BANK OF FINLAND DISCUSSION PAPERS 2/91

Antti Urvas

Bank of Finland Market Operations Department
15.01.1991

VOLATILE EXCHANGE RATES AND SPECULATION – CAN THE DOLLAR MOVEMENTS OF THE 1980S BE EXPLAINED?

ISBN 951-686-275-6
ISSN 0785-3572

Suomen Pankin monistuskeskus
Helsinki 1991

ABSTRACT

The paper analyzes why exchange rates can deviate substantially from levels predicted by economic fundamentals. Chapter 2 reviews traditional exhange rate models and shows how they fail. Since speculation seems to play a role in exchange rate determination, speculation and expectations formation are discussed in chapter 3. Chapters 4 and 5 review results from latest studies in exchange rate determination and short-term behaviour of the foreign exchange market. News' role and foreign exhange market's efficiency are discussed in chapter 6. Chapter 7 describes the speculative nature of the foreign exhange market, market's development in 1980s and central banks' role in the market.

Paper concludes that it may be impossible to consctruct a plausible exchange rate model in a world where speculative and fundamentalist views compete. Economic fundamentals are a key element in the exchange rate determination, but it is not clear how these fundamentals are related to exchange rates. The current foreign exchange market is largely driven by agents who aim to profit by short-term trading in the spot market. Short-term speculative trading may generate accumulative exchange rate movements taking the real exchange rate far away from fundamentals. In addition to the longer-term trend volatility the foreign exchange market seems to be volatile over very short time horizons. Different agents in the market have asymmetrical, differing information sets and accordingly differing views about the "appropriate" equilibrium exchange rate. These differing opinions cause constant price revisions, oscillations around trends. This price oscillation, caused by "human element" in the market, can lead to operational inefficiencies which may offer excess returns to market participants.

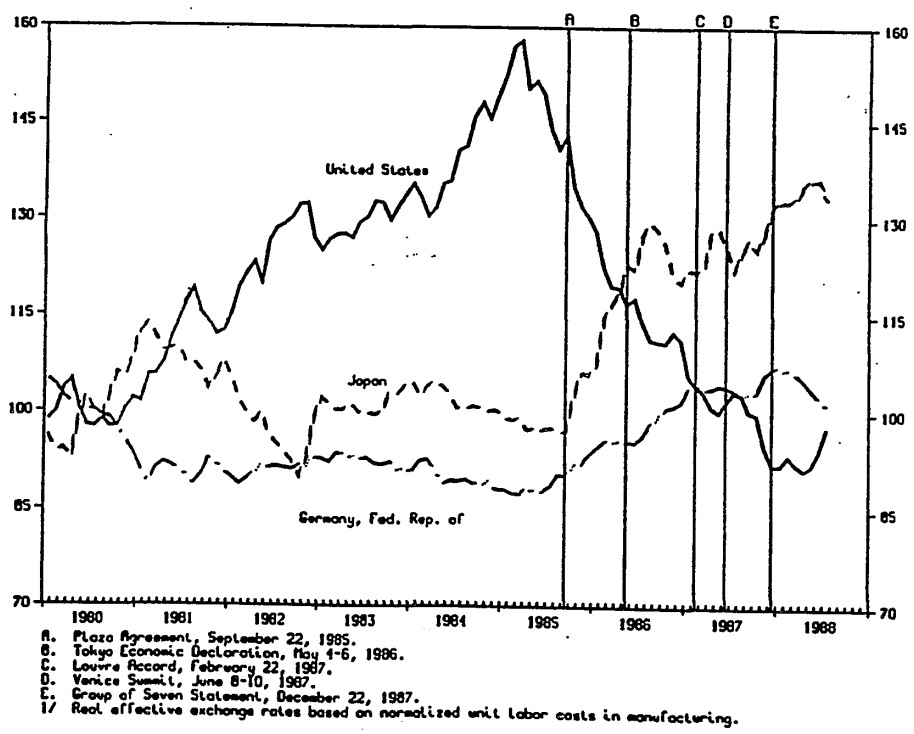
CONTENTS

1 INTRODUCTION

1.1 Background

After twenty or thirty years of exchange rate modelling we have to recognize that the understanding of exchange rate movements is less than satisfactory. During the period of floating exchange rates volatility has increased substantially and exchange rate fluctuations have now become a fact of life. Once exchange rates moved a lot, as they did in the 1980s, most models explaining the exchange rate behaviour seem to have lost their ability to explain what has happened. The dollar movements of the 1980s have been to open economy macroeconomics, what the Great Depression has been to macroeconomics - an unexplained phenomenon (Dornbusch 1988, 1). It seems that the fundamental factors that traditionally have been thought to determine the exchange rate behaviour - relative price levels, relative interest rates, current account developments, money supplies etc. - can explain only a fraction of recent exchange rate movements.

Figure 1
Real effective exchange rates in major industrial countries, 1980-88



Source: Frenkel and Goldstein 1989

In the late 1980s researchers have started to look for the answers from alternative models. Since structural models do not work, or rather explain very little, recent studies have shifted emphasis from economic fundamentals to markets. These studies have shown that some of the assumptions underlying the structural models are unsound. The latest research also probes foreign exchange rate behaviour in the very short-run heretofore impossible due to the lack of relevant data.

The foreign exchange market has changed considerably during the 1980's. Although it is by far the largest market in the world, it remains to many a little understood phenomenon. It is a market which today affects almost everyone in one way or another and impacts either directly or indirectly, upon just about every area of economic activity. Perhaps the greatest change in the market is the growth of trading volumes. The growth is so huge that it cannot be explained by the increase in international trade. Instead, it is speculative trading in the foreign exchange market that has grown substantially. This may be the main reason behind the increased currency volatility and the subsequent inability to explain foreign exchange rate behaviour with structural models.

1.2 Aim of the study, structure and limitations

The aim of this paper is to analyze why exchange rates can deviate substantially from economic fundamentals. We show how structural models have failed to explain and forecast exchange rate behaviour (chapter 2). Speculation in the foreign exchange market seems to play a role in exchange rate determination. We try to analyze whether speculation is stabilizing or destabilizing. Since speculation is related to expectations formation, we study expectation formation in the foreign exchange market in chapter 3. Most structural models explaining exchange rate behaviour assume that expectations are rational and financial markets are efficient. Chapter 4 introduces alternative models of exchange rate determination, which take speculation and non-rational expectations into account. Structural models try to explain exchange rate behaviour over medium- or long-run. The very short-term exchange rate movements are often described as a random walk. Chapter 5 introduces some latest results from studies of the short-term behaviour of the foreign exchange market. These studies show that news and trading process generate volatility.

News' role, short-term volatility and foreign exchange market's efficiency are discussed in chapter 6.
Several changes have taken place in the foreign exchange market in the 1980s. Trading volumes and the number of participants have grown substantially. Chapter 7 describes the nature of the foreign exchange market, its development in 1980s, and shows that a large share of the spot trading is indeed speculative. Central banks' role in the market is also discussed in chapter 7. The main conclusions and suggestions for further research are presented in chapter 8.

Because of the special role of the US dollar in the currency markets this study focuses upon the dollar. The dollar's performance is measured against key currencies - the Japanese yen, the German mark and the British pound. These key currencies are chosen since most of the empirical research in the field concentrates on the markets between these currencies.
Within the three submarkets of the foreign exchange market - the spot, the forward and the swap market - this study concentrates on the most important one - on the spot market. The forward market is included in the discussion only when involved as a functioning part of the explanatory model being discussed.

The main emphasis of the study is the 1980s. Since this paper concentrates on the above mentioned currencies, the models are evaluated only by their predicative ability concerning the key currencies. Speculation is defined and explained as speculation in the foreign exchange markets. The major changes that have taken place in the market were initiated by the global deregulation of the currency markets and by improved technology in the early 1980s. Thus the description of the foreign exchange market starts from the beginning of 1980s.

Since there is no clearinghouse that keeps record on the global transaction volumes or of market participants, it is impossible to know precisely the size of the markets. This paper relies on the best estimations available from the resource material in the description of the markets.

2 GENERAL OVERVIEW OF THE EXCHANGE RATE DETERMINATION

2.1 Introduction

Exchange rates are relative prices of national currencies, and under a floating rate regime they are determined by the interplay of supply and demand in foreign exchange markets. Supply and demand in currency markets are dependent on conditions in real- and financial markets, which are affected in turn by exchange rates themselves. Any general analysis would describe exchange rates as being determined in a complex process of interaction simultaneously with all other variables in international macro-economy. In most standard models it is necessary to use simplifying assumptions to provide explanations which are in varying degrees partial. Each model emphasizes its particular linkages, for example with trade and relative price developments, or with conditions in money and financial markets more generally.

The experience of floating exchange rates since 1971-73 has led to a radical reconsideration of how exchange rate determination may best be understood. At an early stage a broad consensus was reached on the fundamental proposition that exchange rate determination is best viewed as being like the determination of the prices of financial assets (Hacche 1983, 3). Econometric models based on this "asset-market" approach seemed to give encouraging results in explaining the exchange rate determination in the mid- and late-70s, but several studies in the 1980s have shown the apparent failure of econometric exchange rate models to explain the exchange rate behaviour.

This chapter describes and discusses briefly the main theories explaining the exchange rate determination: the Purchasing Power Parity, the Balance of payments approach, the "asset-market"- models and the macroeconomic model. Before analyzing above mentioned theories, concepts "rational expectations" and "market efficiency" are reviewed.

2.2 Efficient markets and rational expectations

In efficient capital markets asset prices fully and instantaneously reflect all available relevant information and are useful for directing the flow of funds from savers to investment projects that yield the highest return. A market is said to be allocationally efficient when prices are determined in a way that equates the marginal rates

of return (adjusted for risk) for all investors. Capital markets are operationally efficient if intermediaries, who provide the service of channeling funds, do so at the minimum cost that provides them a fair return for their services.
Fama has defined three types of efficiency, each of which is based on a different notion of exactly what type of information is understood to be relevant in the phrase "all prices fully reflect all relevant information".

1. Weak-form efficiency. No investor can earn excess returns by developing trading rules based on historical price or return information.

2.Semistrong-form efficiency. No investor can earn excess returns from trading rules based on any publicly available information.

3. Strong-form efficiency. No investor can earn excess returns using any information whether publicly available or not. (Copeland 1988, 332)

It is not easy to understand how the individual's decision-making process, given the receipt of information, is reflected in the market prices of assets. It is impossible to observe the quantity and quality of information or the timing of its receipt in the real world. There is even disagreement among theorists about what information will be used by investors. For example, Forsythe, Palfrey and Plott [1982] identify four different hypotheses. The first hypotheses is particularly nonsensical and it can be called the naive hypotheses. It asserts that asset prices are completely arbitrary and unrelated either to how much they will pay out in the future or to the probabilities of various payouts. The second hypotheses can be called the speculative equilibrium hypothesis. Developed by Keynes, this hypothesis asserts that all investors base their investment decisions entirely on their anticipation of other individual's behaviour without any necessary relationship to the actual payoffs that the assets are expected to provide. The third hypothesis, the intrinsic value hypothesis, says that prices will be determined by each individual's estimate of the payoffs of an asset without consideration of its resale value to other individuals. Asset prices are systematically related to their future payoffs. The fourth hypothesis may be called the rational expectations hypothesis. It predicts that prices are formed on the basis of the expec-

ted future payouts of the assets, including their resale value to third parties. Thus a rational expectations market is an efficient market because prices will reflect all information (Copeland 1988, 339).

Rational expectations imply that exchange rates should not jump except in response to unforecastable information regarding economic fundamentals ("news"), and that any systematic patterns of movement in exchange rates should be incorporated into investors' expectations as reflected, for example, in the forward discount (Dornbusch 1987, 8). In the context of monetary models, this means that exchange rates should not jump discontinuously except in response to news about current money supplies, expected future money growth rates, and real output, and the forward discount or interest differential should be a conditionally unbiased forecast of the future change in the exchange rate. Under rational expectations, we should be able to predict that part of exchange rate changes that is correctly predicted by participants in the foreign exchange market, as reflected in the forward discount.

2.3 Purchasing Power Parity

2.3.1 Statement of the theory

Purchasing Power Parity is a theory of exchange rate determination. In its most common form it asserts that the exchange rate changes between two currencies over any period of time are determined by the change in the two countries' relative price levels. The following presentation follows Dornbusch 1985, "Purchasing Power Parity".

Let Pi and Pi^ represent the price of the ith commodity at home and abroad, stated in home and foreign currency respectively, and e the exchange rate. The exchange rate is quoted as the number of units of domestic currency per unit of foreign money. Further, let P and P^ be the price level at home and abroad quoted in respective currencies.

The strong or absolute version of PPP relies on the "law of one price" in an integrated, competitive market. The price of a given good will be the same in all locations when quoted in the same currency, say dollars: Pi = ePi^. Domestic price index P = f(p1,.., pi,..pn) and a foreign price index p^ = g(p^1,..,p^i,..p^n). If the prices of each good, in dollars , are equalized across countries, and if the same goods enter each country's market basket with the

same weights then absolute PPP prevails. The absolute version of PPP:

$$(2.3.1) \quad e = P/P^{\wedge} = \frac{\$ \text{ price of a standard market basket of goods}}{\text{Pound price of the same standard basket}}$$

where the right hand side is the common multiple of the price of each good in one currency and in the other. The absolute PPP implies that whatever the monetary or real disturbances in the economy because of instantaneous, costless arbitrage the prices of a common market basket of goods in the two countries, measured in the common currency will be the same or $P/eP^{\wedge} = 1$ at all times. Prices of the perfectly homogenous commodity are not literally equalized between countries because of transport costs, tariffs and quotas, information costs and imperfection of competition - spatial price differentiation can occur thus limiting strong PPP.

The weak or relative version of PPP takes into account obstacles of trade and restates the theory in terms of changes in relative price levels and the exchange rate: $e = QP/P^{\wedge}$, where Q is a constant reflecting the obstacles to trade. Relative version can be also stated like:

$$(2.3.2) \qquad {}^{\circ}E = {}^{\circ}P - {}^{\circ}P^{\wedge}$$

where $^{\circ}$ denotes a percentage change.

2.3.2 Purchasing Power disparities

Empirical research on the 1920s and on the very early data of the 1970s initially seemed to support PPP but large movements in real exchange rates of the 1970s led to the currently dominant PPP skepticism. Departures from PPP can be structural or transitory. Structural departures arise systematically in response to new and lasting changes in equilibrium relative prices. Disturbances to which the economy adjusts with differential speeds in goods and assets markets occur transitory departures. These departures imply that even the relative form of PPP cannot be expected to hold closely. They are caused primarily, because the terms of trade may change as a consequence of changes in trade patterns, economic growth systematically affects the relative price of home and traded goods and finally monetary and exchange rate changes bring about transitory deviations

in real price ratios and in PPP as a consequence of imperfectly flexible wages and prices.

The empirical evidence against PPP in level form is overwhelming. The enormous dollar appreciation of the 1980s convinced the remaining doubters even though statistical evidence existed already earlier. As a measure of the departure from PPP table 1 shows the correlation of annual rates of change of various price indices for the period 1971-83. In each case the bilateral comparison is conducted on exchange rate adjusted price indices so that inflation rates are measured in common currency. The weak form of the PPP hypothesis would predict that the correlation coefficients are approximately unity. In fact the values are far off unity and in many cases even negative.

Table 1 Correlation of Inflation Rates Expressed in U.S. dollars (Annual data, 1971-1983)

	US-Germany	US-Japan	Germany-Japan
GDP Deflators	-0.16	-0.22	0.64
Consumer prices	0.28	0.36	0.60
Export prices of machinery	-0.24	0.10	0.58
Deflators for manufactures	-0.10	-0.13	0.61

Source: Dornbusch 1985.

The evidence on deviations from PPP shows that they have been large and persistent. In spite of these deviations PPP remains a benchmark by which to judge the level of an exchange rate. In the very long run it is possible to detect a significant tendency for the real exchange rate to regress to PPP (Frankel and Meese 1987, 125). It remains to be seen whether this long run tendency will continue in the future if exchange rates remain as volatile as they have been in the 1980s.

2.4 Balance of payments approach

Under the Bretton Woods regime analyses on the exchange rate determination were affected by the nature of international financial system. Exchange rates were viewed as "adjustable pegs", to be used for the correction of disequilibria in the balance of payments. Disequilibria were usually defined as imbalances in the current account. The analysis of exchange rates focused on their influence on current account flows, and on the mechanism which parity adjustment could thereby provide for the correction of payments imbalances. The transactions on capital account received less attention, net capital flows were usually viewed to be dependent on the difference between domestic and foreign interest rates, but to be independent on the exchange rate because expectations of currency movements were usually taken as fixed. This view assumed a world where capital is relatively immobile internationally. These assumptions attached together to the traditional "Keynesian" analysis of the determination of interest rates and output in a closed economy provided a framework for exchange rate determination. Domestic production costs were assumed to be fixed in this analysis.

In this framework exchange rates are determined by balance of payment flows which correct current account disequilibria. Current account responds to variations in competitiveness providing the crucial mechanism.
For example, an increase in the domestic money supply puts downward pressure on interest rates and interest sensitive expenditure increases. Output expands towards a new equilibrium where the increased money stock is willingly held. Lower domestic interest rates cause the capital account to deteriorate. Higher income increases imports and current account deteriorates. The incipient deterioration in the overall balance of payments will cause the exchange rate to fall to the point where the competitiveness of domestic goods and services are sufficiently improved for overall external balance to be restored.

A number of features in the balance of payments analysis became inadequate in the light of more recent experiences. The analysis is essentially static and it ignores the lags with which output and trade volumes respond to exogenous disturbances. In reality, exchange rates and interest rates will tend to respond quickly to shocks which disturb supply and demand. Expenditures, income, output and

trade are likely to respond more slowly as plans are changed and contracts re-drawn. These observations imply that in the short run interest rates and exchange rates may overshoot the values required to maintain the equilibrium in foreign exchange and other financial markets because of the slow adjustment of the sluggish variables in the real economy. Also delays in the response of trade volumes to exchange rate changes mean that current account can not, in the short run, play the equilibrating role in the foreign exchange market described above. This means that the role of equilibrator of the foreign exchange market in the short run must pass to the capital account. (Hacche 1983, 5)
The arguments that capital account adjustment provides the equilibrium in the short run and that capital flows represent responses to imbalances between actual and desired portfolios form the basis of the asset-market view of the exchange rate determination.

2.5 Asset market approach

2.5.1 Asset-market equilibrium

This section follows (Hacche 1983, 9-14). The asset market view of the exchange rates is represented in most of the recent theoretical and empirical work in this area. In this approach the behaviour of exchange rates resembles that of other asset prices. Financial assets denominated in different currencies form stocks and the supply and demand of these stocks determine the exchange rates. Freely determined exchange rate will tend in any period towards a value where the stocks of assets denominated in the two currencies concerned are willingly held. These stocks will be willingly held if their expected yields give wealth-holders no incentive to switch out of one currency into the other. This means that expected yields on domestic and foreign assets, when expressed in a form of common currency, must be equalized apart from a risk premium.

The asset market equilibrium condition identifies five contributors to exchange rate movements:

i) the movement of foreign prices in relation to domestic prices;
ii) expectations of foreign interest rates in relation to expectations of domestic interest rates;
iii) expectations of foreign inflation in relation to expectations of domestic inflation;

iv) expectations of future real exchange rates;
v) changes in the risk premium of foreign currency.

The central insight of the asset-market approach is that exchange rates are crucially dependent on expectations, so that changes in them are mainly caused by changes in the underlying expectations resulting from "news".

Within the asset-market framework there are three different models that can be distinguished:

i) The flexible-price monetary model
ii) The sticky-price monetary model
iii) The portfolio-balance model with static or stable exchange rate expectations.

These three models represent most models which have been used to econometrically explain exchange rate determination in the period of floating. Basically they differ from each other by their underlying assumptions. The two first models are called monetary because money is the only asset whose supply and demand determine exchange rate. Other assets are assumed to be perfect substitutes in demand. No risk premia or portfolio preferences are assumed to exist.

This model assumes that both uncovered interest parity and purchasing power parity hold. It also assumes that prices are flexible. The model concentrates on the influence of relative price levels via PPP and it eliminates influences (ii)-(v) of the above framework. In this model the value of the domestic currency is negatively associated with the interest differential in its favor. Changes in interest rates in this model do not represent changes in relative yields: by the assumption of no risk-premia, yields are always equalized. Changes in the interest differential occur in order to offset changes in inflation and exchange rate expectations which would otherwise give rise to disparities in expected yields. Interest rates affect exchange rates only indirectly, via the demand for money. Exchange rates in the flexible-price monetary model are determined by domestic and foreign monetary conditions. Factors which do not affect the supply or demand for money at home or abroad do not affect the external value of the domestic currency.

This model does not assume that in the short run prices are sufficiently flexible to maintain money-market equilibrium or that the PPP holds strictly. In the domestic money market the domestic interest rate is the equilibrating variable. In the currency market exchange rate moves always instantaneously to the point where the uncovered interest parity condition is satisfied. With fixed prices in the short run the exchange rate determines the competitiveness. Competitiveness together with the interest rate helps to determine the demand for domestically produced goods. Again in the short run the output is fixed and domestic prices respond to the excess demand of supply of goods; this movement affects the competitiveness and also the interest rate via the demand for money. The economy moves towards a long-run equilibrium where the supply and demand for goods are in balance and the real exchange rate is not expected to change. This real exchange rate provides the anchor for expectations at each point in time - exchange rate expectations are assumed to be "rational" or consistent with the model. A further characteristic of this model is that when responding to monetary disturbances, the exchange rate will in the short run "overshoot" its new long-run equilibrium.

2.5.2 The portfolio balance model with static or stable exchange rate expectations

The portfolio balance model does not assume that currencies are perfect substitutes. It assumes that investors are willing to diversify their portfolios to interest-bearing assets in different currencies in non-zero amounts. The amounts depend on the relative yields of the assets. Asset market equilibrium does not require the equalization of expected yields, risk premia provide a conceptual measure of divergences between the yields. The supplies of interest-bearing assets and domestic and foreign money have to be brought into the analysis.

The proportion of wealth invested by domestic residents in each asset depends on their relative expected common-currency yields, and hence on interest rates on domestic and foreign bonds and the expected movement of the exchange rate. Movements in the exchange rate affect expectations about its future rate of change. Because the expectations are assumed to be stable the actual appreciation tends to reduce expected future appreciation and thus the relative expected yield on domestic assets.

