that also offer an explanation of the high profitability of these systems. Finally, by looking at the profitability ratios it can be concluded that even if they have high transaction costs they are profitable and the strength of the systems is given by their high profit factor (MACD are the best for the two rates).

In the case of the USD/BP rate, MACD systems are the most profitable. Momentum systems are more profitable than the moving average crossover systems that use two exponential moving averages. In general, MACD systems have the highest percentage of profitable trades. Moving average crossover systems with high periods such as 10/40 or 10/30 have not been affected by high transaction costs, since they also give few trading signals. When consecutive wins and losses are considered, momentum systems are the most profitable.

Conclusions can be quite different when the chosen data set is further split in two sub-periods. It should be noted, though, that by dividing the whole period, systems at the end of each sub-period close their positions for reasons of evaluations. This may result in large losses. In addition, some systems lose some trades at the beginning of the second period because of their construction (i.e., in moving average 2/10 there is no sign for the first 10 days). Taking all of the above into account, one could say that, for the USD/DM rate, the best rule is the moving average crossover 10/30 in all three cases. A second-best rule is the moving average 2/35, despite the fact that it results in a considerable number of trades. For the USD/BP rate while MACD systems were profitable both for the entire period and the first sub-period, considerable losses for the second sub-period were noted. Low volatility of the USD/BP exchange rate seems to follow the 1992 devaluation of the pound and the process of convergence of the two economies.

Part 3 Comparison with "buy and hold" strategy and consideration of risk.

When technical analysis is compared to a "buy and hold" strategy, the percentage of profitable technical rules in some cases decreased because the latter resulted in higher gains. For the time period as a whole, there is a decrease in the percentage of profitable rules for both exchange rates. However, the result remains the same for the two sub-periods (with the exception of the USD/DM for the second sub-period).

V. Risk consideration

A significant t-test value means superiority of technical analysis compared to a "buy and hold" strategy. The sign of the t-test indicates whether technical analysis gives higher profits than "buy and hold" strategy. The significance of the "Gaub test" was also investigated by testing the null hypothesis that differences of profits are zero at a 5% significance level.

According to table 6, over the entire period of investigation there are no technical rules that produce statistically significant profits. In table 7, for the last four years, one should note that the majority of t-tests are very small and some negative, an evidence for the superiority of the "buy and hold" strategy. However, there is evidence that there is some statistically significant rule over the first sub-period.

Results shown in table 7 also indicate that, when risk is considered, the impression of persistent profitability deteriorates. This fact creates some limitations to the measured significance of the short-term superiority of technical analysis profits compared to a simple "buy and hold" strategy. However, one could say that, at least, technical analysis gives profitable signs and can indicate the trend of the market. Tables 4 and 7 indicate that overall performance is a result of first sub-period profitability. Second sub-period lower performance of technical analysis systems and statistically insignificant profitabil-

ity indicate significant period effects that could be explained by changes in the macro-economic fundamentals after 1993.

VI. Discussion of Results - Conclusions

Empirical results in this study do not lead to a clear-cut answer regarding the profitability of using technical analysis in foreign exchange markets. Firstly, technical rules used were profitable over the whole period of the investigation. Secondly, by comparing the profitability of these rules against a simple "buy and hold" strategy, the former still lead to profits. However, it is important to note that when the data set was divided in two, for the second sub-period the number of profitable technical rules for the USD/DM rate decreased while for the USD/BP was zero. Thus it can be stated that the profitability of technical analysis over the whole period is based on the first sub-period's successful trades, which were the result of a high exchange rate volatility following high interest rate differentials.

In the second sub-period, high losses can be explained by the fact that in a period of unclear trends, an investor may be involved in a great number of trades and, therefore, undertake high transaction costs. The volatility of prices as well as the sensitivity of the trading system are bound to influence the number of trades. It is important to note that an investor who follows a technical trading rule would need sufficient capital to absorb losses when false signals are issued. Finally, by incorporating risk, there is evidence against the hypothesis that profits produced by technical analysis are statistically significant.

Based on these results, one can draw arguments as to the effective use of technical analysis in the foreign exchange market. Market participants use technical analysis because they are attracted by the simplicity of the methods and promising surplus yields by previous success stories in other markets (such as a stock market or commodity market). Yet, personal and institutional risk restrictions limit the ability of investors to fully exploit the theoretical profit potential (the Gaub test perspective).

It is mostly the weakness of fundamental analysis to provide satisfactory models for exchange rate predictions that leads investors to use technical analysis. Empirical findings in the past proved that technical models have yielded above-average profits. Technical analysis also has a distinct advantage over fundamental-based models when price swings are unexpectedly large. Technical models are designed to keep an investor with and not against the trend.

Yet why don't all market participants make use of technical analysis rules and still allow profit margins in foreign exchange rates? According to the above analysis, one explanation lies in the fear of risk by many speculators with short-term horizons. Technical analysis may also lead to negative positions and convince investors to interrupt this type of trading.