When exchange rate changes investors revaluate foreign currency denominated foreign assets. Because domestic residents are assumed to be in net credit position abroad, domestic wealth falls when the exchange rate rises, but by smaller proportion than its foreign-assets components. These influences imply that a rise in the exchange rate will switch demand from domestic to foreign assets.

The exchange rate is viewed as being determined in the short run simultaneously with the two interest rates by the equilibration of asset markets. The portfolio balance model distincts the flexible interest rates and exchange rates from the sticky real variables. It also distincts the short-run responses of exchange rates as they help to equilibrate the asset markets from their longer-run responses after the adjustments of real variables have been completed. The long run is defined as the period in which asset supplies again become stationary. The current account should be in balance for this long-run equilibrium to hold. The PPP is not assumed to hold even in the weak form and purely monetary disturbances may change real exchange rates, even in the long run.

2.5.3 Econometric evidence of asset-market approaches

2.5.3.1 The monetary models

Some early empirical tests on the validity of the flexible-price model seemed to give relatively successful results (Hacche 1983, 34). The early optimism about the explanatory power of the flexible-price model has been challenged by the observation of data which contradict its distinctive prediction about the relationship between exchange rates and interest rates. Similar support was found for the sticky price monetary model over the period 1974-78, but subsequent econometric support for this model has also been relatively scarce. In 1983 Meese and Rogoff employed rolling regressions to construct out-of-sample forecasts of the exchange rate using three structural models including both the flexible- and sticky-price monetary models. All three of the structural exchange rate models were based on a common money demand specification. The quasi-reduced form specification of each of the models is subsumed in the general specification below:

$$(2.5.3.1) \qquad s = a0 + a1(m - m^{\wedge}) + a2(y - y^{\wedge}) + a3(r - r^{\wedge}) + a4(p - p^{\wedge}) + a5(TB - TB^{\wedge}) + u,$$

where (p - p^) is the expected long-term inflation differential. TB and TB^ are the cumulated U.S. and foreign trade balances, u is a disturbance term, (m -m^) is the money supply differential, (y - y^) the income differential and (r - r^) the real interest rate differential. In the flexible-price model a1 = 1, a2 is strictly negative, a3 strictly positive and a4 = a5 = 0. In the sticky-price model a1 = 1, a2, a3 and a5 are strictly negative and a4 is strictly positive. (Meese and Rogoff 1983, 84)
The random walk model is also subsumed in the general specification. That model is given by a1 = a2 = a3 = a4 = a5 = 0, and $u_t = u_{t-1} + e_t$, where e_t is a white noise process.

The selected structural models failed to forecast or even explain out of sample as well as the random walk model at horizons up to twelve months. The models did produce better forecasts than the random walk model at longer horizons. At thirty six months horizon the sticky-price model performed better than the other models and did about 50 percent better than the random walk model in root-mean square error and mean absolute error. Many researchers suggest that the reason for failure of the monetary models is the inadequate modeling of expectations formation in existing structural models. On the other hand, it may be impossible to construct a model that captures the expectations formation correctly.

2.5.3.2 The portfolio balance model

Some initial results for the portfolio balance model that were obtained from econometric applications were encouraging and suggested that the model fits data well. Some later results, however, showed much worse results. These results pointed out that "the empirical verdict of the utility of the portfolio balance model... must be judged unfavourable" (Martin and Masson 1979). The portfolio equilibrium model does not provide a complete theory of exchange rate determination because most of the explanatory variables are endogenous, except in the very short run. And even in the short run, the endogenous nature of exchange rate expectations is crucial.

2.6 The macroeconomic model

2.6.1 Theoretical framework

Until the mid 1980's the most widely accepted theory about the behaviour of the foreign exchange markets was Professor Rudiger

Dornbusch's theory, called the "macroeconomic approach". The following section describes Dornbusch's model (Dornbusch 1988). The generally accepted, simple model would look as follows:

(2.6.1.1) $y = a(p^{\wedge} + e - p) + b(i - p) + u$

(2.6.1.2) $m - xp - (1 - x)e = ky - hi$

(2.6.1.3) $i = i^{\wedge} + e$

(2.6.1.4) $p = c(y - y^{\wedge})$

where p and e denote the domestic prices and the exchange rate, y denotes output and i the home interest rate. The term $y^{\wedge}$ denotes potential output and m denotes money. ^ denotes foreign magnitude. All the other terms are positive constants. All variables are in logs, except nominal interest rates, and u is a disturbance representing foreign or fiscal policy. In this approach the asset market (equations (2.6.1.2) and (2.6.1.3)) clears continuously, but prices adjust only gradually. When the future values of exogenous variables - foreign interest rates, money and fiscal policy - are known or forecasted, the model can be solved for the level and path of output, prices and the exchange rate.

Macroeconomic approach provides an explanation for both short-run exchange rate fluctuations and long-run trend behaviour. In the long run the exchange rate and the price level react to unanticipated, permanent shocks in the same proportion. But in the short run, because prices are sticky, exchange rate overshoots its long-run equilibrium level. Model assumes that investors are rational and that asset market adjustment is instantaneous. The overshooting phenomenon is based on these assumptions: If a permanent shock changes the equilibrium home interest rate, exchange rate must react immediately to equalize the international returns. The higher (lower) domestic interest earnings must be offset by expected depreciation (appreciation) of the exchange rate. For expected depreciation the exchange rate must initially appreciate to such level that the interest differential makes the exchange rate to adjust back to equilibrium, in this case to depreciate to the long run equilibrium level. The immediate appreciation of the exchange rate overshoots the longrun equilibrium level of the exchange rate.

The model can also be expressed in terms of real interest differentials and the rate of depreciation of the real exchange rate. Let $q = p^{\wedge} + e - p$. Then we have:

(2.6.1.3a) $r - r^{\wedge} = q$

where q stands for the rate of depreciation , r and $r^{\wedge}$ are the home and foreign real interest rates. The dynamics of the real exchange rate in response to unanticipated, noncurrent money supply changes can be summarized in an equation for the real exchange rate:

(2.6.1.5) $q = q' - v(r - r^{\wedge})$,

where q' is the potential rate of depreciation. In addition to monetary shocks the model is applicable to fiscal or export shocks. A permanent fiscal expansion, for example leads to a real appreciation that crowds out fully the increased demand by an offsetting current account deterioration. The above model captures the forward looking nature of exchange markets, because the current values of interest rates, output and the exchange rate are determined by the future time paths of the exogenous variables.

2.6.2 Real exchange rate variability, interest rates and depreciation

The real exchange rate variability has increased during the flexible exchange rate period. This is not surprise for the macroeconomic approach, in fact the approach does predict the volatility of real exchange rates. This approach argues that real exchange rates move in response to news - the only question is that which news steadily move real rates.

The real effective exchange rate for U.S. appreciated considerably during 1980-85 period. The macroeconomic approach explains this appreciation of the dollar by fiscal policy developments in the U.S. and other industrialized countries. In the early 1980s U.S. fiscal policy became very expansionary where as in other industrialized countries fiscal policy was tightened. The dollar decline from 1985 to 1988 cannot be explained by fiscal policy developments - the view that dollar appreciation could be explained by fiscal policy developments has to be questioned.

The macroeconomic model can be used to explain a pattern of appreciation and depreciation. This can be illustrated for the simple

case of fiscal expansion, after being initiated is then gradually phased out. In terms of earlier equations we have:

(2.6.2.1) $\dot{u} = -z(u - u')$,

where u' is the longrun level to which the budget ultimately converges. The anticipation of the transitory nature of the fiscal expansion implies that following an initial real appreciation the real exchange rate then returns to its initial level.

Even if the broad pattern of the exchange rate behaviour could be explained by the anticipation of future fiscal correction it is difficult to account for the size of the movement in the real exchange rate. The decisive reason to question the macroeconomic model as a full explanation is that it cannot cover the relation between interest differentials and exchange rate depreciation which is central part of the model. Equation (2.6.1.3) in the macroeconomic model assumes that investors are risk neutral. The same equation is repeated here in discrete time and in a rational expectations version:

(2.6.2.2) $E(e_{t+1}) = e_t + i_t - i_{t^*}$

On the assumption of rational expectations the realized level of the exchange rate is equal to the expected level plus a white noise error. Thus the theory predicts that we should observe the following relationship:

(2.6.2.3) $e_{t+1} - e_t = i_t - i_{t^*} + v_{t+1} = i_t - i_{t^*} + \text{"news"}$

where the error term v_{t+1} is orthogonal to the interest differential and thus can be referred to as "news". i_{t^*} denotes foreign interest rates.
According to the model on average interest differentials should be matched by realized depreciation. The model can be tested by looking at the real actual numbers. Table 2 shows averages of the three-month interest differential as well as the depreciation rate during the year.

Table 2 Interest differential and depreciation (Percent per year) between UK-US, GERMANY-US and JAPAN-US in 1981-1987

	UK-US		GERMANY-US		JAPAN-US	
	Diff.	Dep.	Diff.	Dep.	Diff.	Dep.
1981	-2.55	25.5	-4.98	14.3	-12.14	8.3
1982	-0.71	17.7	-4.67	5.4	-6.3	7.3
1983	0.46	11.0	-4.12	14.6	-3.15	0
1984	-0.92	25.8	-5.41	15.6	-4.15	8.1
1985	3.85	-20.1	-3.06	-21.8	-1.72	-20.2
1986	4.11	-1.7	-2.22	-21.1	-1.66	-10.6
1987	2.62	-21.2	-3.12	-18.3	-2.92	-22.3

Note: diff. is the interest differential between a country and the U.S. Dep. measures the exchange rate of as country's currency relative to the dollar. Source: Dornbusch 1988

The divergences are so large that it is easy to see how interest rates fail to forecast depreciation. If the real exchange rate behaviour in the 1980s is to be explained by the anticipated fiscal developments the interest rate pattern must be consistent with the explanation. Interest rate differentials were far smaller than the realized rate of depreciation. One could think that the market responded to a sequence of fiscal contraction news. It is, however, difficult to document this news and it is also impossible to establish it in the joint behaviour of the dollar and longterm interest rates.

2.6.3 Goodhart's critique of the overshooting model

Overshooting model suggests that with the present high level of capital mobility, spot rates should jump beyond their longer-term equilibrium levels on the receipt of news affecting financial conditions. In order to create jumps, these news, should deviate from market's average expectation of the news. Different behaviour would be contradictory with the Efficient Market Hypothesis. If foreign exchange markets are efficient then the exchange rate must fully and instantly reflect all available information and expectations of future information.

Encouraged by his casual observations of the foreign exchange market Charles Goodhart tested empirically the existence of overshooting. During his seventeen-year-career in the Bank of England Goodhart witnessed several occasions when administered changes in interest rates, which must have come as something of a surprise to the markets, did not appear to bring jumps in the spot rate.

The test of overshooting hypothesis was formulated as follows: The occasions or events when the authorities in the UK acted to bring about a swift change in bank base rates were observed. Next step was to analyze how much of the change was anticipated by the markets. This was done by comparing various market interest rates at the close of business in the day before the change with the rate ruling at the close on the day of the change. Four sets of UK interest rates, 1- and 3-month Eurosterling and 1- and 3-month UK Treasury bill rates were used as proxies for an unanticipated, exogenous change in UK monetary conditions. When the estimate of the extent of an unanticipated change in interest rates and in interest rate differentials was obtained, the contemporaneous and subsequent effect of unanticipated change on spot and forward rates was examined. The data set included all fifty base rate changes between March 1981 and April 1986. (Goodhart 1987)

In the event Goodhart did not find any significant response of spot rates to the unanticipated element in the change in interest rates. The variation in the exchange rates was comparatively large on these days and according to Goodhart, largely unanticipated interest rate changes explain effectively none of the exchange rate fluctuations. In other words, there was not any systematic relationship between changes in exchange rate levels and interest rate changes.

Goodhart's other approach was to look at the time series behaviour of exchange rate. His interpretation of the overshooting hypothesis was that one would observe occasional large jump changes, several standard deviations larger than the norm, following the arrival of some (monetary) news, after which the exchange rate would revert slowly back towards its longer-term equilibrium. One could expect to find negative autocorrelation during quieter periods, when the market was slowly reverting to its norm.
Several studies of hourly and minute-to-minute data have indeed found that large changes in the exchange rate tend systematically to be partially reversed in the next hour (Ito and Roley 1986, Whistler

1987, Goodhart 1988). Actually, the size of immediate reversal, the scale of the negative first-order autocorrelation, following large exchange rate changes has been larger than would seem to have been consistent with the efficient market theorem. This is a very interesting finding, because it shows that exchange rates overreact continuously, when they react to news in the very short-run. This finding is against the efficient market theorem because the theorem excludes all free lunch opportunities in the market.

Goodhart argues that hourly data may describe the very short-term dynamics of how markets react to news, but that they are too transient to reflect the important major properties of the market. Goodhart accepts that overshooting model provides a good explanation of why the market might overreact in theory but he challenges those who believe this to show equivalent empirical evidence that the market does overreact to "news" in frequencies longer than hourly. Tests whether changes in spot rate exhibit autocorrelation and the more recent variance ratio tests appear to be more consistent with some initial slight persistence and inertia in the forex market at daily, weekly and monthly frequencies than with overshooting and subsequent reversion. It is, however, only in response to monetary shocks that the overshooting model should unambiguously exhibit overshooting. If in practice most of the shocks are non-monetary, findings of slight persistence would not be contradictionary with the model. Goodhart points out that what has not been established is that markets overshoot in response to news when they actually react to news.

Besides overshooting phenomenon model's lower-frequency, longer-term evolution of the real exchange rate towards the fundamental equilibrium level is also criticized. The theory seems to understate longer-term misalignments. Evidence from recent studies is clear that the long-run equilibrating forces in the forex market appear weak and uncertain in both strength and timing (Goodhart 1987, 7).

2.7 Failure of empirical exchange rate models

The macroeconomic model does well in the goods and labor market, but it explains poorly the price movements of longterm assets including exchange rates. The fact that interest rates fail to forecast exchange rate depreciation implies that there is no model that can

empirically give a satisfactory account of exchange rate behaviour. Structural models try to explain and forecast exchange rate behaviour with the fundamentals, but the fundamentals can explain only a small fraction of the realized exchange rate movements even ex poste. The error term seems to be the best explanatory variable. The difficulty with empirical models and economic fundamentals is that the exchange rate is not related to these variables in any simple and systematic manner. Because exchange rates, international interest rate differentials, and the trade balance or current account are all determined endogenously, there will not necessarily be simple and historically consistent relationship among them (Marrinan 1989, 48). Both the magnitude and direction of simultaneous movements in the exchange rate, the balance of trade, and other variables depend on the nature of the underlying disturbance facing the economy.

The basic message of the recent studies is important. The message is to look for alternative models of exchange rate expectations formation and speculation which are not necessarily closed by consistency of short and longterm speculation. In today's asset markets the average professional thinks he or she can liquidate a position before a major turn in the market. This can lead to the possibility of trading on noise which may generate cumulative exchange rate movements out of thin air, taking the real exchange rate far away from fundamentals. Unless there is strong, offsetting fundamentals speculation, these trips away from fundamentals need not to be neither small nor of short duration. The more diffuse the fundamentals are the more room there is for short run speculation to dominate and hence for exchange rates to depart from fundamentals (Dornbusch 1988, 26).

2.8 Is speculation stabilizing or destabilizing?

Milton Friedman originated the claim that speculation should be destabilizing. Any class of speculators who add to the variance in the exchange rate must be buying when the price is already high and selling when the price is already low; this kind of behaviour causes continuous losses and such speculators should disappear from the market over time. Speculation is also stabilizing in the Dornbusch overshooting model. The high volatility of exchange rates is a result of sticky prices in goods markets combined with instantaneous adjustment in asset markets, not of speculation. When the currency

appreciates in the short-run overshooting equilibrium, the investors recognize that it will depreciate in the future toward long-run equilibrium; in response they sell the currency and dampen the original appreciation. The movement in the exchange rate turns out to be smaller than it would have been in the absence of speculation. (Dornbusch 1987, 8)

It appears, however, that little of the speculation that takes place is stabilizing. It seems that expectations are not rational and that expected exchange rate changes - as reflected in either the forward discount or surveys of market participants - are biased forecasts of actual exchange rate changes.

Even if speculation is rational, it may not be stabilizing. All the random-walk, or "near random-walk" results imply that it would be rational for investors to base their expectations as to the future spot rate almost entirely on the current spot rate, and not at all on an estimate of fundamental equilibrium. If "expected depreciation" is a variable that is always equal to zero, then it cannot have a stabilizing effect on investor behaviour (Dornbusch 1987, p. 20). There is some evidence, that most market participants pay little direct attention to fundamentals. By 1985, most of the forecasting services that appear in an annual survey by Euromoney were described as using technical analysis. "In the early 1980s, the surveys appeared to have convinced many readers that forecasts could be used profitably and that the most profitable foreign exchange forecasters were technical rather than those who focused on economic fundamentals" (Euromoney August 1987, 121). The 1987 survey of services reported that none offered pure fundamentals forecasts, 5 offered fundamentals forecasts at longer horizons and technical analysis at shorter horizons, 3 offered forecasts combining the two techniques, 13 offered only technical analysis, and 4 did not specify a technique.

Most short-term variability of the exchange rates seems to be unrelated to news. There are two serious empirical problems with the standard theory. The proportion of exchange rates that is forecastable in any manner - by the forward discount, interest differential, survey data, or models based on macroeconomic fundamentals - appears to be not just low, but almost zero (Dornbusch 1987, 21). The proportion of exchange rate changes that we can explain ex post after we have observed the contemporaneous macroeconomic determinants also

appears to be low. Exchange rates must be reacting to something else, either economic variables that are unknown to the economist, or to "irrelevant" noise.

Probably the best way to find out whether speculation is stabilizing or destabilizing is to consider how expectations are formed, i.e. whether expected future depreciation responds positively or negatively to a current change in the exchange rate. If a current depreciation generates anticipations of further depreciation, speculators will sell the currency and thereby exaggerate the depreciation. If it generates anticipations of future appreciation, speculators will buy the currency and thereby dampen the depreciation.

3 EXPECTATIONS FORMATION IN THE FOREIGN EXCHANGE MARKET

3.1 Rational expectations and the forward discount

As rational expectations have become a popular benchmark in thinking financial and macroeconomic hypotheses, many economists have become more interested in directly measuring expectations of market participants. However, it is only recently when survey data on foreign exchange rates have become available and been analyzed (Ito 1988, 1).

Frankel and Froot have shown extensive evidence of large discrepancies between forecasts gathered from market surveys, forward premia and realized depreciation. Table 3 shows some of their data for the yen/dollar exchange rate. One can clearly notice that forecast averages differ widely from forward rates and from realized depreciation. Table 3 shows that the forward discount is a biased predictor of the future spot rate. Large econometric literature statistically rejects the hypothesis that the forward discount (or equivalently, by covered interest parity, the interest differential) is an unbiased predictor of the future spot rate. The most common test in this literature is a regression of the ex post change in the spot exchange rate against the forward discount at the beginning of the period.

Table 3 Frankel-Froot Dollar-Yen data
(Percent per year, sample average)

Period	Horizon	Actual	Survey	Forward discount
10/84-2/86	1 month	10.1	-11.91	-3.85
6/81-12/85	3 months	-6.43	3.66	-0.06
6/81-12/85	12 months	- 9.47	3.38	0.36

Note: The one month forecasts are from one survey, the 3 and 12 months forecasts from a different survey.
Source: Frankel and Froot 1986a.

Under the null hypothesis the coefficient should be unity. Most authors have rejected the null hypothesis, finding that the coefficient is much closer to zero, and some even finding that the coefficient is of the incorrect sign. This implies that one could expect

to make money by betting against the forward discount whenever it is non-zero. (Frankel and Froot 1986c, 2-6)

Most of the literature does not interpret this finding as necessarily rejecting the hypothesis of rational expectations. Two other explanations are given: the existence of risk premium and the "peso problem".

3.1.1 Risk premium and the forward bias.

The first possible explanation for the systematic prediction errors made by the forward market is a risk premium separating the forward rate from investors' true expectations. Because expectations are not directly observable it is difficult to refute or confirm this argument; more information is needed. The theory of optimal portfolio diversification says that the risk premium should be related to such factors as the degree of investor risk aversion, the "outside" supplies of nominal assets denominated in various currencies, the variance-covariance matrix of exchange rates, and covariances with returns on other assets and opportunities. It seems plausible that a positive risk premium on dollars of this type explains some positive fraction of the 1985 forward discount (or interest differential) given the great increase in recent years in the supply of dollar assets as a share of the world portfolio, relative to the likely determinants of demand (i.e. given the record federal budget and current account deficits without likely corresponding movements in residents' minimum-variance portfolios). The theory of optimal portfolio diversification together with the standard estimates of the coefficient of relative risk-aversion being in the neighborhood of 2.0 implies that the magnitude of the risk premium is on the order of only a few basis points. Unless the true coefficient of risk-aversion is much higher than is conventionally thought, the risk premium cannot explain more than a small fraction of the bias in the forward discount. (Frankel and Froot 1986c, 8)

There are alternative sources of information to help isolate the risk premium out of the prediction errors made by the forward discount. The Economist's Financial Report and the American Express Bank Review conducted a survey of market participants' exchange rate expectations between 1981-85. Frankel and Froot (1985) showed that those data reflect a considerably greater expectation of dollar depreciation than do the forward discount or interest differential.

They repeated standard tests of unbiasedness in expected depreciation and found even more significant rejections when the survey data, which must be free from any risk premium, are used than when the forward discount is used. One would have persistently made money in the early 1980s either by following the rule "buy and hold dollars" (unconditional bias) or by following the rule "always bet against the forward discount". Another paper by Froot (1985, 21-23), shows that the rejection of rational expectations holds up even if one allows for measurement error in the survey data: one can reject the hypothesis that expectations are rational and that the apparent bias in the survey numbers is entirely due to measurement error. In addition, Froot tests the hypothesis that no information about the risk premium is revealed in regressions of the ex post change in the spot rate on the forward discount. This hypothesis cannot be rejected, suggesting that the risk premium does not help explain why changes in the forward discount mispredict future changes in the spot rate (Frankel and Froot 1986c, 10).

3.1.2 A test of Safe-Haven hypothesis

The survey numbers imply a large negative risk premium paid on dollar assets during the 1981-85 period (a sharp decline from the near-zero risk premium in the 1970s). Standard tests of bias in the forward discount imply positive risk premium and portfolio optimization near-zero risk premium. According to standard portfolio considerations a negative risk premium is not plausible.
The exchange risk premium in theory should depend on such variables as asset supplies and on return variances and covariances. Asset supplies should be driving the dollar risk premium up, not down, because of the large U.S. budget and current account deficits. One could explain the negative dollar risk premium with an increase in the perceived riskiness of European currencies relative to the dollar, attributable to for example to an increase in uncertainty regarding European monetary policy relative to U.S. monetary policy. The riskiness of European currencies should drive European interest rates up and thus, it would be difficult to explain the increase in the U.S. interest differential after 1980; by itself a shift in demand toward U.S. assets due to uncertainty should have driven U.S. interest rates down.

The so-called "safe haven" explanation has been seriously proposed to explain the dollar appreciation in the 1980s that is consistent

with both a fall in the risk premium on dollars and an increase in the interest differential. This explanation suggests that there has been an exogenous shift in demand toward U.S. assets due to perceptions of reduced country risk in the United States relative to abroad. According to this theory, risk has declined in the United States because of an improved business climate, in particular improved tax treatment for investment after 1981, which also explains the increase in U.S. real interest rates via an alleged investment boom. Risk has increased in the rest of the world. In addition to the debt problem in Latin America political and country risk in Europe has increased.

Frankel and Froot conducted a simple test to evaluate the safe haven hypothesis. They compared interest rates paid on securities that are physically located offshore, but that are denominated in dollars or otherwise covered on the forward exchange market to get around the problem of exchange risk. In other words, they tested international closed, or covered, interest parity. They concluded that safe-haven explanation cannot explain the continued dollar appreciation from 1982 to February 1985 any better than real interest fundamentals. This conclusion appears to open the field for bubble theories.

3.1.3 The Peso Problem

The "Peso Problem" is an alternative explanation that can support the possibility of rational speculative bubble. This explanation is often given for the econometric findings of biasedness in the forward exchange market. The standard tests presume that the error term, the difference between expected depreciation and the ex post realization, is distributed normally and independently over time. But if there is a small probability of a big decline in the value of the currency, like an expected devaluation, the distributional assumption will not be met, the estimated standard errors will be incorrect, and the apparent rejection of unbiasedness may be spurious. This problem is thought to be relevant for pegged currencies like the Mexican peso up until 1976, and normally less relevant for floating currencies. If the dollar was on a single speculative bubble path for four years between 1981-85, there could well have been a small probability of a large decline in the form of a bursting of the bubble. It has been suggested that the forward discount may have properly reflected that possibility, and that tests found bias only because the event didn't happen to occur in the sample.

Calculations in Frankel (1985) find that the chance that such a bubble would have persisted for four years without bursting is only 3 percent. Thus the peso problem cannot give reasonable explanation. The period during which the forward discount was positive with no realized depreciation continued for so long that the rational expectations hypothesis cannot give satisfactory explanation.

3.2 Are expectations rational in the foreign exchange market?

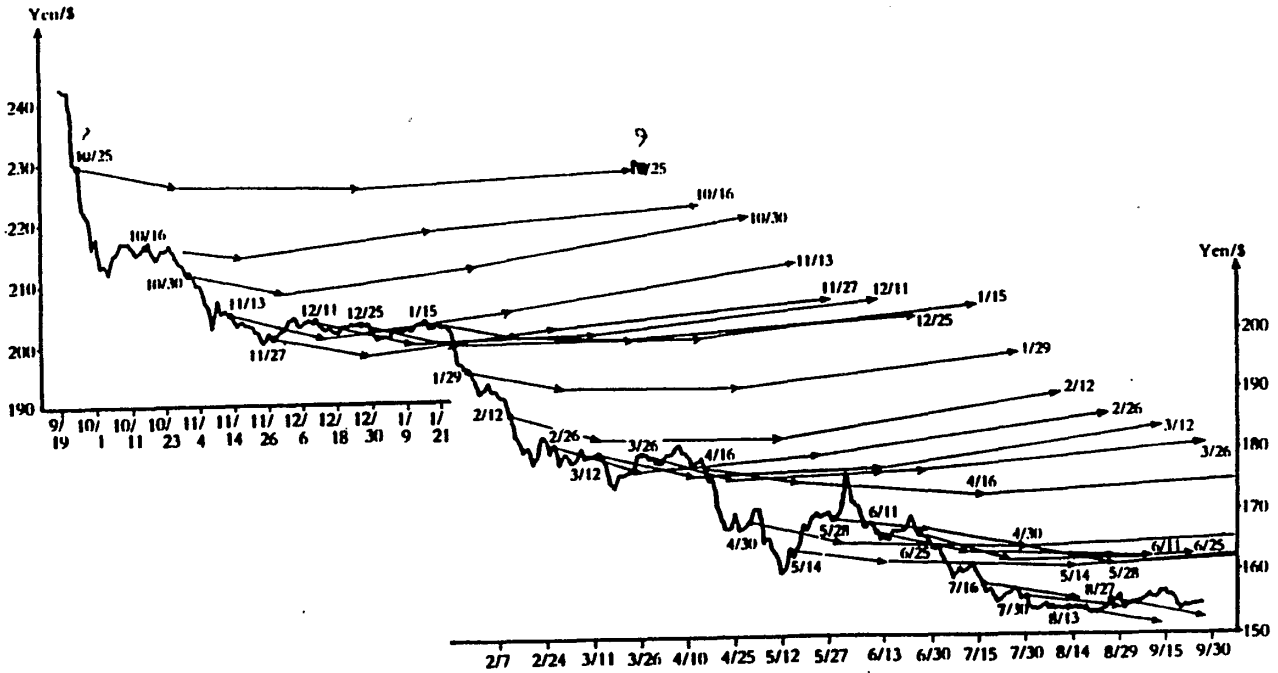
3.2.1 Data summary

Takatoshi Ito conducted a study on the consistency of foreign exchange market expectations among market participants in the Tokyo market (Ito 1988). His study is perhaps the most detailed study in this particular field so far including 44 different reporting agents.

The data was collected twice a month with a telephone survey, in the middle and the end of the month, on wednesdays since May 1985 till June 1987. Forecasts for the yen/dollar exchange rate for one-three-, and six-month horizons were obtained from foreign exchange experts in 44 companies: 15 banks and brokers, 4 securities companies, 6 trading companies, 9 export-oriented companies, 5 life insurance companies, and 5 import-oriented industries. It is important to have a data set with individual responses rather than one with summary or statistics, because distributions of individual responses, which are discussed later, are quite different.
The total average, standard deviation, maximum and minimum of 44 responses and also industry group averages and standard deviations were calculated. On the day after the survey the members were informed of the summary statistics. The overall average was also released to the press and other media. The unit in the study was yen per one U.S. dollar, so that negative movement indicates yen depreciation.

Figure 2 illustrates the average expectation and the movement of actual exchange rates during one year period from September 1985. The solid line is the actual daily spot rate, while the base of each sequence of three rows shows the timing of the poll and the spot exchange rate of that day. Three arrows point to the average forecasted exchange rate with the one-, three- and six-month horizons. The vertical deviation of the tip of an arrow from the spot rate line represents an ex post mistake of expectation.

Figure 2
The average expectation and the movement of actual exchange rates in the Yen/$ market between September 1985 and September 1986



Source: Ito 1988.

It appears that the market didn't anticipate several waves of sharp yen appreciation. Also the long-run expectation of the market is not the simple extrapolation of the short-run expectations.

Table 4 shows us in more detail the time means of expected percent changes from the spot rate at the time of survey for the cross section total average, group averages and in a separate distribution table for each individual. The mean of forward premium (FOR) and the actual ex post changes of the spot rate (ACT) are reported in the same table. The difference of the forward premium and the forecasts yields the implied risk premium for each horizon and each individual group.

Table 4
Time means of expected changes from the spot rate (Yen/$) for the cross-section total average and group averages between May 1985 - June 1987

Horizon	1 month	3 month	6 month
Ave	-1.420	-1.431	-0.044
Ban	-1.404	-1.658	-0.957
Sec	-1.097	-0.834	+0.621
Tra	-1.956	-2.453	-0.948
Exp	-0.775	-0.137	+1.736
Ins	-1.746	-2.309	+0.302
Imp	-1.937	-1.536	-0.430
FOR	-0.150	-0.430	-0.957
ACT	-2.064	-5.970	-11.987

Source: Ito 1988.

In a one month horizon all groups did better in forecasting than the forward rate. Most of the participants had a positive risk premium for the dollar. The total average on a typical week expected a 1.4 % yen appreciation, the group averages ranged from 0.8 percent to 2 percent appreciation.

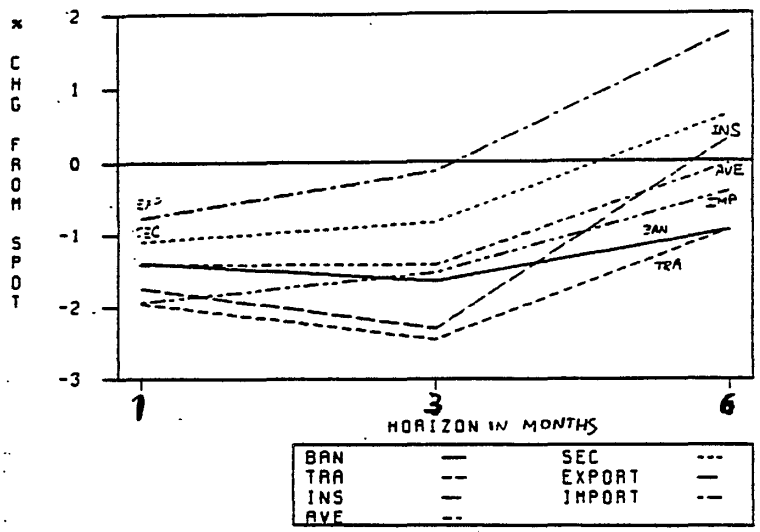
The three month average expectation was nearly the same as the one month expectation. In the aggregate forecast participants expected little movement after the first month to the third month in the forecast horizon. However, the examination of individual responses shows that there was a wide disagreement among forecasts in the three month horizon: one group believed that yen would depreciate from the one-month to three-month in the forecast horizon, while the other believed that yen continues to appreciate.

In the six-month horizon, forecasters expect uniformly yen to return to its original level. This expectation implies a negative risk premium for the dollar. This contrasts to the positive risk premium in the one-month horizon. The agreement among different groups in forecasting the sharp yen depreciation from the third to the sixth

month is quite surprising, because they differ in forecasting the direction of the yen from the first to the third month.

Figure 3 shows that the degree of diversity of the individual forecasts increases as the forecast horizon is longer. Looking only at the averages of figure 2 wouldn't give this observation.

Figure 3
The average individual 1-, 3- and 6-month group forecasts in the Yen/$ market between September 1985 - September 1986



Source: Ito 1988

These results above are highly suggestive of heterogeneous market participants. They also show that short- and long-horizon forecasts form a "twist", the former predicting appreciation and the latter depreciation.

3.2.2 Wishful expectations, heterogeneity and rational expectations

The individual forecast formation at time t was supposed to consist of the common structural part based on the public information, $f(I(t))$ and the individual effect, e_j. The expected exchange rate for individual j is

$$S_j(t) = f(I(t)) + e_j + u_j(t) \qquad (3.2.2.1)$$

where $S_j(t)$ is a k-step ahead forecast of the spot exchange rate at time t, by individual j, $u_j(t)$ is a pure random disturbance representing, for example, a forecast error.

It was assumed that the structural part and past values of the exchange rates in exchange rate forecasts are identical for all individuals, but with possibly different coefficients. Half of the 44 individuals in the study had a significant bias in their forecast. Exporters had a depreciation bias in their expectation formation in relation to importers and trading companies. One could explain the formulation of biases or individual effects by different models being used. The study shows that the heterogeneity is more like a constant bias rather than difference in how to react to the recent changes in the exchange rate.

The rational expectations hypothesis requires that market participants are homogeneous in their formation of expectations, because the true stochastic process is unique. Therefore Ito's study results cast some doubts to the homogeneous agent model commonly used in finance and macroeconomics. Heterogeneity could be consistent with rational expectations if agents were slow learners due to a strong biased individual prior. The study noticed some group effects in the expectation formation process. Different groups tended to form wishful expectations consistent with the groups interests. Exporters wished yen to depreciate in the future when importers on the contrary reflected a wish for stronger yen in their forecasts.
This "wishful" expectation may be a reflection of non-rational honest mistakes in expectation formation.

If forecasts are rational, the forecast errors should be random, survey forecasts should be unbiased. Rational expectations assume that forecast errors should be uncorrelated with any information available at the time the forecast is made. Otherwise it would be possible to make a better forecast by using the variable correlated with the ex post error. Ito's study shows that most market participants violate a necessary condition of the rational expectations hypothesis in that their forecasting methods could benefit from analyzing the relationship between their own forecast errors and information available at the time of forecasting.
Under the null hypothesis of rational expectation, the realized spot rate is the sum of a forecast and a forecast error:

$$s(t+k) = se\ (t,k) - e(t,k) \qquad (3.2.2.2)$$

where e(t,k) is mean zero forecast errors and uncorrelated with any variables available at t (Ito 1988, 14). The past forecast errors

se(t-k,k)-s(t), the forward premium f(t,k)-s(t) and the recent actual change in the spot rate s(t-k)-s(t) have been popular candidates in the literature for a variable in the information set to correlate with forecast errors. Ito regressed the ex post forecast errors on these candidate variables and found that for the six-month horizon the null hypothesis was unanimously rejected.

The variables in the information set are not restricted to those tested above. When the second lagged term was added in regressing the recent movement of the exchange rate, the number of rejection cases increased dramatically to cover also the shorter horizons. Thus in all horizons, the forecasting methods could have benefitted from analyzing the relationship between their own forecast errors and information available at the time of forecasting.

3.2.3 Expectational twist

As table 4 shows, the average market participant expected 1.42% appreciation in one-month, 1.43 % appreciation in three-month and only 0.04% appreciation in six-month horizon. The short-term expectation is one of bandwagon type but the long-term expectations show some regressive characteristics. By observing the figure 2 one can notice "twist " in the arrows. The long-term expectation is more stabilizing than the short-term one.

A long term forecast should be identical to a result of sequential substitutions of short-term forecasts if an expectation formation is internally consistent, given a function of expectation formation. Thus the consistency of expectation formation process becomes a testable hypothesis. Expectation formation can be consistent even in the presence of a twist, if it is sufficiently complicated to allow for non-linear forecasts.

In Ito's test consistency was overwhelmingly rejected. One common reaction from market participants to the result of rejecting consistency was that they used different economic variables for forecasting the future spot rate with different horizons. Technical analysis was being used in the short-term, while other factors, like balances of payments, inflation and interest rate differentials etc., come into consideration for long-term horizon. If these factors are relevant in the long run, they should matter also in the short run. The results of the study indicate that market partici-

pants who trade every minute, are naive enough to give inconsistent forecasts of months ahead.

The actual trading in the foreign exchange market is done on much shorter horizons than the forecast horizons in the study. Even the shortest one-month horizon may be irrelevant from trader's point of view. The violation of rational expectations hypothesis in the forecast formation does not necessarily imply that the actual trading decisions (that affect the formation of the spot rate) would be made irrationally.

Ito's study's main conclusions are that market participants are heterogeneous and rational expectation formation doesn't hold in the Tokyo foreign exchange market. What would these results imply for the formation of the spot rate?

Investors do behave irrationally if they form wishful expectations. In the case of export and import companies and trading houses this behaviour is understandable. A genuine investor, however, cannot form wishful expectations because for him it doesn't matter which particular currency offers him the best return. Today's foreign exchange markets are dominated by international investors, who seek the best returns in their view best performing currencies.

3.3 Consistency of short-run and long-run exchange rate expectations

3.3.1 Consistency as a testable hypothesis

Property called consistency is weaker property than rationality. Consistency does not require that the expectations process match the stochastic process generating actual exchange rates. Consistency is a necessary condition if expectations are to be rational. (Froot and Ito 1989, 488)
Froot and Ito examined whether short-term exchange rate expectations 'overreact' by comparing them with long-term expectations (Ito and Froot 1989). The aim of the study was to test whether agents' expectations at different forecast horizons lead to equivalent predictions of the level of the exchange rate far into the future. If expectations at different forecast horizons lead to different predictions, consistency of expectations is rejected. Short-term expectations may be said to be inconsistent relative to long-term expectations if a positive shock to the exchange rate

leads agents to expect a higher long-run future spot rate when iterating forward their short-term expectations than when thinking directly about the long run. In other words, investors exaggerate the implications of current exchange rate change for the value of the spot rate in the short-term compared to the long-term.

In the following we will shortly describe the steps being used to test consistency of expectations. Variable $e_{k,t+k}$ denotes the k-period change between t+k and t in the log of the spot rate expressed in terms of dollars per unit of foreign currency. The market's expectation at time t of the log percentage change over the same period is denoted by $m_{k,t+k}$. It was assumed that one-period-ahead expectations are formed as a linear combination of current and lagged spot rate changes, $a_1(L)e_1$, plus other residual factors that are conditionally independent of current and past exchange rate changes:

$$(3.3.1.1) \qquad m_{1,t+1} = \tau_1 + a_1(L)e_{1,t} + \mu_{1,t}$$

where $E(\mu_{1,t}/e_{1,t}\ldots e_{1,t-p+1}) = 0$, L is the lag operator. Similar to equation one, the market's expectation of depreciation over the subsequent k periods is given by :

$$(3.3.1.2) \qquad m_{k,t+k} = \tau_k + a_k(L)e_{1,t} + \mu_{k,t}.$$

In developing the test of consistency, the long-horizon forecasts in equation (3.3.1.2) were expressed in terms of the parameters from equation (3.3.1.1). Then certain restrictions (which are not discussed here) were derived. Assuming that short-term expectations are formed according to equation (3.3.1.1), long-term expectations are consistent only if the restrictions are satisfied. The parameters in equations (3.3.1.1) and (3.3.1.2) can be estimated consistently in a statistical sense using OLS.

In the simplest case agents use only the most recent change in the spot rate to predict the subsequent change. The derived restrictions require that if agents have short-term bandwagon expectations, i.e. they extrapolate past exchange rate changes into the future, then they must have long-term bandwagon expectations if their expectations are to be consistent. Considering the concept of consistency, evidence that short-term expectations are of bandwagon type while

long-term expectations are of the distributed lag type would imply inconsistency.

Study used four surveys on foreign exchange rate expectations as its data base. The first survey is conducted by the Economist Financial Report. Each six weeks since mid-1981, the report has polled currency-room traders and economists at 14 major banks for their expectations of the value of the dollar against five currencies (the pound, French franc, Deutch mark, Swiss franc, and yen) in three-, six- and 12-months' time. The second and third surveys have been conducted by phone on a weekly basis since early 1984 by Money Market Services. About 30 traders report weekly their expectations of the value of the dollar against four currencies at horizons of one week and one month. The fourth survey was the same that Ito used from the Tokyo foreign exchange market, described earlier in page 34. The independent measure of the market's expected future spot rate was the median survey response from these four surveys. The estimation method, however, allowed for different sources of measurement errors and it was assumed that the median investor's expectation reported by each survey was an imprecise estimate of the market's expectation. The regression results reveal that for all data sets and currencies, only the shorter-term, one-week and one-month forecasts are related positively to the past exchange rate change. One-week forecasts showed particularly strong bandwagon effects. Bandwagon expectations do not appear at any of the longer horizons. The results indicate that the short-term expectations overreact in comparison with long-term expectations.

Because it is difficult to interpret the economic importance of all regression results the graphical implications of the results were studied. Following experiment was carried out. The exchange rate was assumed to be in a steady state in which current and past exchange rate changes are equal to zero. Then the spot rate was shocked and its expected future path was traced as implied by both the short- and long-horizon forecasts.
This experiment supports the earlier results, i.e. that shorter-term expectations are more explosive than longer-term expectations.

When the Economist data was used, for all three forecasting horizons part of the original 1 percent dollar appreciation was undone, so the long-run expected exchange rate increases less than proportionately in response to current shocks. This indicates that investors

believe there is a statistically and economically significant temporary component to exchange rate changes. They do not believe that exchange rates follow a random walk even over horizons as short as three months.

If this 'significant temporary component' really exists one should be able to find an explanation for it. In a sense this same phenomenon was found by Goodhart (Goodhart 1987). Goodhart's study didn't try to explain this phenomenon, it rather regarded this to be further evidence against efficiency in the foreign exchange market. Plausible explanation for this anomaly would explain why expectations tend to be inconsistent.

3.3.2 Conclusions

The overall results of the study show that expectations generally fail to be consistent. Investors seem to fail to coordinate their predictions. In their shorter-term forecasts investors tend to exaggerate the implications of current exchange rate changes for the value of the spot rate further into the future. In every one of 20 sets of time-series estimates shorter-term expectations overreacted relative to longer-term expectations when the exchange rate changed. Unless all four survey sources being used systematically mismeasure the market's true expectation or the tests are misspecified, plausible explanation for expectations' inconsistencies should exist. If agents use different models to forecast the spot rate at short versus long horizons, short-run and long-run exchange rate expectations can be 'inconsistent' in the way defined above.

Evidence from earlier studies and market inquiries (Ito 1988, BoE 1989) supports the idea, that different models and forecasting methods are being used at different horizons. The logical question to be asked next is that is it inconsistent to forecast future exchange rates at different horizons with different models. Both (Ito and Froot 1989) and (Ito 1988) suggest that market participants use different forecasting methods in different horizons. Short-term expectations tend to be "explosive" and regressive. Most of the foreign exchange market volume is generated by short-term interbank trading (look page 98). Thus short-term expectations are more important element in the exchange rate determination than long-term expectations. If investors behave consistently with their expectations, their behaviour can be destabilizing and accordingly specu-

lation would be destabilizing, potentially leading exchange rates to deviate from fundamentals.

These studies also find that technical analysis is widely used in short-term forecasting. The next section discusses technical analysis in more detail.