There must be a tradeoff when applying technical analysis between long-term profit opportunities and short-term risk limits for the foreign exchange dealers, under the given circumstances. In periods that a trend can be easily determined, it can result in considerable profits. Some technical analysts will be successful over a finite horizon and this may

encourage others to attempt to imitate them and enter the market, ignoring the fact that these successful traders had, in fact, taken on more risk.

Technical analysis has been extremely profitable over previous years as shown by Menkhoff-Schlumberger (1995), Levich-Thomas (1993), Schulmeister (1988), Sweeney (1986), and Dooley-Shafer (1983) because economic forces have been driving values sharply higher or lower. However, a growing convergence of economic policies and government philosophies among major nations leads to less variability of exchange rates. In addition, the development of technical advisory services has led to a more competitive foreign exchange market and thinner profit margins. As a result, profits from technical analysis will be harder to come up. Only economic shocks such as a sharp rise in oil prices or the collapse of currencies may still produce sharp movements in exchange rates.

Summing up, technical analysis in the foreign exchange market could be used as a tool for determining the trend and, for periods with clear trends, a trader might produce profit. However, one should never neglect considerations of risk. Analysis showed that technical systems over the period of investigation were profitable but there was evidence that these profits were statistically insignificant compared to a "buy and hold" strategy.

Endnotes

1. Short-term /long-term 2/10, 2/15, 2/20, 2/25, 2/30, 2/35, 2/40, 3/10, 3/15, 3/20, 3/25, 3/30, 3/35, 3/40, 4/10, 4/15, 4/25, 4/35, 5/15, 5/25, 5/35, 7/15, 7/30, 10/30, 10/40
2. Momentum 5, 9, 10, 13, 19, 20, 21, 22, 23, 24, 30, 35
3. MACD 8 to 20
4. Pring (1991)
5. Menkhoff and Schlumberger (1995)

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Table 1: Summary of other studies

<i>Researchers</i>	<i>Period of Investigation</i>	<i>Data</i>	<i>Currencies</i>	<i>Technical Rules</i>	<i>L/S</i>	<i>Trade Cost</i>	<i>Risk</i>
Dooley and Shafer (1983)	3/73-11/81	daily	9 vs.USD	7 Filters	l/s	+	-
Sweeney (1986)	4/73-12/80	daily	10 vs.USD	7 Filters	l	-	Risk Premium
Schulmeister (1987)	4/73-9/86	daily	DM/USD	9 Filters 9 Oscillators 5 Momentum 7 O+M	l/s	-	T-statistics
Menkhoff and Schlumberger (1995)	1/89-12/91	daily	DM/USD DM/Yen DM/BP	33 Oscillator 10 Momentum	l/s	+	Sharpe ratio Gaub-test

L/S= Long and Short positions

Table 2: Testing criteria

<i>Summary Statistics</i>	<i>Trade Statistics</i>
Total net profit	Total No. of Trades
Total percentage gain/loss	No. Profitable Trades, Amt. of Profitable Trades, No. of stops hit
Annualized rate of return	Largest Profitable Trade, % Profitable Trades, Avg. Profitable Trade
Average trade gain/loss	No. Losing Trades, Amt. of Losing Trades
Average trade gain/loss (%)	Largest Losing Trade, Avg. Losing Trade, Avg. Gain/Loss per Stop
<i>Profitability Ratios</i>	<i>Trade Durations</i>
Profit Factor - gain divided by loss	Total No. of Periods in Test
Ratio Avg. Profit/Avg. Loss	Most consecutive wins, Amt. of consecutive wins
Ratio Profit/Commissions	Number of days in the test
	Most consecutive losses, Amt. of consecutive losses

Table 3: Number of profitable technical rules

<i>Exchange Rate</i>	<i>Period tested</i>	<i>Profitable rules</i>	<i>%</i>
USD/DM	03/01/89 - 31/12/96	50	100
	03/01/89 - 31/12/92	50	100
USD/BP	01/01/93 - 31/12/96	37	74
	03/01/89 - 31/12/96	43	86
	03/01/89 - 31/12/92	50	100
	01/01/93 - 31/12/96	-	-

Table 4: System ranking performance comparison

Exchange Rate	Period	System Name	No of Trades	Net Profit (\$)	Avg Trade Gain (%)
USD/DM	1/3/89-12/31/96	1. expo-crossover10/30	50	38761.20	.72
		2. expo-crossover2/35	95	62540.65	.51
		3. expo-crossover2/40	93	50512.70	.45
	1/3/89-12/31/92	1. expo-crossover10/30	26	21609.91	.90
		2. expo-crossover2/35	45	41392.21	.78
		3. Variable MACD19	47	34940.03	.72
	1/1/93-12/31/96	1. expo-crossover10/30	24	12300.70	.51
		2. expo-crossover3/35	40	13135.59	.34
		3. expo-crossover10/40	26	8117.25	.32
USD/BP	1/3/89-12/31/96	1. Variable MACD14	128	31399.11	.25
		2. Variable MACD13	130	31243.66	.24
		3. Variable MACD16	125	25844.66	.22
	1/3/89-12/31/92	1. expo-crossover7/15	42	42521.53	.96
		2. expo-crossover5/15	48	40634.53	.81
		3. expo-crossover3/20	52	44149.27	.79
	1/1/93-31/12/96	1. momentum-stef-21	121	-14096.60	-.11
		2. momentum-stef-5	234	-25031.99	-.12
		3. expo-crossover2/10	152	-19603.54	-.14