3.4 Technical analysis in the foreign exchange market

3.4.1 Introduction

In studying the role of non-economic or non-fundamental factors recent research in financial economics has concentrated on speculators in asset markets. Major, and perhaps the most important form of non-fundamentalist analysis in financial markets is technical analysis, or chartism. In order to ascertain the influence and widespreadness of technical analysis among foreign exchange market practitioners, Bank of England conducted a questionnaire survey of chief foreign exchange dealers in the London market in 1989 (Bank of England 1989). The survey had a wide coverage of dealing institutions and over 200 responses were received and analyzed.The aim of the survey was to assess the manner in which chartism is used in the foreign exchange market - the methods used in practice, the input of chartists into trading decisions and the importance which the actual market participants attach to chartism. Before this study, virtually no work exists on the extent and manner by which chartism is used in the foreign exchange markets and whether the techniques in any way contribute to price movements.

In principle an essential difference between chartists and fundamentalists is that chartists study only the price action of a market, whereas fundamentalists try to find and predict the reasons behind that action. Chartists think that the market price embodies all aspects of the market balancing all the forces of supply and demand. These aspects include both fundamentals and non-fundamentals, disregarding whether they are rational or irrational. The market price is seen as nearly immediately discounting all relevant information and therefore encompassing all the fundamentalists' views. If all market information was automatically reflected in the price, market participants would not have incentive to gather costly information, in which case it is hard to see how information gets discounted into market prices. The agents get the incentive to gather and process

new information from the possibility to make abnormal profits by very short-term arbitrage.

Basic chart analysis tries to visually identify recurring patterns in time series price data. The most important patterns include trend reversals and continuation patterns within established trends. Chartists will often identify broad ranges within which exchange rates or asset prices are expected to trade, and the upper and lower limits of such ranges are called "resistance" and "support" levels respectively. When forming a general view technical analysts generally also employ one or more 'mechanical indicators', such as moving averages and price oscillators. Moving averages are used to identify trend reversals. Oscillators calculate the rate of change of prices, with the assumption that there is a tendency for markets to 'correct' when an asset has been 'overbought' or 'oversold'. Technical analysis is also used to provide quantitative level of fundamental view.

3.4.2 Technical analysis and the market - the surveys results

Chartism appears to be most used for forecasting over short time horizons. Obviously there is a lack of immediate economic data at such frequencies. Approximately 90% of respondents use some chartist input in forming their exchange rate expectations at the shortest horizons, intraday to one week. Some 60% judge charts to be at least as important as fundamentals. The weight given to fundamentals increases at longer forecast horizons, of one to three months or six months to one year. At horizons above one year nearly 30% of respondents rely on pure fundamentals and 85% judge fundamentals to be more important than charts.

Survey participants' comments indicate that technical analysis is important in measuring swings in market psychology, which may dominate the price movements in the shorter term but may be harder to forecast over the longer horizons. Chartism may actually obscure the underlying fundamentals over the shorter horizons, charts merely prevent fundamentals coming through over the short term. Because charts are widely used as trading tools they can be self-fulfilling. This was explicitly stated by some 40% of respondents. Many comments in the survey sample bore the suggestion that sophisticated speculators will not trade purely on consideration of economic fundamen-

tals, but will also aim to exploit market movements generated by non-fundamentalists.

In participants' opinion chartist and fundamental approaches to exchange rate analysis are rather complementary than competing. Only 8% replied that they thought the approaches to be competing to the point of being mutually exclusive. Respondents' general comments implied that charts should be used to confirm but not contradict the message from fundamentals. Often technical analysis is used to quantify the level of price movements initiated by fundamental views. Almost exactly a quarter of respondents reported that their organization employs in-house technical analysts, when 38% reported having in-house economists. 21% of respondents relied on advice from outside commercial chartist companies and 43% subscribed to particular chartist publications. Some 74% of respondents reported using some form of on-line data and graphics computer services. (Bank of England 1989, 4)

It is difficult to create a mathematical or statistical model that would adequately reproduce chartist behaviour. Chartist advice is largely subjective and dependent in construction upon the individual chartist's approach. In order to get a representative way of collecting chartist advice, researchers constructed a survey database of chartists' exchange rate expectations. Each contributor could employ whichever methods were felt to be the most appropriate to the particular market situation.

Data was collected by a weekly telephone panel over the period June 1988 -March 1989. Panel included chartists who were highly regarded in the City (London's financial area) both by fellow chartists and by foreign exchange dealers. Survey recorded each analyst's expectations with respect to the sterling-dollar, dollar-mark and dollar-yen exchange rates for one and four weeks ahead.

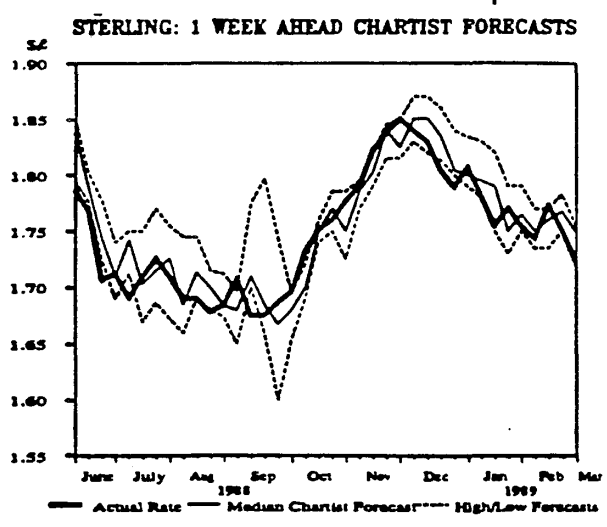
Figures 4a-f show the sample median, high and low chartist forecast for each currency and time horizon, together with the materialized spot rate. The forecasts are shifted forward so that points vertically in line on the graphs compare predictions with actual outcomes. Figures point out that prediction errors are noticeably greater at the four-week horizon. Forecasts tend to miss turning points and forecast errors seem to narrow when the exchange rate is trending. There is also a broad tendency to underpredict in a rising

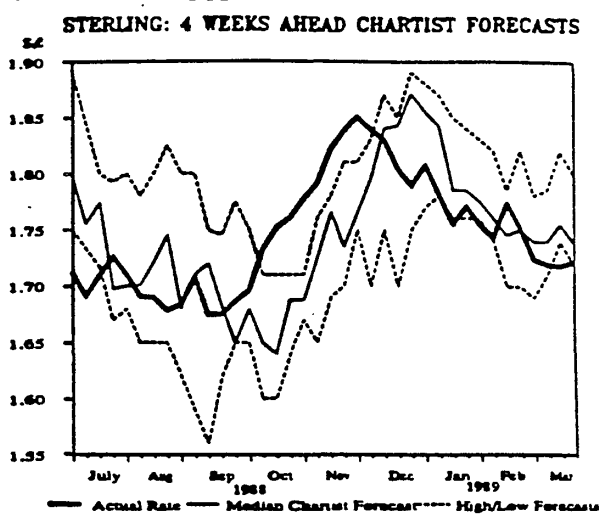
market and to overpredict in a falling market. This suggests that the average "elasticity of expectations" is less than unity - a 1% rise (fall) in the rate appears to induce a less than 1% expected rise (fall) next period. Intuitively one would expect forecasts to be correct on 50% of occasions purely by chance. This seems to be close to survey forecasts' qualitative correctness.

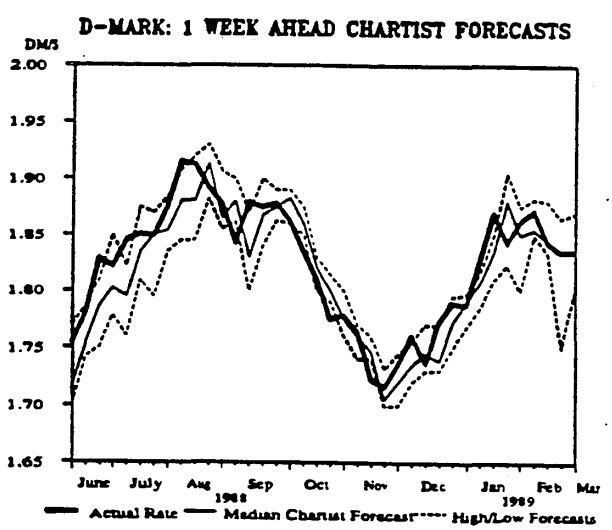
These figures also suggest chartists' expectations to be extrapolative. The formal tests on the systematic differences in the accuracy of forecasts among the panel suggest that there are systematic differences in forecast accuracy among chartists, and that at least one chartist appears to be systematically more accurate than the group average. The accuracy of chartist predictions was also compared with various economic and statistical approaches, using the root mean square error of the forecasts of each.

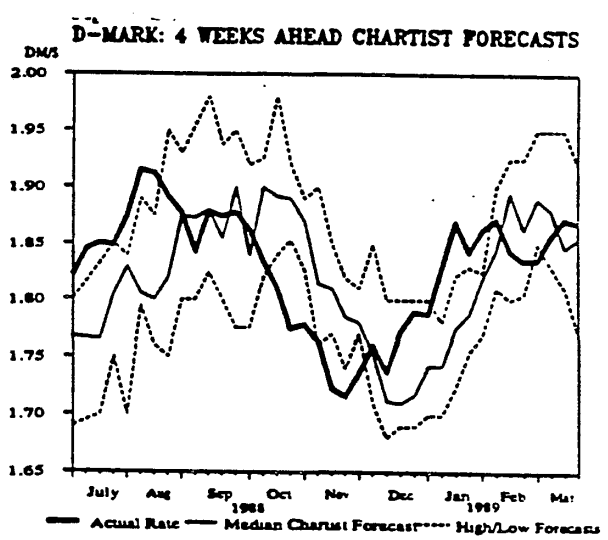
Figure 4a-f

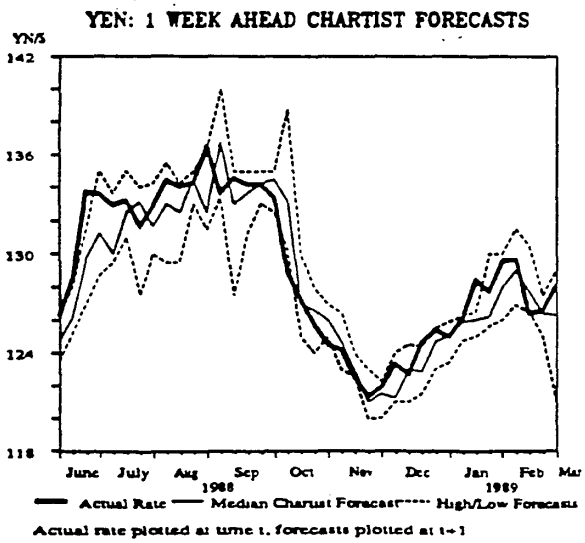
Graphs of the sample median, high and low chartist forecast for the £/$, DM/$ and Yen/$ rates for 1 and 4 weeks ahead with the actual materialized rate over the period June 1988 - March 1989

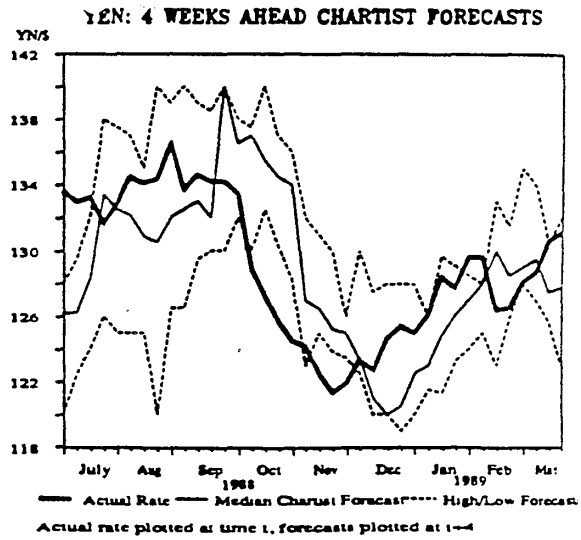












Source: Bank of England 1989A

The results showed that there are substantial differences between individual chartists. One chartist appeared to be particularly accurate across all currencies and time horizons and was the only chartist consistently to outperform the median. On aggregate it was clear that the median chartist view was generally unable to outperform a random walk. This is a significant finding, as Meese and Rogoff 1983 found that no economic model was able to outperform a random walk in out of sample forecasting tests.

3.4.3 Technical analysis - stabilizing or destabilizing?

To test whether chartists' expectations are stabilizing or destabilizing one has to formalize different expectation patterns and then regress these against available data.

In the following alternative expectations hypotheses S_t denotes the spot rate at time t, ${}_tS^e_{t+n}$ the expected value of S_{t+n} at time t, S°_t is the "equilibrium" exchange rate at time t and d is the first-difference operator (Bank of England 1989, 14):

Static expectations: $${}_tS^e_{t+n} - S_t = 0 \qquad (3.4.3.1)$$

Bandwagon expectations: $${}_tS^e_{t+n} - S_t = \alpha dS_t, \quad \alpha > 0 \qquad (3.4.3.2)$$

Extrapolative : $${}_tS^e_{t+n} = (1-\beta)S_t + \beta S_{t-1}, \quad 1 > \beta > 0 \qquad (3.4.3.3)$$

expectations

Adaptive expectations : $_{t}S^{e}_{t+n} = {}_{t-n}S^{e}_{t} + \tau[S_t - {}_{t-n}S^{e}_{t}], \quad \tau > 0$ (3.4.3.4)

Regressive expectations : $_{t}S^{e}_{t+n} - S_t = -\theta[S_t - S^{\circ}_{t}], \quad \theta > 0$ (3.4.3.5)

If the elasticity of expectations is higher than unity, expectations are destabilizing in the sense that chartists' expectations overreact systematically to changes in the current exchange rate. In the static expectations case the elasticity of expectations is unity - a 1% change in the current rate will cause expectations of the future rate to appreciate by 1%. If chartists' expectations are of bandwagon type, the elasticity of expectations will be $(1+\alpha) > 1$. In this case chartists would have a destabilizing effect on the market, if they heavily influenced foreign exchange dealers' behaviour. Extrapolative, adaptive and regressive expectations each have an expectations elasticity less than unity and so imply rather stabilizing than destabilizing chartist influence.

In order to test chartists' expectations stability, following regression tests were carried out using survey data collected for six individual chartists selected at random from data base:
test for static expectations against bandwagon or extrapolative expectations, test for adaptive expectations and test for regressive expectations. All tests were carried out for both one and four week predictions.

The results from these tests suggest an inelasticity of expectations. Static expectations were never rejected in favour of bandwagon expectations for any chartist at any horizon. Thus the general result from the analysis is that chartist advice does not appear to be intrinsically destabilizing. Figure 4 informally agrees with this result.

Another issue, which was not analyzed in this test, is whether chartist advice is destabilizing in the sense of leading the market away from the underlying fundamentals. With the present evidence from the literature it can be said that chartist advice may at most cause mean-reverting deviations from the fundamentals.

3.4.4 Conclusions

The analysis of exchange rate predictions from the panel reveals that chartists are heterogeneous as a group. They adopt several different approaches and produce distinctly heterogeneous forecasts of differing accuracy. Comparison of chartism with other forecasting approaches showed that the better chartists could in fact outperform a random walk.
Technical analysis is widely used especially at the shorter end of the market. Many market participants believe that chartism is so widespread that its impact has to be taken into account when forming a view.
Majority of foreign exchange dealers appear to view fundamentals and charts as complements rather than substitutes.

Any results of this study should be regarded as tentative because of the limited sample size and relatively short sample period. Analysis of chartist forecast did not include intraday and day-to-day use of charts. Therefore the short-term volatility was not examined. It is possible that at the very shortest horizons chartism is even more important tool for market participants than the study concluded. If the reason for chartism's popularity as a forecasting tool is the lack of immediate economic data(ie. fundamentals) over short time horizons, one could expect to find a straightforward relationship with the significance given to chartism and the length of the time horizon.

The results of the study overall give further evidence of non-fundamental influences in the foreign exchange market. Even if chartism itself doesn't create destabilizing expectations, the fact that charts can lead the market away from underlying fundamentals is interesting. Since most of the foreign exchange trading currently taking place is caused by short-term capital flows the actual spot rate is most affected by short-term trading decisions. Accordingly if chartism's influence is greatest to the short-term trading decisions chartism's relative impact on the formation of spot rate can be actually higher than implied by the Bank of England's study results.

4 ALTERNATIVE MODELS OF EXCHANGE RATE DETERMINATION

4.1 The dollar as an irrational speculative bubble

In this chapter we examine more recent models of exchange rate determination, which take speculation and possible non-rational expectations into account.

As an empirical implementation of their results Frankel and Froot (1986c) have proposed a model where forecast errors are made systematically. An investor or "portfolio manager" forms exchange rate forecasts relying on two sources: chartist's predictions which extrapolate the current rate of depreciation and predictions based on the fundamentals. The latter would be based on a theory such as the current account model where real appreciation leads to unsustainable deficits. Portfolio manager weights the two sources to his exchange rate forecast in Bayesian fashion based on the recent relative forecasting performance of the two kinds of prediction.
This model generates extended cycles in the real exchange rate and it does not have the constraint of fully rational expectations.

Sections 4.1 - 4.1.1.2 follow (Frankel and Froot 1986c, 14-33).
Frankel and Froot made the following conclusions before introducing their model:

(1) The dollar continued to rise even after all fundamentals (the interest differential, current account, etc.) apparently began moving the wrong way. The only explanation left seemed to be that investors were responding to a rising expected rate of change in the value of the dollar, i.e. that the dollar was on a bubble path.

(2) Evidence suggested that the investor-expected rate of depreciation reflected in the forward discount is not equal to the rationally-expected rate of depreciation. The failure of a fall in the dollar to materialize in four years implied that the rationally expected rate of depreciation had been less than the forward discount.

(3) Current account calculations made by Krugman and Marris in 1985 suggested that the rationally-expected rate of depreciation was greater than the forward discount.

(4) The survey data showed that the respondents had since 1981 held an expected rate of depreciation substantially greater than the forward discount. But interpreting the responses from the survey data as true investor expectations, and the excess over the forward premium as a negative risk premium raised several problems. If investors seriously expected the dollar to depreciate so fast, why did they buy dollars? The theory of exchange risk says that the risk premium should generally be small, and for the dollar in the 1980s, that it probably has moved in a positive direction.

(5) The covered interest differential between European and U.S. interest rates fell after 1982 suggesting that perceptions of country risk shifted against the United States. Thus the Safe-Haven theory cannot explain the foregoing paradoxes.

The model of fundamentalists and chartists proposed by Frankel and Froot was designed to reconcile these conflicting conclusions. They hypothesized that the views represented in the American Express and Economist 6-month surveys were primarily fundamentalist, like the views of most economists. They also stated that expectations are heterogeneous. The model suggests that the market gives heavy weight to the chartists, whose expected rate of change in the value of the dollar had been on average much closer to zero, perhaps even positive. Paradox (4) can be answered if fundamentalists' expectations are not the only ones determining positions that investors take in the market.

The model explains the increasing dollar overvaluation after the interest differential peaked in 1982 by a shift in the weights assigned to the fundamentalists and chartists by the portfolio managers. The portfolio managers are the agents who take positions in the market and determine the exchange rate. They gradually put less and less weight on the big-depreciation forecasts of the fundamentalists, as the forecasts continue to be proven false, and more and more weight on the chartists.

The very short-term expectations (one-week and two-week) reported in a third survey of market participants, by Money Market Services, Inc., behave very differently from the medium-term expectations (3, 6, or 12 month) reported in any of the three surveys. This shows that there is not a single homogeneous expected rate of depreciation reflected in the survey data. Table a1 in appendix shows expected

depreciation at a variety of time horizons. The standard deviation of the mean falls as the forecast horizon increases. None of the means from the one-week forecasts is significantly different from zero at the one percent level, and the standard deviations are large, ranging from 4.2 percent to 9.1 percent. At the one year forecast horizon, all of the means are highly significant with t statistics approaching 30, and the standard deviations are below 0.6 percent. The intermediate horizons in between confirm to this pattern of decline.

The one-week and the one-month surveys, which were conducted only for 10/84 to 9/85, indicate that respondents on average expected the dollar to appreciate, often at a rapid annual rate. During the comparable period for which 12 month forecasts are available (1/85-4/85), expected depreciation was still large and positive at 7.32 percent as well as significant
(t= 8.29). These observations suggest that there are far more consistent views about the value of the dollar in the longer run than in the shorter run; while short-run expectations may predict appreciation or depreciation at different times, longer-run forecasts consistently call for substantial depreciation.

It seems that there are two models of the dollar operating at the different ends of the time spectrum. The fundamentalist model, for example such as the Dornbusch overshooting model, can be identified with the longer-run expectations. The chartist model can be identified with the shorter run. Respondents use under this view some weighted average of the two models in formulating their expectations for the value of the dollar at a given future date, with the weights depending on how far off that date is.
The results above suggest an alternative interpretation of how chartist and fundamentalist views are aggregated in the market place, an aggregation that takes place without the benefit of portfolio managers. The chartists may be people who tend to think short-term and the fundamentalists are people who tend to think long-term. The former may by profession be foreign exchange traders, who trade on a short-term basis and have evolved different ways of thinking than the latter, who may by profession buy and hold longer-term securities.

One could interpret the two groups as taking positions in the market directly instead of only issuing forecasts for the portfolio mana-

gers to read. The foreign exchange rate would then be determined by demand coming from both groups. The weights given by the market two the two change over time, according to the groups' respective wealth. If both groups buy and sell dollars consistently with their forecasts (that are opposite), one of the two groups loses money while the other one gains.

The two ways of thinking may also represent conflicting forces within the mind of a single representative agent. The agent may think about the fundamentals when he answers the longer-term surveys but when he gets to the trading room he gives greater weight to his instincts. This may be the case especially when the agent has recently lost money because of betting on the fundamentals. The respondent may think that when the trend turns he or she will be able to get out before everyone else does. Frankel and Froot preferred the interpretation where the survey reflects the true expectations of the respondent, and the market trading is done by some higher authority.

The aim of the authors was to construct a model that reconciles the apparent contradictions between the conclusions (1)-(5) discussed earlier. They thought of the value of the dollar as being driven by the decisions of portfolio managers who use a weighted average of the expectations of fundamentalists and chartists. Specifically,

$$dS^m_{t+1} = w_t dS^f_{t+1} + (1-w_t) dS^c_{t+1} \tag{4.1.1}$$

where dS^m_{t+1} is the rate of change in the spot rate expected by the portfolio managers, dS^f_{t+1} and dS^c_{t+1} are defined similarly for the fundamentalists and chartists, and w is the weight given to fundamentalist views. For simplicity they assumed that $dS^c_{t+1} = 0$ and thus equation (4.1.1) becomes

$$dS^m_{t+1} = w dS^f_{t+1} \tag{4.1.2}$$

or

$$w = \frac{dS^m_{t+1}}{dS^f_{t+1}} \tag{4.1.3}$$

The 6-month forward discount was taken to be representative of portfolio managers' expectations and the 6-month survey to be repre-

sentative of fundamentalists' expectations. This enabled to estimate how the weight w varies over time.

Table 5 Estimated weights to fundamentalists by portfolio managers

	year					
	1976-79	1981	1982	1983	1984	1985
Forward discount	1.06	3.74	3.01	1.10	3.07	-0.16
Survey expected depreciation	1.20	8.90	10.31	10.42	11.66	4.00
w	0.88	0.42	0.29	0.11	0.26	-0.04

Source: Frankel and Froot 1986 C.

Table 5 indicates that portfolio managers gave almost complete weight to the fundamentalist view in the late seventies. Since 1981 the forward discount increased less rapidly than the expected depreciation. This indicates that the portfolio managers were beginning to pay less attention to the fundamentalists' view. According to the computations in table 6 fundamentalists were being completely ignored by 1985.

4.1.1 Expectations and Exchange rate dynamics

Frankel and Froot started to extend their framework by first focusing on the dynamics of the spot rate which are generated by the changing expectations of portfolio managers. A general model of exchange rate determination can be written

$$(4.1.1.1) \qquad S_t = cdS^m_{t+1} + Z_t$$

where S_t is the log of the spot rate, dS^m_{t+1} is the rate of depreciation expected by the market and Z_t represents other contemporaneous determinants. In this very general formulation, the first term can be thought of as speculative factors and the second as fundamentals. The key point behind equation (4.1.1.1) is that an increase in the expected rate of future depreciation will reduce demand for the currency today, and therefore will cause it to depreciate today.

The paper of Frankel and Froot was based on a model given by equation (4.1.1.1). Market expectations come to the model following equation (4.1.1). Fundamentalists in the model think that the spot

rate regresses to long-run equilibrium. Chartist use time series models as a basis of their forecasts.In the view of fundamentalists:

$$(4.1.1.2) \qquad dS^{f}_{t+1} = v(\underline{s}-s_t)$$

where $\underline{s}$ is the logarithm of the long-run equilibrium rate and v the speed of regression of st to $\underline{s}$. In the complete model equation (4.1.1.2) is not the rational form of expectations. In the case in which the chartists believe that the exchange rate follows a random walk, $dS^{c}_{t+1} = 0$. Equation (4.1.1) becomes

$$(4.1.1a) \qquad dS^{m}_{t+1} = w_t v(\underline{s}-s_t)$$

Because the changing weights by themselves generate constant changes in the exchange rate the expectations of fundamentalists will no longer be rational, unless the fundamentalist and chartist expectations are the same, v=0.

The "bubble" path of the exchange rate will be driven by the dynamics of portfolio managers' expected depreciation. The paper assumes that the weight given to fundamentalist views by portfolio managers, w, evolves according to:

$$(4.1.1.3) \qquad dw_t = \delta(\underline{w}_{t-1}-w_{t-1})$$

$\underline{w}_{t-1}$ is the ex post computed weight that would have accurately predicted the contemporaneous change in the spot rate, defined by the equation:

$$(4.1.1.4) \qquad ds_t = \underline{w}_{t-1} v(\underline{s}-s_{t-1})$$

Equations (4.1.1.2) and (4.1.1.3) give us:

$$(4.1.1.5) \qquad dw_t = \delta \frac{dS_t}{v(\underline{s} - s_{t-1})} - \delta w_{t-1}$$

The coefficient δ in equation (4.1.1.5) controls the adaptiveness of w_t. δ is chosen by portfolio managers who use the Bayesian inference to combine prior information with actual realizations of the spot process. To simplify the analysis it was assumed that δ is constant. Since δ is a weight, it lies in the interval [0,1]. The evolution of the spot rate was expressed by taking the derivative of equation

(4.1.1.1). The authors picked up values for the coefficients v and δ and starting values for w_t and s_t to simulate the motion of the system.

It was found out that if portfolio managers use only the most recent realization of the spot rate to choose w_t (that is, if δ=1), the system will be stable and it will tend to return to the long-run equilibrium from any initial level of the spot rate. If portfolio managers give substantial weight to prior information (δ is small), the spot rate will tend to move away from the long-run equilibrium when it is perturbed. Authors assumed that portfolio managers are slow learners and give substantial weight to prior information.

In the late seventies market expectations reflected the views of fundamentalists and the system was in steady-state equilibrium. $S_t = \underline{S}$ and $w_t = 1$ as the calculations presented in table 5 suggest. But because δ is small, this equilibrium is unstable and any shock starts things in motion. For example an unanticipated appreciation of the dollar causes the w_t to fall over time and chartists start to gain prominence. The exchange rate begins to trace a bubble path, moving away from long-run equilibrium. Eventually market expectations are determined only by chartist views and bubble dynamics die out since weight w_t falls to zero. The spot rate stops moving away from long-run equilibrium as it approaches a new, higher equilibrium level.

Due to the implicit stock adjustment the equilibrium spot rate appreciates along its bubble path even though none of the actors expects appreciation. As portfolio managers reject the fundamentals, they buy more dollar denominated asset. Because relative asset supplies are fixed, a greater dollar share can be obtained in equilibrium only by additional appreciation. This unexpected appreciation further increases the weight given to chartists and the rising dollar becomes self-sustaining. Finally, when $w_t = 0$, currency becomes stuck at a fully rational equilibrium level.

Because it seemed unreasonable that spot rate would get stuck at a disequilibrium level the model was developed further. The most obvious factor which had to force the dollar eventually down was the stock of net foreign assets. Large U.S. current account deficits would reduce this stock. If foreigners associated large current account deficits with the potential for moral hazard, they would

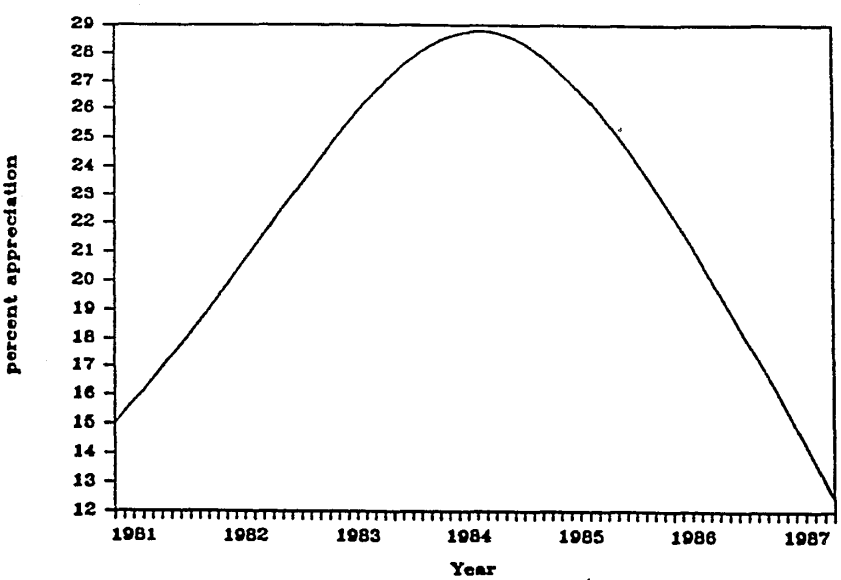
have treated U.S. securities as increasingly risky and would have forced a decline in the level of the dollar. Equation (4.1.1.6) incorporates the effects of current account imbalances:

$$(4.1.1.6) \qquad s_t = \alpha + cdS^m_{t+1} - df$$

where f represents the log of cumulated U.S. current account balances. The coefficient, d, is the positive semielasticity of the spot rate with respect to transfers of wealth.

Actual current account data for f, the change in the stock of net foreign assets, was used in the simulation of the model. The current account, which responds to the dollar appreciation with a lag, starts to affect the spot rate when w becomes small. The external deficits of 1983-85 turn the trend of the rising dollar and dollar starts to depreciate. When w is small and portfolio managers observe an incipient depreciation of the dollar, they begin to place more weight on the forecasts of fundamentalists, thus accelerating the depreciation initiated by the current account deficits. Fundamentalists are initially driven out of the market as the dollar appreciates, even though they are ultimately right about its return to $\underline{s}$. The results from the model are sensitive to the parameters chosen. With all alternative sets of parameter values in the simulation of figure 5, the qualitative pattern of bubble appreciation, followed by a slow turnaround and bubble depreciation, remains evident.

Figure 5 Simulated value of the dollar above its long run equilibrium over 1981-87



Source: Frankel and Froot 1986c

Table 6 Alternative measures of expected depreciation
(in percent per annum)

Expectation from:	Line	1981	1982	1983	1984	1985	1986
Chartists in the simulation	(1)	0	0	0	0	0	0
Fundamentalists in the simulation	(2)	7.63	9.82	11.68	11.98	10.33	7.69
Economist 6 month Survey	(3)	8.90	10.31	10.42	11.66	4.00	na
Weighted average expected Depreciation in the simulation	(4)	5.29	3.31	1.59	0.99	1.49	2.08
Rationally Expected depreciation in the simulation	(5)	-2.97	-5.16	-4.38	-0.72	3.89	6.22
Actual forward discount	(6)	3.74	3.01	1.10	3.07	-0.16	na

Source: Frankel and Froot 1986c.

One of the main aims of the model was to solve the paradox between conclusions (2) and (3). Table 6 clarifies how the model solves the problem. During the 1981-1984 period, the rationally expected depreciation is less than zero. This pattern agrees with the market efficiency tests discussed earlier. The rationally expected depreciation, however, increases over time. Sometime in the late 1984 or early 1985, the rationally expected rate of depreciation becomes positive and crosses the forward discount. Rationally expected depreciation is now greater than the forward discount and the paradox of propositions (2) and (3) is resolved within the model.

4.1.2 Conclusions

In this model the bubble is the outcome of portfolio managers' attempt to learn the model. When the bubble takes off, they are learning more slowly about the model than they are changing it by revising the linear combination of chartist and fundamentalist views they incorporate in their own forecasts.

Portfolio managers' estimation of the true force changing the dollar comes closer to the true one when the weight given to fundamenta-

lists approaches zero or one. Revision in weights continues until the approximation is perfect. Portfolio managers have learned the behaviour of exchange rate by changing the model more slowly than they learn.

Although this model is on the right track since it takes the widely used technical analysis-method into account in the forecast formation process, it has two difficulties. It involves obvious forecast errors and as such is probably too crude to be a reasonable description of the market process. It involves also a very smooth peaking of the real exchange rate but the recent experience has shown that the peaking is far from smooth. Trend changes have been very sharp and they probably reflect abrupt shifts in expectations.

The BoE's study of technical analysis suggests that majority of foreign exchange dealers appear to view fundamentals and charts as complements rather than substitutes. This conclusion is in contradiction with the above model, where the chartist-fundamentalist relationship is set up as competitive.

4.2 The foreign exchange market - a random walk with a dragging anchor?

Professor Goodhart has pointed out four puzzling phenomena that appear to exist in the forex market:

1. The spot exchange rate seems to follow an approximate random walk path over short periods (one week to three months), but the forward exchange rate diverges systematically from this path, and does not contain predictive power whatsoever.

2. Surveys of market opinion and forecasts regularly tend to diverge even more than the forward rate from the historical random walk path.

3. In the medium term there appear to be major misalignments, from some fundamental PPP.

4. In the short run, Goodhart's assessment of the empirical evidence indicates that the reaction of exchange rates to "news", notably of interest rate changes, is an underreaction rather than overreaction. (Goodhart 1987)

Goodhart continues, that these observations are not consistent with the view of the world, in which a combination of rational expectations, long-term confident expectations of future equilibria and certain sticky current prices forces the remaining free variables, exchange rates and interest rates, into discrete jumps, followed by steady adjustments to some longer-term equilibrium. The contrast between the empirical regularities and some current theories is obvious.

Does speculation have any role in what we observe in the markets? Investors' attitudes towards the risk of taking speculative market positions must be responsible for much of what we observe. Evidence seems to support the fact that speculation in the foreign exchange market is rather short than long-term. The risks of longer-term speculation are so great that speculative positions are intended to be closed within hours or minutes. Goodhart's qualitative survey of London forex specialists suggests that open forward positions are very rare, but strictly limited open spot positions are common. Losing positions are normally closed out quickly, because investors are realistic about their limited ability to predict the future path of exchange rates. In aggregate the volume of such open spot positions could be large. Thus the longer-term speculation is probably much less in volume and less clear in direction than would be required for the standard theory to hold. Speculation is likely to have an often unpredictable effect on the market, because it is based on differing information sets. At least three different forces influence investors' decisions; random walk expectations, fundamental analysis and technical analysis.
Goodhart believes that there are two, usually opposing, groups of speculators operating at any time in the markets. Both groups possess only limited funds; they are highly risk-averse, and conscious of their own forecasting limitations. The first group takes positions on the basis of random walk news, the second seeks to rely on fundamentals. The market value of the forward rate records the balance of power in their struggle. Goodhart thinks that this is a promising partial hypothesis to explain at least puzzles 1. and 2. The puzzles result from the interaction of those speculating on the basis of different information sets, notably fundamentalists and random walkers.

Goodhart argues that the forward rate is driven from the current spot rates by fundamentalists. Those who are paid to forecast the future are unlikely to put much weight on the random walk view, because random walk implies that it is impossible to forecast the future accurately, the best forecast is the current spot rate. On the other hand, those who place money on a random walk basis do not take any view of the future. If they did it would be the shortest possible one at maximum. Thus any sample of market expectations, or collection of forecasts, will have a disproportionate number of random walk agents in the "don't know" or "nil return" category. A longer-term survey will include an excessively large number of fundamentalist forecasters. If forward rate is actually determined by the balance of random walk and fundamental views, survey and forecast results should indeed differ from current rate levels by more than the forward rate. Goodhart argues that this is necessary in order to achieve market balance between the two groups, each operating on a different, but equally valid and rational, information base.

Goodhart's approach can possibly explain some of the major misalignments of recent years. One particular feature of the market can exaggerate initial market reactions to news. Investors with open spot positions, being uncertain of their own and their economic advisers' forecasts, tend to close out loss-making positions quickly. Assume that the current value of spot and forward rates is established by random walk agents and fundamentalists. Suppose that then the currency moves say against the fundamentalists' view causing losses to their positions. Being uncertain of both the timing and even the basic validity of their forecast, fundamentalists will want to close out their losing positions. This would simultaneously exacerbate the initial move against fundamentals and weaken the validity of fundamentalists' short-term forecasting ability. What could initiate a currency move against fundamentals? A sequence of random events, like changes in oil prices, capital outflows from Latin America or unexpected political events can weaken fundamentalists' credibility and encourage speculative flows to follow random walkers.

Goodhart has reached his conclusions independently from Frankel's and Froot's results. Goodhart's qualitative explanation can explain the dollar appreciation until 1985 and the following depreciation. During the period 1981-85 investors may have given increasing weight

to random walk views and less to fundamentalists' forecasts since fundamentalists seemed to fail continuously. In 1985 investors switched back to follow fundamentals and random walk based positions started to make losses.

4.3 Conclusions

Goodhart's explanation is very similar to the portfolio manager model by Frankel and Froot. His model is qualitative and an ex post explanation for recent dollar movements. It is probably impossible to model all speculative elements of the market properly into any quantitative model. Both models raise interesting questions about the meaning and nature of rationality in a market where various agents attach different and possibly time-varying weights to differing models. The hypothesis that all agents homogeneously follow a single correct model does not hold in the foreign exchange market. The fact that investors give different weights to different models is very important and it can partly explain why exchange rates can and do move away from fundamentals.

Frankel and Froot 1986c and Goodhart 1987 models try to explain exchange rate movements over medium- or long-term time periods. These models do not examine the short-term properties of the market.

The following chapter studies the forex market's behaviour and price determination over short time horizons.

5 STUDIES ON THE SHORT-TERM BEHAVIOUR OF THE FOREIGN EXCHANGE MARKET

5.1 Evidence from end-hourly data in the foreign exchange market

The short-term characteristics of time series data for the foreign exchange market became appropriately available for empirical study only in 1986, when MMS (Money Market Services) International collected end-hourly data for the four main bilateral spot exchange rates, for British Pound, DM, Yen and Swiss Franc against the dollar. Six months of this series, running from January 2 to July 15 1986 with 3409 observations, has been studied by several authors.

The main theoretical guideline for the probable characteristics of this kind of time series is the efficient markets theory. Since the expected return on a safe asset over time interval of one hour is approximately zero, the efficient markets theorem would suggest that it is impossible to predict the hourly change in bilateral exchange rate on the basis of previous known data, including current and past values of the exchange rate. It has been commonly observed for exchange rate series with frequencies of a day, a week or a month that one cannot reject the hypothesis that the level of exchange rates can be described in terms of a first order lagged auto-correlation with a coefficient of unity (Frankel and Meese 1987, 122). Coefficient of unity - a unit root - is often described improperly as indicating random walk. It is not strictly correct to term bilateral exchange rates as random walks when they do have unit root because random walk is defined as having constant variance. The empirical evidence indicates clearly that exchange rates do not have a constant variance (Goodhart 1988A, 2). One of the most important questions to be answered was to find out whether random walk characteristics are typical for hourly data.

The data examined was collected from the electronic screens where bid and ask rates are quoted by market makers. The studies that are introduced here used quoted bid rates as their data source. The basic hourly data was collected from Telerate electronic screens. MMS international recorded the last four bid rates, exhibited on the screen by approximately fifty major international banks. Such data was collected for the four main bilateral spot exchange rates against the US $, for the Pound, Yen, DM and Swiss Franc. The data ran continuously during the week, from Asian opening (23.00 hours on Sunday in London) to US close on friday (23.00 hours on Friday in

London). Because any international bank branch open for business can quote a price on the screens it is impossible to divide the trading hours into strictly separate geographical markets. MMS divided the day into three periods, 23.00 - 07.00 hours GMT, as representing the domination of Asian markets; 07.00 - 16.00 hours GMT as the European markets; and 13.00 - 22.00 hours GMT being the period dominated by the US markets.
The data provided by MMS international represents over 3000 observations on each of the four series.

Diane Whilster has analyzed the basic characteristics of this hourly exchange rate series. The characteristics were transformed into first differences of the logarithms of the prices, into mean, variance, kurtosis and skewness. For a normal distribution the value of skewness is zero and the value of kurtosis is 3. Kurtosis value higher than 3 indicates a leptokurtic distribution that is more sharply peaked and has thicker tails than the normal distribution. Whistler's results show that all the distributions support a skewness value of zero. However, kurtosis values for the hourly, daily and weekly data were high, only values for monthly data showed less departure from normality. An overall test for normality, that is computed as the range of observations in the sample divided by the square root of the sample variable, shows that there is strong evidence of non-normality for the hourly, daily and weekly data. Monthly data conformed into normal distribution. (Goodhart 1988 A, 9)

These results suggest that periods of turbulence and quieter periods follow each other in the foreign exchange market. Time series exhibits marked leptokurtosis and heteroskedasticity at frequencies less than one month. These results formed a starting point for a more thorough study of the same hourly time series.

5.1.1 From Hour to Hour in the Foreign Exchange Market

C. Goodhart and M.Giugale continued to examine the above exchange rate series (Goodhart 1988 A). Their purpose was to clarify whether the exchange rate series could be regarded as random walks and if not, what would be the behavioural patterns of this series. They started their work by running a Dickey-Fuller test; equations of the form,

$$de_t = a+b1e_{t-1} + b2de_{t-1} + b3de_{t-2} +...$$

where de is the first difference of the log of the level of the exchange rate and e is the log of the level, where ran.

5.1.1.1 First order negative auto-correlation

The main finding of this test, that is directly in accord with Whistler's and with Ito and Roley's finding (Ito and Roley 1986, 16), was that of significant first order negative auto-correlation in three of the four exchange rates, in all exchange rates except the Dm/$. In the other three rates test suggests that any move in the rate is likely to experience a 7 % reversal of the earlier move in the next hour. Authors point out the limitations of this result. It only relates to three out of four currencies for a limited time period of six months. In addition the significance tests are not strictly accurate in the presence of non-normal distributions. One should carefully study the impact of trading costs etc, to ascertain whether this kind of mild negative first order auto-correlation was inconsistent with market efficiency.

Ito and Roley noticed that in the Yen/$ exchange market negative autocorrelation described above was particularly typical after large jumps in the exchange rate. They did not, however, find evidence that large jumps happened after changes in the opposite direction. Therefore these large jumps could not be identified as the bursting of a bubble. Ito and Roley found clear evidence that a large jump was followed by profit-taking. The results indicate that for example a positive jump of 3 Yen would be followed by a fall of 0.5 Yen during the next segment of the day. This kind of behaviour is in contrast with the efficient market theorem.

Goodhart and Giugale studied whether it was possible to identify similar behaviour in their data set. Occasions when the % change in the exchange rate was greater than 3, or 2, standard deviations from the mean were classified as jumps. The results strongly reconfirmed Ito and Roley's results for the Yen/$ spot rate, and indicated similar reactions to jumps in the Pound/$ and SwFr/$ rates. Interestingly, there were no such reactions identified in the DM/$ market. For the three other exchange rates a major jump in one hour was followed by a 50% reversal in the next hour. While this finding appeared to be significant and systematic, it only explained between

5 and 10 percent of the variation in these exchange rates following jumps. One explanation for the 'efficient' DM/$ exchange rate is that it is the central rate of the system. Otherwise authors do not have a good explanation for the differing behavioural patterns of the DM/$ rate compared to the other three.