Table 5: Number of profitable technical rules compared to “buy and hold”

Exchange Rate	Period tested	Percentage of profitable technical rules (table 3)	Percentage of profitable technical rules (better than buy & hold)
USD/DM	01/03/89-12/31/96	100%	76%
	01/03/89-12/31/92	100%	98%
	01/01/93-12/31/96	74%	38%
USD/BP	01/03/89-12/31/96	86%	82%
	01/03/89-12/31/92	100%	100%
	01/01/93-12/31/96	-	-

Table 6 Number statistically significant rules

Exchange rates	1/3/89-12/31/96	1/3/89-12/31/92	1/1/93-12/31/96
USD/DM	0	13	0
USD/BP	0	17	0

Note: 95% level of significance

Table 7: Risk analysis (t-statistics)

Exchange Rate	System Name	1/3/89-12/31/96	1/3/89-12/31/92	1/1/93-12/31/96
USD/DM	ma2/35	0,55	1,56	-0,26
	ma3/35	0,03	0,33	-0,33
	ma10/30	0,73	1,83	-0,06
USD/BP	macd19	1,27	2,49*	0,87
	ma3/20	1,22	2,51*	-2,12*
	ma7/15	1,59	2,59*	-1,53
	mom21	1,95*	2,78*	-1,08
	macd14	0,77	1,76	-1,68

Note: * means statistically significant at 95% level of significance

Figure 1-GDP Growth and Rate of Inflation
 Source: OECD, Global Financial Data (www.globalfindata.com)

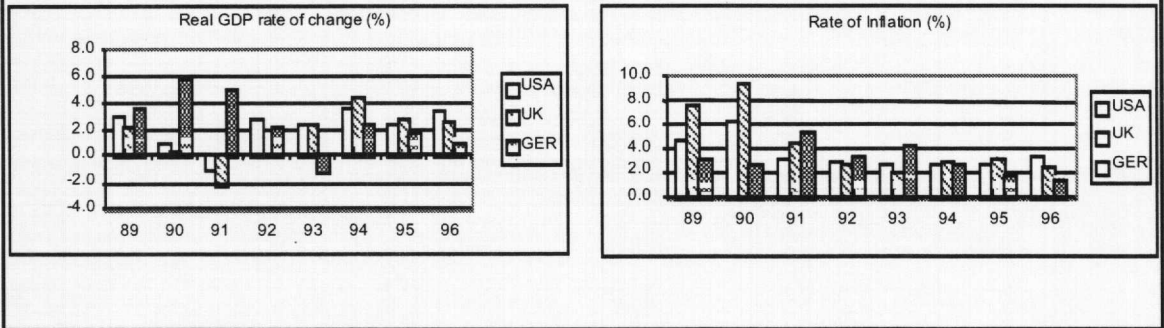


Figure 2.-Interest Rate Differentials (10-year bond yields)
 Source: Data Stream

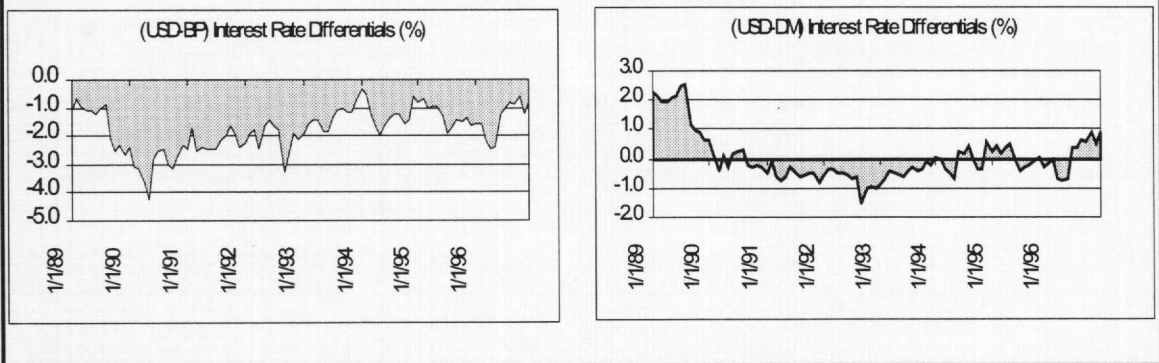


Figure 3.-Exchange Rates
 Source: Pacific Exchange-Rate Service (Pacific.commerce.ubc.ca/xr)