Authors mention several possible reasons for the significant first order negative auto-correlation in the high frequency differences of spot exchange rates and specially for the increased negative auto-correlation on occasions of jump changes. It could be that market makers need the expectation of excess returns in order to commit capital in order to absorb volatility. Thus when bad news breaks, the market maker will only come in to absorb sales when the price has moved sufficiently far down to guarantee a sufficient expected excess return (on a return to fundamentals) to justify committing capital in order to absorb the expected volatility (Grossman 1987, 10). Because the size of the dealing spread is often determined by institutional tradition and cannot be widened enough from market maker's point of view, he may seek to obtain returns by waiting until a temporary overshoot has occurred before entering the market. This overshoot can actually be caused by market makers' mark up or mark down of the spot rate. Because market maker does not know by how much the rest of the market will react to news, he is forced to estimate the size (and possibly the direction) of the move when he gives bid/offer price quote to his customer. Normally in volatile conditions the bid/offer spread is wider than during calm periods but it may not be wide enough to protect market maker from violent moves in the spot rate, i.e market maker's open spot position can very quickly swing into loss in spite of the "buffer" he has received from the bid/offer spread. This is why market maker tends to mark the level of the bid/offer spread, that he is prepared to give, either sharply up or down from the level preceding the news. Behaving this way he tries to ensure that the next move in the spot rate after the mark up (or mark down) is not as violent (and as risky from market maker's point of view) as the initial move after the news. This explanation, however, would seem to explain shorter than hourly movements in the exchange rate and also reveal why the initial jump or overshoot takes place in the very short run.

Authors mention another possible explanation: differing investors either observe different news, or interpret news differently. Intuitively it would be plausible that in most cases investors agree on

the directional effect of news. Investors probably give different weights to news and this causes turbulence or extra volatility to the spot rate immediately after news come to the market. For example, the initial move caused by those observing news first, or giving common news the greatest weight, may take prices beyond the level thought appropriate by other investors, who have different perceptions of the news. Thus the spot rate will adjust dynamically when the changing information in the markets moves the price into new equilibrium. Eventually information will be fully revealed in asset prices and the new equilibrium presents the weighted average interpretation of the news. Again, this explanation is more likely to be apparent on shorter time intervals than hourly, since one might expect the dynamic adjustment process towards the equilibrium to be largely complete in intervals as long as one hour.

5.1.1.2 Other special features of the market

Next topic of the study was to see if there were any signs that a currency significantly appreciated (or depreciated) in a particular market (European, US or Asian), on a particular day of the week, on a particular hour in a particular day and also for a weekend effect. Remembering, that the tests completed were not strictly accurate given the presence of a non-normal distribution, four significant results were found. Firstly, the value of the Pound systematically fell slightly over the week-end break. Second, there appeared to be a tendency for the Yen, Sw Fr and Pound to weaken in the opening hour of their own local trading on Mondays. Third, there was a clear tendency for the US$ to weaken against all four other currencies in the opening hour of its local trading in New York on Mondays. Fourth, the $ appeared to strengthen against the Yen, DM and Sw Fr, but not Pound, at the opening of New York market on Wednesdays. The equations that were used explain, however, hardly any of the fluctuations in exchange rates.
The study of multivariate interrelationships, done by regressing the % change in each currency, against its own past level, two lags of its own lagged % change values, and two lags of the % change in other three currencies, showed a degree of inefficiency in the Swiss Franc market. Findings indicated that 5% of the hourly movements in the Swiss Franc could be explained on the basis of its own and other three currencies' prior hourly changes. Changes in Swiss Franc were strongly related to the DM. In author's opinion the evidence shows that Swiss Franc dealers could have operated more sharply.

The above tests were run by using univariate equations that could explain less than 1% of hourly daily changes. Nonetheless they revealed that the four main spot rates differed in their efficiency. The DM/$ spot rate seemed to be almost perfectly efficient when the Swiss Franc spot market exhibited clear signs of inefficiency. The Pound/$ and Yen/$ exchange rates exhibited significant first order negative correlations, especially after major jumps.

Next the pattern of heteroskedasticity was explored by examining the absolute value series. One interesting finding was that there appeared to be a Monday market opening effect. The volatility in the first hour of trading on Mondays for the European bilateral exchanges in Europe, at GMT 09.00, was higher than at other daily openings. This suggests that 'week-end news' is not fully incorporated into prices until the main relevant markets are trading. This 'opening volatility effect' was not repeated at the same time later in the week. The Tokyo market behaved differently. The morning volatility in the Yen becomes on Tuesdays, after the other exchanges have reacted on Mondays by adjusting the Yen rate for week-end and other news. These findings confirm the view that trading in the key markets is necessary to complete the filtration of news into prices. The differences in asset price variance between trading periods and non- trading periods has gained attention recently. Assuming that the price generating mechanism, news, was continuous, and asset prices followed a random walk, the variance of prices between market close and market re-open, a gap n hours, should be n times the normal hourly variance (French and Roll 1986, 6). In practice the increase in variance in the foreign exchange market is much less. The absolute value of the percentage change in foreign exchange rate prices over the week-end break of 48 hours could be expected to be approximately 7 times as large as the regular hourly change.

Goodhart and Giugale found that the break coefficient was usually only about 1 1/3 times as large as the size of the largest hourly coefficient in each day. They regard this finding to be in contrast with the hypothesis that news drive asset prices.

One intuitively acceptable finding was the absence of volatility during Tokyo lunch hour (GMT 04.00-05.00) and during the European lunch hour (GMT 12.00-13.00). The European lunch hour was less concentrated and more widely spread. There was also a quite clear

Friday effect, with trading volatility being less, and coming to a close sooner. These two latter results have already been well-known in the market qualitatively but were now quantitatively reconfirmed.

Finally the inter-relationships between the volatility in different exchange rate markets were studied. Results showed that the DM/$ spot market is the key market. Volatility in this market sets the other three markets going.

5.1.2 Conclusions

The two best known theoretical guidelines that help to understand the short-term working of markets are the efficient markets theory and the hypothesis that news drives asset price volatility. The results of the above study challenge the efficient markets theory to some extent, because the foreign exchange market did not appear to be uniformly efficient.
The 'news' hypothesis obtained support in some respects, but in authors' opinion not in others, mainly because of the too low level of volatility over the week-end break. One has to bear in mind, however, the assumption behind the hypothesis that suggests larger than normal volatility after a week-end break. The assumption is that price generating mechanism, news, is continuous. In the foreign exchange market this is not necessarily an accurate assumption. For example, news that move foreign exchange rates and stock market prices differs from each other to some extent. Forex prices are mainly moved by news that are either directly or indirectly related to macroeconomic fundamentals. These news are announced or come to the market almost without exception during the trading week, very few such news are released during the weekend. Stock market prices react to both macro- and microeconomic news. Unlike most of the macroeconomic news, microeconomic news, i.e. company and industry news, can occur or come out to the temporarily closed markets' knowledge during the week-end break.Considering this aspect foreign exchange markets' behaviour can plausibly differ from the stock markets' behaviour without violating the news hypothesis.

5.2 Evidence from minute-to-minute data in the foreign exchange market

C. Goodhart continued to study the short term properties of the market with minute-to-minute data (Goodhart 1988 B). Reuters London office provided copies of their on-line foreign exchange rate page FXFX, giving their continuous record of bid/ask prices four eight main currencies, at the end of each minute on three days, September 14th and 15th and October 21th, 1987. The spot exchange rates were for the DM, £, French and Swiss Francs, Yen, Lira, Dutch Guilder and Ecu, in each case bilateral with the $. September 14th and 15th were rather calm trading days but on the October 21st, two days after the Crash of October 19th, the markets were more disturbed. The data for October 21st was obtained to examine differences in market behaviour between disturbed and quiet periods. The data were taken directly from the screen in the form of end-minute snapshots and then arranged in time series. Obvious data errors were filtered out of the series. Changes in spot rate four times the standard deviation, which were then reversed between 3/4 and 1 1/2 times the original jump in the next few minutes, were identified as errors. Errors were assumed to have arisen from incorrect basic observations in the data set. The original "incorrect" observations were removed and substituted by a linear interpolation from the nearest "true" observations on either side.

An observation of bid/ask spreads for each individual currency showed that they almost always had one out of few conventional values.For the DM, £, Yen and NLG the main three conventional values in their respective units were 5, 7 and 10. The most common standard spread among all observed currencies was 10. If spread deviated from 10, the next most commonly chosen spread was a unit in multiples of 5. For Swiss Franc and Yen, the vast majority of quotes remained at conventional level of 10. In the other currencies the distribution was basically tri-modal, in most cases 5, 7 or 10. To authors' surprise there were no signs of spreads on average being wider on Oct 21st than on Sept 14th and 15th. Thus the spread did not change between disturbed and quieter periods. There was no evidence that posted spreads in the forex market are sensitively responsive to changes in market conditions. Authors assumed that instead of changing conventional market spreads banks will respond to changing perceived risk by shifting the amounts in which they will be subsequently prepared to deal with investors.

Since the size of the spreads was largely conventionally determined, and appeared to remain roughly constant on average, the rest of this study was carried out with the series for the ask price in each case. The basic characteristics of the series for the change, the first difference, from minute to minute of the logarithmic value of each currency series for the "ask" price for each day, i.e. the mean, standard deviation, kurtosis and skewness, were as follows: The means were very low and none were significantly different from zero. Standard deviation, kurtosis and skewness exhibited some indication of time dependence. The averages over all currencies were highest on Oct 21st and lowest on Sept 15th. Earlier work for a set of hourly, daily and monthly spot exchange rates by Diana Whistler indicated that lepto-kurtosis rose as periodicities became shorter. The estimates of kurtosis for minute to minute data were lower on average than those found by Whistler for hourly and daily data. The amount of activity in each market appeared to vary over time. One way to observe the variation of activity is to measure the number of minutes in each hour in which the ask price remained unchanged. A summary text table below shows the comparative numbers of no change observation by hour and by currency over all three days:

Table 7 Number of No Change Observations by Hour

8-9	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18
271	479	504	572	699	500	426	451	618	80

Number of No Change Observations by Currency

DM	BP	Yen	Sw Fr	FrFr	IT	NLG	XE
304	518	661	639	509	599	756	615

Source: Goodhart 1988 B.

Table 7 shows that market activity is high at the market opening and that the activity tends to fall slowly towards the lunch-time. Activity picks up again after American market's opening in New York around 1.30 PM and falls away towards European close. The DM market is clearly the most active market and the Dutch guilder the least active. These results show that none of these markets moves continuously, and also that the activity in the markets is time dependent.

5.2.1 Negative Auto-correlation around Jumps

The high frequency minute to minute data enabled to examine separately the auto-correlation properties around the observed jump in the exchange rate as compared with the auto-correlation properties of the series during calmer periods without jumps. An earlier study of the hourly data had shown that the scale of negative auto-correlation appeared to be greater when the exchange rate had its largest changes, i.e. jumps. Jump in the exchange rate is defined as a change that is more than three times the standard deviation.

In this study the properties of the auto-correlations centred on all those observations whose change was less than three times the standard deviation were examined first. Then the auto-correlations centred on jump observations, with changes greater than 2 or 3 standard deviations were examined. The number of jump observations larger than 3 standard deviations was so small, that observations with changes more than twice the standard deviation had to be included to the latter test.

Table 8 shows the calculated ratios of the absolute size of the negative first-order cross-correlation in jump situations to those under non-jump conditions. The ratio has been averaged over three days.

Table 8
Ratio of 1st order negative correlation coefficients of the change in the log from t+i to t+i+1 in jump (SD >2) compared with non-jump (SD<3) occasions.

	SD>2 / SD<3					
Average of three days	t-3	t-2	t-1	t	t+1	t+2
DM	0.2	1.2	1.5	2.0	0.9	0.1
£	0.9	2.4	2.5	2.2	2.8	0.1
Yen	0.1	1.0	2.2	2.1	1.9	0.4
SwFr	0.4	1.6	1.2	1.9	2.0	0.7
FrFr	0.6	0.0	1.6	1.3	0.8	1.5

Source: Goodhart 1988 B.

The results in table 8 indicate that the absolute size of the negative first order cross correlation is high on the occasion of the

jump. The size of the cross-correlation increases also in the two minutes before the jump, and in the minute afterwards. So the jump itself and immediately surrounding changes tend to be followed by a partial reversal. A jump from t to t+1 is followed by an inverse, negative, move between t+1 and t+2. It is also tended to be proceded by an inverse, negative, move between t-1 and t. The size of the first-order cross-correlations returns to normal, as the length of time in both directions widens.

Authors do not find any satisfactory explanations for the finding of large negative auto-correlation both immediately after and prior to a jump. The possible reasons were already discussed in section 5.1.1.1, and authors regard this as a puzzle still to be explained.

5.2.2 The effect of time aggregation on the characteristics of the time series

In order to find out on which time frequencies the observed heteroskedasticity feature would be at maximum the minute to minute data were time-aggregated into 5 and 10 minute intervals. Earlier studies for a set of hourly, daily, weekly and monthly spot rates had shown that heteroskedasticity and lepto-kurtosis rose as periodicities became shorter. On ultra high frequency minute to minute data the estimates of kurtosis were,however, lower on average than those found for daily and hourly data.
The heteroskedasticity in the data sets increases dramatically when the one minute intervals are aggregated to five minute intervals. Authors estimate that time series of exchange rates with frequencies around 10/15 minutes will exhibit higher heteroskedasticity than any other periodicity.
The clear pattern of negative first-order auto-correlation observable in the minute to minute data diminished as time aggregation was increased to 5 and 10 minutes. The rate of diminution depended on whether the market was calm or excited. On the calm days the first order negative correlation was much less for the 5 minute intervals and had totally disappeared with 10 minute intervals. On the excited day of Oct 21st, first-order negative correlation was clearly apparent in the 5 minute interval case and marginally observable in the 10 minute case.

The results of this exercise suggest that there may be two forms of negative auto-correlation in the data. The first is a very high

frequency regular pattern that occurs continuously, but diminishes with limited time aggregation. The second source of negative auto-correlation appears to be jumps in the spot rate followed by immediate reversals. This latter feature was observed already in the hour-by-hour data set.

The examination of multivariate relationships between exchange rate changes and lagged changes in both own and other currencies revealed some signs of inefficiency in the market. All other currencies' move away from the path of the DM was partially reversed over the next few minutes. This indicates that traders in other currencies do not react quickly enough to the movements of the DM/$ exchange rate. It also shows that the DM/$ rate dominates the foreign exchange market by pulling other currencies to follow its movements.

These results altogether suggest that a number of the characteristics of the foreign exchange market are time dependent.

5.3 Negative auto-correlation and geographical structure of the foreign exchange market

The minute-to-minute study of the forex market revealed that on high frequencies negative auto-correlation is caused by different factors. Large jumps in the exchange rates are followed by immediate reversals, but negative auto-correlation persists also during quieter periods, when there are no jumps. What would be the factor behind the latter kind of negative auto-correlation behaviour? Persistent negative auto-correlation essentially means that there is a continuous process of price adjustment in the market. This process of price adjustment reveals the existence of the differing information sets in the market. One plausible reason for differing information sets could be found in the geographical structure of the forex market.

In one sense the forex market does not have geographical locations, but is a global market, because investors can operate from any of their open branches worldwide. For example during the Asian trading hours (23.00 - 07.00 hours GMT) a European investor (and in this case market maker) could follow the prices from his office in London and submit a new bid/ask quote onto the screen. When a bank keys in its bid/ask price into an electronic screen (e.g. Reuters), it also includes symbols that identify the name of the price contributor and

the contributor's geographical location. If for example the new bid/ask spread for the Yen/$ bilateral spot rate came from the Union Bank of Switzerland in London, UBS LDN would be included in Reuters screen text (on page FXFX). An example of Reuters' FXFX page is shown in table 9.

Table 9 Major spot rates on the 4th of April 1990

0756	CCY	PAGE	NAME	*	REUTER	SPOT RATES	*	CCY	HI*EURO*LO	FXFX
0655	DEM	DKBQ	DAI-ICHI		TOK	1.6970/80	*	DEM	1.6976	1.6955
0655	GBP	BBSI	BARCLAYS		SIN	1.6358/65	*	GBP	1.6365	1.6350
0655	CHF	CSXX	C SUISSE		ZUR	1.5010/20	*	CHF	1.5010	1.5002
0655	JPY	NPCK	NIPPON		H.K	158.70/80	*	JPY	158.90	158.65
0655	FRF	SGHK	SOC GEN		H.K	5.7000/20	*	FRF		
0638	NLG	ABHK	A B N		H.K	1.9107/17	*	NLG		
0655	ITL	BCAD	COM ITAL		ADI	1246.00/7.00	*	ITL		
0647	ECU	KBHX	KB INTL		H.K	1.2048/55	*	ECU		

Source: Reuters screen.

The forex market in this particular example, and also generally, has local geographical features, since by far most of the investors participating in trading during the Asian hours are physically located in Asia. Participation in the forex market tends to be dominated by America-based investors during the American hours and by European investors during the European hours. The activity in the European market is divided within and between different local centres. Could this geographical "localization" lead to somewhat differing information sets between centres and accordingly cause persistent negative auto-correlation in the exchange rate?

C. Goodhart has actually tested whether negative auto-correlation in the minute by minute data set can be explained by prices bouncing between the major geographical centres. His hypothesis was that the apparent first-order negative auto-correlation in the minute by minute data series might be due to a process of price adjustment between centres with different information sets (Goodhart 1988 C, 22).

The data both for locality and for bid/ask prices were taken from the end-minute snapshots of Reuters' FXFX screen during the European market. The same data set was used as in the minute by minute study discussed earlier on. On the three days involved there were forty four centres that participated in trading. London was the main centre in European trading. New York became dominant in the £/$ spot market in a quantitative sense between 13.00 and 13.30 London time. In other currencies New York became dominant later between 16.00 and

16.30 London time. The European markets could be divided into two groups. Currencies in the first group, DM, SwFr, FrFr, NlG, Lira and Ecu, were traded between home centres and London. Other non-resident financial centres hardly participated. The Fr Fr/$ market divided between London and Paris. In the case of Sw Fr, DM, NlG and Lira several domestic centres entered the market for their own currency. Yen and £ exhibited different geographical characteristics. In addition to London these currencies were actively traded in other centres, £ in Dublin, Oslo, Copenhagen and Zurich, Yen in Zurich, Oslo and Frankfurt. This study revealed that most European centres were essentially single (domestic/$) spot market centres. Centres such as Paris, Milan, Dublin and Amsterdam and most of the remaining smaller centres are essentially single currency centres. London and Copenhagen, Oslo and Zurich proved to be the international centres. During the three days being studied there was no quote for £/$ either from Paris or Frankfurt.

The "islands" hypothesis assumes that the news and information set available in the home country is identical. In the case of the first group of currencies the domestic centre(s) were taken as a single group with a single information set. Against these London was taken as the second centre with a potentially different information set. In the case of Yen and £ London was taken as the home centre and other centres were grouped together, as having a potentially different information set. When the actual testing of the hypothesis was done, the New York entry and its effects on the afternoon trading were taken into account.

Now the principle of the test and the results are presented. Firstly, normally one expects news to have a random effect on market prices. Separately located agents with different starting information sets may react differently to any given piece of news. Thus the market price may bounce back and forth between the centres, as the market price adjusts towards an equilibrium. Secondly, on the basis of the earlier evidence, various centres can be aggregated into two groups, i.e. domestic centre/ other. Then the following series of price change in each of the following four market cases is calculated:

(1) Home centre close - Other centre open
(2) Other centre open - Other centre close
(3) Other centre close - Home centre open

(4) Home centre open - Home centre close.

The "islands" hypothesis was that changes in price quotations in cases (2) and (4) would be random, reflecting the arrival of further news, but that changes in price quotations in cases (1) and (3), involving locational changes would be non-random. One could expect on this hypothesis a negative relationship between price changes in cases 1 and 3, but no significant correlations otherwise.
Following the steps above authors tested whether changes in price quotations between market centres with potentially different information sets were non-random, and if they exhibited negative correlation. They also tested whether changes in price quotations within a centre were random.

The results were consistent with a mild tendency for minute by minute changes in price quotations to show greater negative correlation between centres than within centres, consistent with the hypothesis. The results of this exercise did not,however, provide much support for the hypothesis that prices bounce between centres due to differences in the receipt or interpretation of news. This result is not surprising, because electronic linkages between different centres should lead to very similar information sets among the centres. Actually electronic linkages that enable equal real time access to information flows independently from the geographical location should mean that it is not the difference in geographical location but something else that explains the differing information sets among market participants. Differing information sets among the players should, afterall, explain the perceived negative first-order auto-correlation behaviour in the short frequencies in the exchange rate prices. Therefore a similar kind of study, where different banks were used in stead of different centres with differing information sets, could reveal why prices jump back and forth. Testable hypothesis would be that different information sets and differing interpretation of news between major market participants (i.e. between major banks) causes persistent negative auto-correlation behaviour in the spot rates.

6 NEWS AND THE FOREIGN EXCHANGE MARKET

6.1 What is news?

The current dominant view is that in an efficient market the current price discounts and incorporates appropriately all publicly available news. Over longer period of time an asset's price must be expected to move so that the market return on the asset is appropriate for asset's relative riskiness. Over very short time periods the efficient market hypothesis implies that asset prices are as likely to rise as to fall over the near future, i.e. they will follow a martingale. The subsequent move in the asset price depends on whether the subsequent news is good or bad.
By definition, news that moves asset prices is unpredictable in advance. The expected part of the news should not influence the asset's price since it is already taken into account before the news comes to the market. In this context, news refers to an unexpected change in a fundamental variable relevant to the asset's price determination. What are then the fundamental variables relevant to the asset's price determination? These variables can be public in the shape of public economic announcements. They can also be privately observed. Internal customer driven order flow arriving with a market-maker and a revised price quote on the screen by an other market-maker represent privately observed factors. It is obviously difficult to measure news, because there are various sources of news, specially what comes to privately observed news.

The main sources of public fundamental variables are reports of economic news coming over the electronic screens. The date and timing of future forthcoming announcements are usually specified and known by the market in advance. Figures that show the previous occasion's outturn and market's expectation of the forthcoming figure are usually also available from Reuters and Telerate news pages. An example of such Reuters page, FXNB, is shown in table 10.

Table 10 Reuters' consensus of global market forecasts on the 4th of April 1990

		YEN	DM	
RANGE/DLR		159.30-160.10	1.6930-1.7010	
SUPPORT		158.00/155.80	1.6920/1.6870	
RESISTANCE		159.90/160.30	1.7060/1.7160	
GMT		KEY INDICATORS	FORECAST	PREVIOUS
0800 WE	W.G.	UNEMPLOYMENT	MAR -24,000	-35,000
0800 WE	W.G.	UNEMPLOYMENT	MAR 8.1 PCT	8.2 PCT
WED-FRI	W.G.	INDUSTRIAL ORDERS	FEB +2.0 PCT	-5.5 PCT
THU-FRI	FRA	M2 (SA)	FEB +0.1 PCT	-0.1 PCT
THU-FRI	FRA	M2 (SA-Y/Y)	FEB +3.6 PCT	+3.8 PCT

Source: Reuters Screen.

When the actual news comes out one can compare figures for prior market expectations against the actual figure; the difference between the expectation and the actual reported outcome represents the news in each case.
How does a market react to news when it immediately arrives? Initial reaction should depend on the existing circumstances, or world. In a world of identical rational representative agents exchange rate follows a random walk. Lets assume that private information, like order flows etc., drives the spot rate until some news arrive at time t. The identical representative agents react to these news rationally and similarly. When the fastest agent has inputted new price quote, all the other agents immediately agree that this is the new appropriate price level. From this new level price continues to follow random walk path on the basis of private information flows. This kind of behaviour would suggest that the event of the news shock should not have any impact on other characteristics such as frequency of price revision, volatility and kurtosis (kurtosis measures whether the distribution of prices has more outlying observations than normal distribution). Results from earlier studies show that this is not the case. Thus one can question the assumption of identical rational representative agents.

One can alleviate this assumption and propose a world where agents normally agree on the direction of change caused by a news shock. If agents were highly risk averse they wouldn't move prices far out of line with previous levels. Thus the first response of a trading bank could be to move the price partly away from the old equilibrium to the new subjective level. This initial move could encourage other investors to move a bit further and the price would adjust to the new equilibrium. Price changes following the news shock would be positively auto-correlated.

Finally one can assume a world where agents interpret news differently. In this world news could lead to a widening in the subjective distribution of views among agents. Agents would have different views about the new "correct" equilibrium price and the first new inputted price quote would differ from the best estimates of other agents. The new quoted price by the fastest inputting agent would be news to other agents and the initial distribution of views would be affected. Other agents would probably revise their initial price estimates towards the first new quoted price and the initial distri-

bution would shrink. In spite of this there would probably be sufficient differences in view left (on the other side of the distribution of views) and a differing belief about the appropriate level of exchange rate would be inputted. This in turn would be news to other agents and the distribution of views would shrink again. The market would "hunt" towards the new equilibrium and the resulting price path would involve first-order negative auto-correlation.

6.2 Response of foreign exchange rates to news - evidence from recent studies

Among the recent studies examining the effect of news the response of exchange rates to economic announcements has received considerable attention. Most of these studies concentrate on the impact of U.S. monetary and economic announcements and they measure the change in exchange rates over 24 hours, a change from a close to a close. It is, however, desirable to take the shortest interval possible around potential news since other shocks may dilute the estimated effect over 24 hours. It is also important to recognize that bilateral $/foreign currency exchange rates respond to not only U.S. news but foreign news as well. Therefore, news analysis of the exchange rate needs to take into account all relevant domestic and international news.

6.2.1 Yen/$ exchange rate and news from the U.S and Japan

Ito and Roley examined intra-daily movements in the Yen/$ exchange rate in four non-overlapping segments within each business day from January 1980 to September 1985 (Ito and Roley 1986). The data set consisted of the opening and closing quotes of the Yen/$ exchange rate in the Tokyo market and the 9 A.M., noon, and 4.30 P.M. quotes in the New York market for each business day. Announcements of the money supply, industrial production, and wholesale producer prices were collected both for the U.S. and Japan.
Four major segments within each day were considered to compare movements of the Yen/$ exchange rate in different markets throughout the world. Exchange rate movements from the opening (9 A.M.) to the close (3.30 P.M.) in the Tokyo market mainly reflect traders' responses to news originating in Japan. Both the London and New York markets are closed during business hours in Tokyo. The second, European segment,dominates from the close of Tokyo market to the opening of the New York market. Third, changes of the Yen/$ rate

from 9 A.M. to 4:30 P.M in New York mainly reflect the effects of U.S. news. The fourth, "Pacific" segment for 3½ hours, differs from the others. There is no major market between New York and Tokyo and most of the Japanese, American and European market participants are not trading. This segmentation enables the analysis of trend and volatility behaviour in and between different markets.

The exchange rate at the end of the sample, September 20th 1985, happened to be at about the same level as that of the start of the sample period, January 1st 1980. Total net changes summed over all markets for the entire sample period were less than one Yen. Decomposition of all markets into separate markets revealed interesting differences. Generally Yen tended to depreciate during the New York market and appreciate in the European market. The drift of the exchange rate in the Tokyo market appeared to be trendless. The data suggests that economic announcements in the U.S. tended to push $ higher, while the European markets recorded opposite effects. Examination of Yen/$ rate in response to monetary and economic announcements supported the above findings. The U.S. monetary information affected the Yen/$ rate significantly. The exchange rate did not adjust fully to the 4:10 P.M. monetary announcement by 4:30 P.M. New York time. A response of almost equal magnitude was incorporated in the opening Tokyo quote. The Japanese money announcements did not have any significant impacts on the Yen/$ rate and this suggests that money announcements in Japan do not have any information value for traders about the future course of the exchange rate. Yen/$ exchange rate responded to inflation announcements from the U.S. but not to announcements from Japan. Industrial production announcements from Japan were more relevant than such announcements from the U.S.. The overall response to this announcement in New York was statistically insignificant; In Tokyo Yen tended to appreciate in response to positive industrial production surprises.

These differences in market responses can be partly explained by different market characteristics. Generally the Bank of Japan appears to be more sensitive to the level of the exchange rate than the Federal Reserve (Ito and Roley 1986, 23). Non-reaction to money or inflation announcements in the Tokyo market is possible if traders think that the Bank of Japan tries to target real interest rates and/or the exchange rate.

The volatilities of the Tokyo and New York markets changed significantly during the sample period. During 1980 the Tokyo market was slightly more volatile than the New York and European markets. For the rest of the time the New York market was most volatile. Since October 1982 the New York market was about twice as volatile as the Tokyo market. This was mainly due to the major decline in the Tokyo market's volatility. Higher volatility in the New York market is consistent with the observation of Yen/$ rate's higher responsiveness to the U.S. news. The Pacific market had consistently low volatility. This can be partly explained by the absence of news. Another possible explanation for the low volatility in the Pacific segment could be its lack of self-generating trading. French and Roll (Is trading self-generating?" 1984) have proposed that trades self-generate volatility. This proposal in based on evidence that when the stock market is closed during regular business hours, the volatility between closing and opening quotes is significantly less than during other times.

6.2.1.1 Is there always major news behind a large jump in the rates?

If all large changes in exchange rates were caused by major news it would be possible to ascertain factors which traders think are most important in the determination of the Yen/$ exchange rate. If many large changes occur without observed major public news, the existence of a bubble or a bandwagon effect in the market may be suspected. These effects are caused by private news or information flows. Ito and Roley examined closely days in which a large change in the exchange rate occurred. All days in which the Yen jumped by more than 3 absolute Yen, which is more than two standard deviations, were recorded. Accordingly newspapers relevant to the days of large changes were examined in order to identify major news items. This comparison suggested that not all jumps can be associated with major news. Since authors could not identify news responsible for all large jumps, they tested an alternative hypothesis, a bubble hypothesis. If the exchange rate can deviate from an otherwise stationary stochastic process for a short period of time, a "rational" bubble can then emerge and burst occasionally. The bubble hypothesis was that the jump is caused by the final stage of a bubble or bandwagon effect. A large jump can be interpreted as a sudden correction to the natural equilibrium level from an exploding bubble process. This hypothesis assumes that the large jump is preceded by a significant

change in the opposite direction. Formally, the bubble hypothesis is presented as follows:

(6.2.1.1) Jump = a + b(change in previous segment) + e, b < 0.

Authors also hypothesized that a large jump is followed by profit-taking behaviour. Under this hypothesis the subsequent move after the jump is in the opposite direction regardless of the reason for the jump. Profit-taking behaviour can be represented as

(6.2.1.2) (Change in the subsequent segment) = a + b(jump) + e, b < 0.

The empirical results for days with large jumps indicated that there is no evidence that large jumps are preceded by changes in the opposite direction. Therefore the bubble hypothesis does not seem to hold and large jumps cannot be identified as the bursting of a bubble. In contrast, there was clear evidence that profit-taking took place after a large jump. The results indicate that a positive jump of 3 Yen was followed by a fall of 0.5 Yen during the next segment of the day. This last finding is strongly against market efficiency.

6.2.2 Charles Goodhart's study with continuous data set

The most recent study on this subject is C. Goodhart's study "'News' and the Foreign Exchange Market" (Goodhart 1990). The main data series for this study was collected from Reuters' FXFX page. Direct data from the screen was transformed to a separate continuous time series for each currency. The data feed ran continuously from Sunday April 9th 1989 to Monday July 3rd 1989, for some 12 weeks. The size of this time series is larger than normal in economics. The largest continuing series, for the DM/$, consists of approximately ¼ million observations. The data set is unique since it is the first continuous record of the price series in the foreign exchange market. The objective of Goodhart's exercise was to study the factors that cause exchange rates to be revised, and the characteristics of the forex market.

Starting point for his exercise was to find out whether news announcements and exchange rate jumps were related. For this purpose discrete samples of Reuters pages FXNB and AAMM were taken several

times each day during the period April 9th - July 3rd. AAMM page is a main news page that reports all main news, which have been editorially selected. During the observation period more than 250 news items were recorded. Table a2 in appendix shows part of the record of the exact timing of each public economic announcement prefigured on Reuters, indicating the recorded result and the prior forecasts. After recording all relevant news, both a graph and a data print-out of the exchange rate were examined for each economic announcement, to see if there were clear jumps in the exchange rate that could be related to the prior news. In the case of U.S. news, for example, the bilateral $ rates with the DM, Yen and the £ were followed.

The second approach to relate news and exchange rate jumps was to first identify a jump in the time series of exchange rate and then look for associated news.

The first finding was that hardly any of the reported announcements led to any identifiable jumps in the forex series. No signs of any visible response in the forex market to any of the recorded domestic news items in the exchange rates in Japan, West Germany or France were recorded. Two occasions in the UK and five in the U.S. were identified with jump responses to domestic news. This inability to identify jumps on the occasion of news does not necessarily mean that economic announcements do not change attitudes and views about the equilibrium exchange rate. In some cases the announcement did not contain much "news" to the market anyhow and in other cases the subject of the announcement may not have been relevant to the foreign exchange market. The significance of each economic announcement from market's point of view depends on the particular circumstances of that time. For example, when the U.S. economy is in "normal" phase, i.e. it is not overheated or approaching a recession, the U.S. Unemployment or Non-Farm Payrolls figures may be highly irrelevant for the forex market. The reason would be that the Federal Reserve would very unlikely in this situation either tighten or ease its monetary policy because of the change in unemployment. The actual announced Unemployment figure could considerably deviate from market's average expectation without having any impact on the short term interest rates in the U.S.. On the other hand, if the U.S. economy was overheated, unexpectedly strong Unemployment and Non-Farm Payroll figures might cause a jump upwards in the $ rate against other currencies. In this case market would anticipate a tigh-

tening by the Federal Reserve in order to slow down the economy and inflationary pressures.

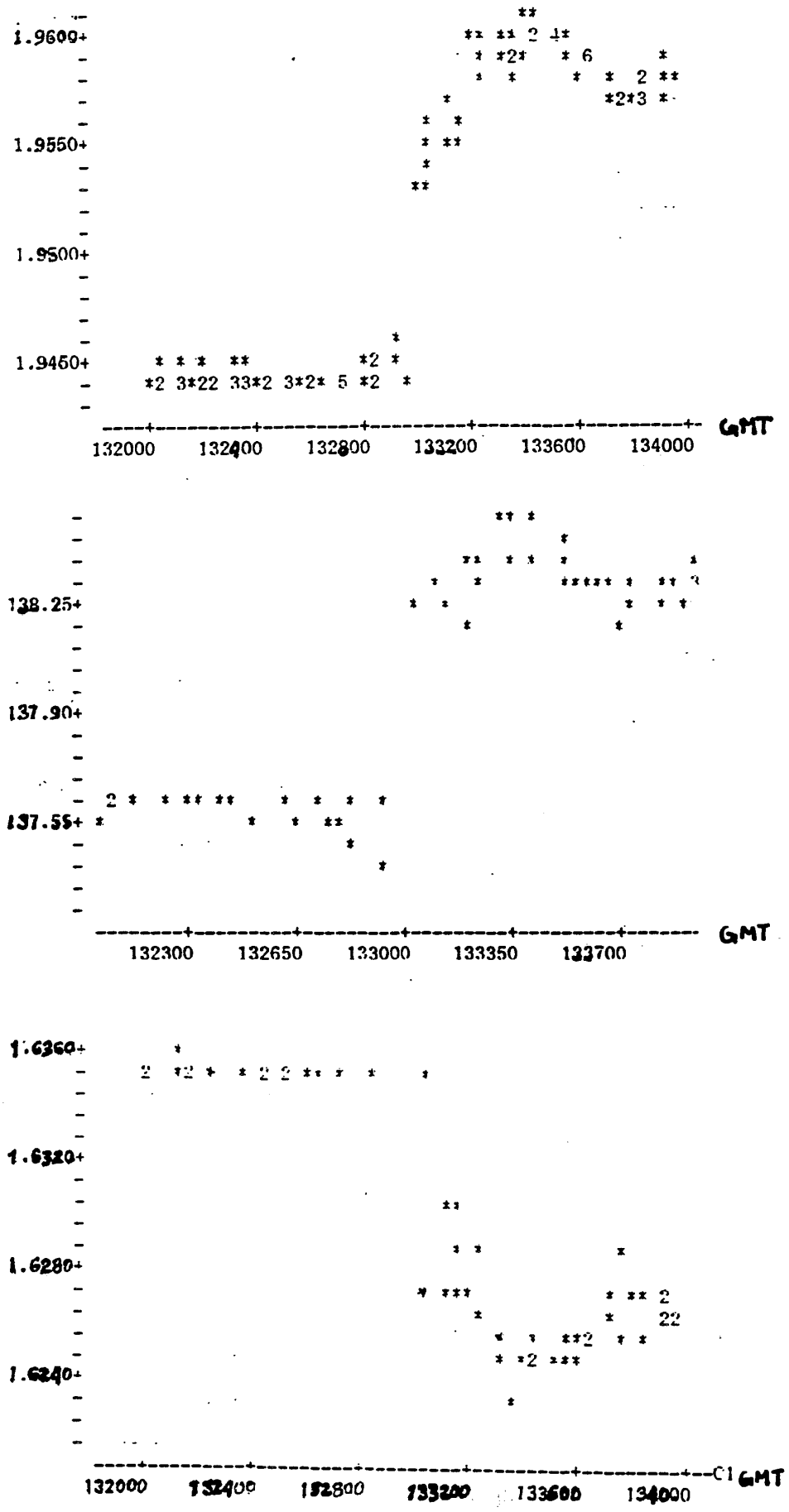
It is very difficult to pick up the market sentiment and market's attitude towards different economic announcements in an academic exercise. Most economic announcements come out monthly and the "weight" of attention given by the forex market to a particular announcement probably varies every month. It is clear that when an economic announcement is important for the market and the actual outcome differs considerably from market's average expectation, the corresponding exchange rate reacts. The bigger is the difference between the average expectation and the actual outcome,the larger is the reaction of the exchange rate.

One other problem is that an economic announcement can have a "dual" effect on the exchange rate, it can affect exchange rates through at least two channels. For example, news which is bad for the balance of payments, and therefore might be expected to cause exchange rates to fall, may simultaneously cause expectations about domestic monetary policy changes. Increases in interest rates would be expected to cause exchange rates to rise. So, even if news as such can be identified, unless the expectations about the policy regime can be very tightly specified, the expectation for the resultant exchange rate change can remain ambiguous.

Authors could identify 8 jumps that followed economic announcements. Details of these are given in table a3 in appendix. The plates of the announcement of the U.S. trade figures for May 17th for the DM/$, £/$ and Yen/$ rates are shown in figure 6. One can notice that the movement in the £/$ and Yen/$ mirrors closely the movements in the DM/$ rate. Note that the £/$ rate is actually quoted as the number of dollars per pound, thus nominal fall (rise) in the £/$ rate means actual pound depreciation (appreciation).

Figure 6

Movement in the DM/$, Yen/$ and £/$ rates on announcement of the U.S. trade figures for May 17th 1989



Source: Goodhart 1990.

In addition to these 8 jumps on the arrival of news, there was one, unanticipated, occasion when interest rates in the UK were increased from 13% to 14% by the Bank of England. This clearly caused a simultaneous jump in the exchange rate and a subsequent period of volatility. The largest single percentage change on the forex market in this data set occurred on the evening of June 15th between 18.00 and 22.00 British Summer Time. Dollar fell very sharply against other exchange rates and there were several occasions when the exchange rate change was precipitous. The dollar fall was probably caused by Central Bank interventions. Several precipitous falls in the $ rate indicate that several consecutive intervention rounds, when Central Banks sold dollars against other currencies, took place.

Once these 10 jump occasions were identified, the next step was to examine the price revisions over particular temporal intervals prior to and subsequently after the news announcement. All price revisions in the 45 minutes before and 90 minutes after the announcement were looked at. Then these time spans were divided into appropriate sub-periods.In the case of the DM/$ responses to U.S. news sub-periods were 15 minutes. The period during the evening of June 15th was divided into half-hourly intervals. Earlier studies have shown that for high frequency data for the forex market activity and volatility are time dependent. Therefore it is desirable to be able to distinguish variations in volatility that are caused by news from those that are a feature of regular time dependency. In order to make this distinction the price revisions, occurring over an exactly similar time period on a similar day of the week when no news occurred, were examined.

Finally the mid-point between the bid and the ask price was transformed into logs. The first differences of the log levels where then looked at. The main characteristics of the series for the changes in the log of the levels were looked at over each time period in the series. These were the frequency of observation, mean, standard deviation, kurtosis and skewness together with the change from the beginning to the end of the period.

6.2.2.1 Initial hypotheses and results

This section follows (Goodhart 1990, 12-17). The final stage of Goodhart's exercise was to examine closely how the forex markets

behaved around the time of a sizeable news shock. Before describing the obtained preliminary results we will look at the hypotheses entertained by the author and possible alternative hypotheses. Goodhart's hypotheses are labeled G and "standard" academic versions A.

(1) Frequency of price revision
H1G Frequency would decline relative to the null jump observations before the known timing of announcement, as dealers would prefer to wait for news to be revealed.
H2G Frequency would rise immediately after announcement.
H3G Frequency would then revert slowly back towards null average.

(2) Spreads
H4A Spreads would increase as uncertainty increases being at their maximum just after the news shock.
H5G Spreads would be expressed in the main conventional round numbers.
H6G Spread would remain essentially unchanged.

(3) Mean
HG7 There would be no signs of correct anticipation of news
HG8 The size of means would tend to be higher immediately after news shocks.

(4) Standard Deviations
HG9 Volatility would rise from the null norm shortly before the expected announcement, would peak immediately after the news shock and then revert slowly to null norm.

If agents are risk averse, volatility should possibly fall from the null norm shortly before the expected announcement, since agents were unwilling to deal (and open new positions) and quote new prices immediately before a possible jump in the price level.

(5) Kurtosis
HG10 There is no excess kurtosis in the continuous price revision series even after jumps.

Because most other studies of discrete high frequency time series have tended to find that excess kurtosis is positively correlated

with periods of high volatility, Goodhart's alternative hypothesis is

H11G Excess kurtosis would follow broadly the same time path as the standard deviation.

(6) Skewness
HG12 The series would exhibit no skewness.

(7) Autocorrelation
HA13 The series would not exhibit any significant auto-correlation
HG14 All series would exhibit significant first order negative correlation
HG15 The first order negative coefficient would become larger and more significant immediately after shocks, then reverting slowly to its null norm.

Each statistic, e.g. of frequency, spread, etc., was calculated in each time period for each announcement case study for both the jump and its associated null. Then following regressions were ran:

(6.2.2.1) $$Xij - Yij = a + bi + cj + dZ$$

where X is the statistic of interest from the jump period,
where Y is the same statistic from the associated null,
i represents the temporal intervals in each case, (e.g. t+30 t+45)
j represents the separate occasions, i.e.of jump and associated null and Z represents a vector of other possible explanatory variables.
Thus the test examined whether there was a significant difference between jump and null (non-jump) occasions dependent on a particular time-period and particular announcement/null pairing.

The results were as follows:

(1) Frequency
There were no major differences in the average frequency of price revision between null- and jump observations. There was more variation in the average frequency among null observations than among jump observations. There was no sign of correlation between the frequency on jump occasions and the absolute % size of the jump. These results suggest that the market activity does not particularly

depend on the number of news announcements. Activity seems to be rather dependent on the time of the day. Earlier minute by minute study showed that market opening times are specially busy and active.

(2) Spreads

The number of spreads of differing sizes reveals that spreads did rise after a news shock and on the occasion of disturbed markets. The widening of the average spread resulted from more observations of larger conventional round numbers and fewer of the small conventional spreads.

(3) Exchange rate movements before and after the shock

The examination of the actual changes over the 45 minute period before the news shock did not reveal any news leaks being sensed in the market immediately beforehand. Then the size of the % changes in the fifteen minutes following the shocks were examined. The absolute size of these changes was larger after shocks than in the same periods in the nulls.

(4) Standard Deviations

In order to compare the volatility of the forex market during jump and non-jump conditions, author examined how the standard deviation in each period and occasion varied relative to the chosen null. The DM results showed a significant rise in volatility in the final 15 minutes before an announcement, but comparatively low volatility in the preceding half-hour. Other results did not show unusual volatility prior to the announcement. In all cases the volatility was higher relative to the null immediately after the shock than at any other time period.

(5) Kurtosis

The results on this continuous time data showed fewer signs of abnormal lepto-kurtosis than minute-by-minute data. This gives support to the mixture of distributions hypothesis, which is that per unit of news arrival, the distribution of price revision would be normal. The interaction of two separable distributions, of news arrival and of price revision per unit of news, causes the higher lepto-kurtosis in longer discrete time intervals.

(6) Skewness

The series did not exhibit any skewness.

(7) Auto-correlation
The data included significant 1st order negative auto-correlation. The most surprising initial result was that the extent of negative first-order auto-correlation was no larger on jump occasions than on nulls. There appeared to be no systematic relationship between the size of negative auto-correlation and proximity to news shock. Now, since the variance of the forex series increased after a shock, and auto-correlation remained roughly constant(as between the jump and the null), the auto-covariances were larger after a news shock.
In order to examine both the form of the auto-correlation and the stationarity of the series in more detail, the change of the spot rate was regressed against the prior three price changes, both with and without including the prior level of the spot rate in the previous observation. The regression test and a following significance test indicated that the forex market does show significantly more negative auto-correlation, and negative auto-covariance, around jumps than on calmer periods. The extent of stationarity was, however, somewhat higher in the jump occasions.

6.2.2.2 Goodhart's conclusions

Goodhart concluded his study suggesting that during calmer, null, periods the distribution of differing views is smaller and that the first-order negative adjustment between adjacent price revisions is somewhat less than during turbulent periods. However, the extent of negative auto-correlation even on calmer, null occasions in the data set was surprising. This confirms the results from earlier studies that volatility in the foreign exchange market is caused by both news shocks and some other factors. Market practitioners are naturally familiar with the market behaviour. The following, descriptive, comment was received from one practitioner when he was asked about negative auto-correlation: "Is not this what you would expect from normal market behaviour... oscillations around a trend? Start from equilibrium. Banks are trying to sniff out the trend in the market and hope to get one step ahead. The bank only trades if it thinks the price is too high/too low. Bank A raises quote to see if it can push prices higher and sell dollars expensively which it will then hope to buy back cheaper. But it will then tend to attract more sellers than buyers, and it will end up with a long, unwanted, $ position. It will then ring round the market, notably to brokers, to sell the long $ position. Other dealers aware of a big long overhan-

ging $ position in the market will then cut quotes. Eventually bank B deals, thinking it is picking up cheap dollars, which it will be able to sell more expensively. It raises quote, etc., etc. (Goodhart 1990, 33)". An arrival of news shock widens the dispersion of views about the fundamental equilibrium and the extent of negative auto-correlation and auto-covariance increases. The tendency to "hunt" towards an equilibrium level remains much the same, as before the news shock.

Goodhart emphasizes that his results are tentative and much more work needs to be done to test whether they are robust.

6.3 News and the foreign exchange market - conclusions

Goodhart's findings appear to provide a plausible picture of the adjustment of market prices to news. His study also confirmed that news is not the only source of volatility in the foreign exchange market. The surprisingly high negative auto-correlation during "calmer" periods suggests that the continuous trading process in the market generates volatility, i.e. causes prices to bounce back and forth. During this process it is not the public news (i.e. economic announcements, or central bank interventions), but private news that lead to constant price revisions. Private news are essentially market participants' private observations about capital flows, other investors' behaviour, etc..

The trading process in itself does not seem to cause large changes in exchange rates, but rather continuous small changes. Are large changes in exchange rates always related to public news? If they were, we could ascertain the factors which traders think are most important in the determination of exchange rates. Ito and Roley concluded after an examination of selected days with large jumps that not all jumps can be associated with major news. Their method, however, was not the most accurate one, since only newspapers relevant to the days of large changes were examined. C.Goodhart could relate all major jumps in his data set to some public news, that consisted of economic announcements or coordinated central bank intervention. His data set had recorded all relevant public news from Reuters news screens during the sample period, therefore Goodhart's observation should be more reliable than Ito and Roley's. The biggest jump in Goodhart's data set was caused by coordinated central bank intervention on 15th of June 1989, when DM, Yen and £

appreciated almost 2% against the dollar during 4 hours time. From economic announcements the U.S. trade figures appeared to have the most significant influence on rates (see table a3 in appendix). More work needs to be done on this topic, but at least Goodhart's results suggest that major changes in exchange rates are always caused by public news. It would be useful to study this question with a longer continuous time series. Thus we could possibly identify the factors that are considered by traders to be the most important in the determination of exchange rates. It is, afterall, the market makers, not the fundamentals, that eventually (and continuously) decide which is the appropriate "equilibrium" exchange rate level at any given moment.

Both Ito and Roley, and Goodhart found strong evidence for "profit-taking" or immediate reversals in the exchange rate after a jump. Goodhart also found that the tendency to revert back towards an equilibrium after a jump is relatively much the same for jumps of different size. This essentially means that the bigger the absolute size of the jump is the larger is the absolute size of the corrective move. It is difficult to rationalize these findings in an efficient market.

6.4 Is the foreign exchange market inefficient?

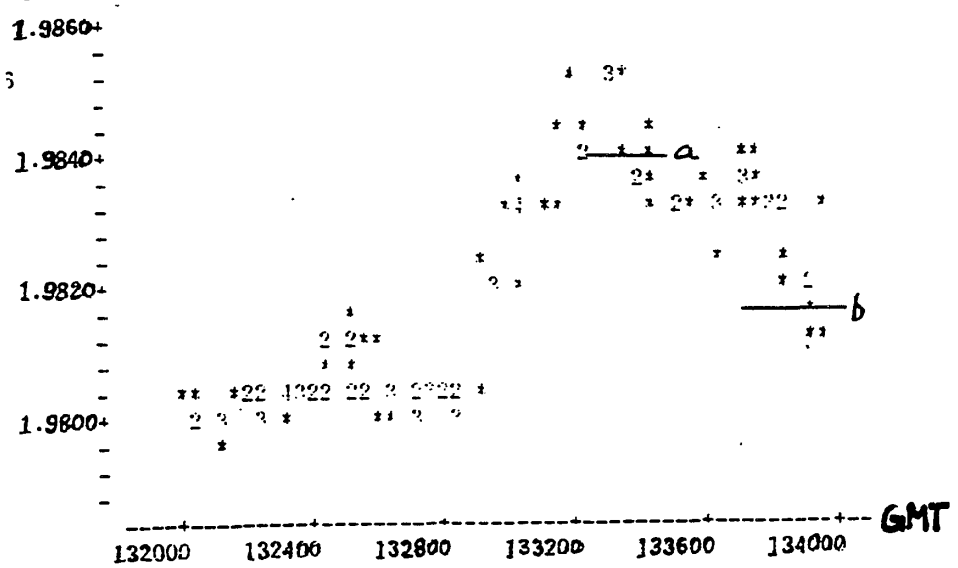
The consistent tendency of the foreign exchange market to revert back after jumps is against the strict definition of efficient markets, since it seems to be possible to predict future price movements (i.e. movements immediately after the jump) without any new information, but instead with past information that should be completely reflected already in the current price! So, from theoretical point of view the foreign exchange market seems to be inefficient.

Does this rejection of efficiency mean that there exists an unexploited profit opportunity each time a jump occurs? Is the size of the post-jump reversal sufficient to create an exploitable profit opportunity after transaction costs, i.e. after taking the bid/ask spread into account? In fact, from market makers' point of view the bid/ask spread enhances the profit potential and his net transactions costs are very small indeed.
The following example sheds light to this question. Figure 7 below

shows graphically the DM/$ rate movement on the 18th of May 1989 between 13:20 and 13:40 British Summer Time.

Figure 7

Movement in the DM/$ rate on announcement of the U.S. Consumer prices on the May 18th 1989



Source: Goodhart 1990.

At 13:30 BST the U.S. Consumer prices were reported and immediately shown on both Reuters and Telerate screens around the world. The reported figure was higher than the market had expected and $ jumped (appreciated) against other currencies immediately after the announcement. The higher than expected Consumer prices in the U.S. implied to the markets that short-term interest rates in the U.S. would rather tighten than ease because of the higher inflationary threat. Consequently expected tightening of interest rates caused the appreciation of the $.

Lets assume that trader X has a view, that the jump to some extent is an overreaction and that he tries to profit from his view. When trader X observes from the screen that $ starts to revert, depreciate, back from the highest peak (around 1.9850 DM/$ level) he decides to sell dollars in order to buy them back at a lower level later on. We can also assume that our trader has a stop-loss limit, where he is prepared to cut out his position, if his view proved to be wrong. Now, he sells dollars at 1.9840 DM/$ level (level a in figure 7), when the market maker's bid/ask price quote is 1.9835/45 (here we assume that the size of the bid/ask spread is 10 pfennigs, which is the most common spread in the DM/$ market, see section minute data), and his stop-loss level is at 1.9850 DM/$ level. Since trader X is selling dollars, his dealing price is market maker's bid

price, 1.9835 DM against each dollar. When dollar has drifted further down from the highest levels, trader X decides to buy his dollars back at 1.9816 DM/$ level (level b in figure 7). Market maker's quote is 1.9811/21 and the deal is done at the offer price 1.9821 DM/$.
The net profit for trader X is calculated below for $ 1 million:

(1) Trader X sells 1 million dollars against DM at 1.9835 DM/$, he receives 1,983,500 DM.

(2) Trader X sells 1.9835 million DM to buy dollars, at 1.9821 DM/$ rate; he receives back 1,000,706 dollars; His profit in this case is 706 dollars.

Now we can assume that trader X is a market maker himself, so he can deal at more advantageous prices than his customers. At 1.9840 DM/$ level his bid/ask quote is 1.9835/45 and he can sell dollars at 1.9845 DM/$. Accordingly at 1.9816 DM/$ level he can buy his dollars back at 1.9811 DM/$. Thus, market maker X:

(1) Sells 1 million dollars against DM at 1.9845 DM/$, he receives 1,984,500 DM,
and
(2) sells 1.9845 million DM to buy dollars, at 1.9811 DM/$ rate; he receives back 1,001,716 dollars; his profit is 1716 dollars.

This example shows that exchange rate jumps can be exploited profitably even after transactions costs. This suggests that, in some occasions, the foreign exchange market is inefficient also in practice. One should not be able to use past price information successfully to predict the future price movements, but our evidence shows that post-jump reversal movement in the exchange rate is predictable and can be exploited profitably. Market makers can exploit profitably even small jumps in exchange rates. Table a3 in appendix shows that the size of the jump in this example was not exceptionally large. The size of the preceding jump on May 17th was considerably bigger. Goodhart's evidence about increased auto-correlation on jump occasions implies that the absolute size of the reversal in the exchange rate is positively correlated with the absolute size of the jump. Thus the bigger the jump is, the larger is the profit potential. Since in most cases the timing of the economic announcements is well known beforehand, traders can anticipate potential jumps

and accordingly exploit them. Goodhart's twelve-weeks long sample period included some nine jump occasions, that were caused by economic announcements.

In order to profit from jumps it is crucial to estimate correctly the turning point, i.e. the point and level when the exchange rate starts to revert back from the highest peak. An experienced market practitioner should be capable to identify the reversal pattern. Here we have to remind that the investor buying the appreciating, "jumping", currency at the peak, will always make a loss, at least in the very short-term (since he could buy the same currency cheaper later on).

6.4.1 The foreign exchange market - an almost efficient market?

Is the perceived negative auto-correlation of the spot rate on high frequencies, i.e. oscillations around a trend, an anomaly or contradiction within an efficient market? The Efficient Market Hypothesis declares that new information is impounded in asset prices perfectly and instantly, it views the market mechanism as an instant information processing mechanism. Market mechanism is supposed to work like a powerful computer that processes new information extremely quickly and gives instantly the new perfect equilibrium price level. Unless the arrival of new information is as frequent as price revisions are, the market does not seem to work as efficiently as EMH requires. The arrival of publicly available information in the foreign exchange market is certainly not as frequent as revisions in spot rates (the estimated average in the busiest spot market, DM/$ market, is 5,000 price revisions on each single weekday (Goodhart 1990, 2)).
A new field of research - behavioural finance - incorporates insights from the psychology of human decision-making under conditions of uncertainty to offer better descriptions of market behaviour and how people really make decisions (Wheeler, July/August 1989, 8). Behavioural finance has found that volatility is self-generating and that decision makers are not as rational as rational expectations hypothesis states. These findings suggest that the human element in the foreign exchange market must naturally cause some instability in spot rates. This human element explains why the foreign exchange market is not perfectly efficient. Dynamic price oscillation, which is caused by the human element in the market, can create "operational inefficiencies" in the market. These "ineffi-

ciencies" potentially create opportunities to earn excess returns, which should gradually disappear, when market participants start to exploit them. Eventually the market should become more efficient.

We have already discussed one operational inefficiency in the forex market, the immediate reversal or "profit taking" after a jump in the spot rate. Another operational inefficiency emerges from central bank interventions in the forex market (this is discussed in more detail in page 108). These inefficiencies can give excess returns to some market participants in certain occasions, but most participants are highly unlikely able to earn conventional excess returns.

It appears that the foreign exchange market is an almost efficient market where human elements cause some operational inefficiencies.

7 CHANGE OF THE FOREIGN EXCHANGE MARKETS IN THE 1980S

7.1 Liberation and growth of the foreign exchange market.

Liberated by improved technology and a global wave of currency deregulation that began with Margaret Thatcher's lifting of British exchange controls in 1979, money has escaped geographic and governmental boundaries. It has become a protean mass of purchasing power, changing identity at the press of a button as it moves through a global network of telephones and computer terminals.
The surge of capital into foreign exchange markets over the past decade has been "like a volcanic eruption", commented one veteran desk chief at a major British clearing bank. "The growth has been geometric, not arithmetic". From an already hefty $75 billion a day in the late 1970s, foreign exchange trading volume rose steadily to $425 billion a day by the third quarter of 1987, according to estimates by Morgan Stanley & Co.- about $100 billion in London, $90 billion in Tokyo, $70 billion in New York and the rest scattered from Bahrain to Singapore. (Institutional Investor June 1988, 89)

From virtually a nil position in foreign assets in 1980 US pension funds invested an estimated $59 billion abroad by year-end 1987. In the same period, long-term securities purchases of and sales by American firms to non-US residents grew at a compound rate of 60 percent to reach nearly $3 trillion in 1987 - roughly double total US imports and exports. This could be the primary pump in foreign exchange trading growth. Trading figures may seem to be a bit "rich ", as traders say, but no one, not even the central bankers, knows exactly how big the global foreign exchange market have become. There is no central exchange or clearinghouse to calculate the statistics. In March 1986 the Bank of England, the Federal Reserve, the Bank of Japan and the Bank of Canada conducted surveys of their respective foreign exchange markets. In April 1989 central banks and monetary authorities in twenty-one countries conducted surveys of the foreign exchange operations of banks, other dealers and brokers operating in their markets (Bank of International Settlements 1990). Both of these surveys give approximate, not precise, estimates about the volumes. Over the three years between March 1986 and April 1989 the foreign exchange market turnover has expanded very rapidly. Estimated net global daily turnover (after adjustment for cross-border double counting and estimated gaps in reporting) rose by estimated 116% from $290 billion in 1986 to $640 billion in 1989.

Table 11 shows that this expansion was more than twice the 56% increase in the dollar value of those four countries' foreign trade recorded over the same period, and also above the 76% increase in international banking activity in their markets. The expansion of foreign exchange market activity seems to be loosely positively correlated with the growth of international banking activity. Japan recorded the highest rate of increase in both international banking operations and foreign exchange market activity, whereas Canada registered the smallest rise in exchange market transactions. Canadian banks did not expand their international banking claims during this period. Table 11 also shows that the customer business has grown rapidly since 1986. This growth may reflect the more active management of foreign exchange exposures by companies and non-bank financial institutions and the growing international integration of financial markets. This integration has led to continuous adjustment of currency positions, since the volume and volatility of gross international capital flows has increased.

Table 11

Foreign exchange market transactions with customers and in the spot market, market turnover, foreign trade and international banking activity in March 1986 and April 1989

Country	Net turnover			Business with customers			Spot business[2]			Exports and imports of goods and services	International claims of BIS reporting banks
	March 1986	April 1989	% change	March 1986	April 1989	% change	March 1986	April 1989	% change	% change between first quarter 1986 and first quarter 1989	% change between end-March 1986 and end-March 1989
	in billions of US$			in billions of US$			in billions of US$				
United Kingdom ..	90.0	187.0	108	8.1	26.0	221	65.7	(119.0)	(81)	62	40
United States	58.5	128.9	120	4.1	9.6	134	34.4	80.6	134	44	39
Japan	48.0	115.0	140	16.0	33.7	111	19.0	45.9	142	82	203
Canada	9.5	15.0	58	2.9	4.0	38	4.0	6.1	53	44	- 4
Total	206.0	445.9	116	31.1	73.3	136	123.1	257.6	104	56	76

[1] Net of double-counting arising from local interbank business.
[2] In cases where net spot turnover was not reported directly (United Kingdom and United States) net figures were calculated by multiplying reported gross spot business by the ratio of total net turnover to total gross turnover.

Source: Bank for International Settlements 1990.

7.2 The foreign exchange market today

The foreign exchange market is the largest market on earth. One day's foreign exchange trading generates settlement volume three times as large as US budget deficit in 1987, or about as much as Latin America owes its creditors. Stock, bond and commodity markets barely register such standards: The $25 billion that Wall Street

traded on Black Monday in 1987 is one twentyfifth of a busy foreign exchange day.

The foreign exchange market is a vast world-wide network of buyers and sellers of currencies, operating from approximately 12 major centres and countless minor ones. The technical advancement has largely enabled the foreign exchange market to reach its current state of development as quickly as it has. The markets in the international centres around the world are now largely indistinguishable from each other - except perhaps in terms of the depth of the market at certain times in the 24-hour dealing day when the larger centres for a particular currency are closed. Most of the larger banking groups and some of the world's major international corporates are now making markets on a 24-hour basis from three or more centres around the globe.

It is the Asian market that opens the trading day in Tokyo, Hong Kong and Singapore. The Asian market stays active until well into Europe's "early morning" with most of London's foreign exchange dealing rooms now being active from 7.30 am. From the early European afternoon New York joins the London activity, often working fairly late into the night until the Far Eastern centres re-open. Trading day volumes are usually at their highest during the early European afternoon when New York joins the market.

London is the world's biggest centre for foreign exchange dealing with its $187 billion daily turnover. New York, Tokyo, Switzerland, Singapore and Honk Kong, in this order, are the major centres by volume after London. The foreign exchange market in London is more diversified than elsewhere. Table 12 shows the currency composition of the forex market in London, Tokyo and New York in 1989.

Table 12 The currency composition of the foreign exchange market in London, Tokyo and New York in 1989

	London	Tokyo	New York
$/£	27	4	15
$/DM	22	10	33
$/Yen	15	72	25
$/Sw.Fc.	10	4	12
Other (including cross-currency)	26	10	15

Source: Bank of England 1989 B

It is notable that 72% of overall turnover in Tokyo related to business between the U.S. dollar and the Yen. About 90 percent of world-wide currency trading is now against the US dollar with most

of the remainder being either against Deutchmarks, Yen or sterling. Most of the trading activity accounts for by DM/$ transactions. About two-thirds of London's and New York's foreign exchange trading volume consists of spot foreign exchange trading. The spot market is very much the motor of the foreign exchange market with other trading activity generally riding on the back of the spot market. (Bank of England 1989 B, 531)

Most transactions are consummated over the telephone. Today's dealer generally requires a minimum of two computer screens, a set of telephones, squawk boxes linking him to the brokers and a keyboard. One screen is likely to display market prices and the other the most recent news items via a Reuters link or the equivalent. Telephones provide direct lines into the dealing rooms of other banks, most local currency brokers and perhaps to one or two of the bank's most important customers. Dealer uses the keyboard to update his own prices on the screen and to change the page numbers displayed on his Reuters screen.

Demand for terminals from Reuters, the primary forex-dealing network, is such that the number of screens installed has more than tripled in the past five years to 145,000 (Institutional Investor June 1988, 89).

7.3 New market participants, interbank trading and profits

The volatility of the currency markets in the 1980s has created a profit potential that has attracted new players to enter the market. These players range from investment banks and cash-rich corporations to money managers and high-net-worth individuals. Once a gentlemanly arena of few commercial banks and their central bank counterparts has transformed into multicurrency "betting parlor".

With the new players volume of speculation in foreign exchange market has grown, which can be seen in the increased interbank trading. Most of the trading volume seems to be unrelated to trade in goods, as well as to long-term or medium-term investment. At an annual foreign exchange transaction rate of somewhere $160 trillion, foreign exchange trading clearly dwarfs the world's $6 trillion trade in goods and services. Foreign exchange trading volume has been growing far faster than the trade itself. Even counting the funds used to pay for the huge surge in cross-border investment

since the mid-1980s, at least three quarters of foreign exchange action is considered pure position taking - betting in the interbank market. Clearly, trading among themselves is a major economic activity for banks and other financial institutions.

As a result of wider range of entities active in the forex market it is difficult to make an exact distinction between "interbank" and "customer" business. Non-bank financial institutions and large commercial and industrial companies have become more active in the types of arbitrage and position-taking that were once mainly the domain of banks and other dealers. On the other hand, banks themselves have become "customers" of the forex market, because they have to manage the currency risks arising out their rapidly expanding international credit and securities operations. Classification of deals by type of counterparty does not necessarily clarify the nature of the business, since foreign exchange transactions are increasingly related to international capital flows, not to foreign trade flows. The joint 1989 survey estimated that interbank business, defined as transactions between banks or other reporting dealers, accounted for about 77% of net transactions in the forex market and 21% being with other entities. In London over 80% percent of all transactions take place between banks and financial institutions.

In March 1986, transactions in the U.S. foreign exchange market averaged $50 billion a day among banks (up 92% from 1983), and 34.4 billion a day among brokers and other financial institutions. Most importantly, only 11.5 per cent of the trading reported by banks was with non-bank customers (of which 4.6 per cent was with nonfinancial customers), only 14.3 per cent of the brokers' transactions involved a non-bank, and only 19.2 per cent of trading reported by other financial institutions was with customers (of which 7.7 per cent were nonfinancial institutions) (Dornbusch 1987, 22).

The scale of the profits made in foreign exchange market is huge. Schulmeister has found that in 1985 twelve large U.S. banks earned a foreign exchange trading income of $1,165 million (Schulmeister 1987, 24). Every single bank reported a profit from its foreign exchange business in every single year he examined. Eight major US money center banks alone - Chase Manhattan, Citicorp., Bank of America, Morgan Guaranty Trust, Manufacturers Hanover Trust, Chemical, Bankers Trust and First Chicago - reported total of $2 billion

(pretax) in foreign exchange profits as agents and principals in 1987, up almost 50 % from 1986. Citicorp, Which holds the largest market share in global foreign exchange dealing, made $453 million in foreign exchange profits in 1987. Bankers Trust reported a $338 million pretax profit on foreign exchange trading in a single quarter - 1987's fourth. (Institutional Investor June 1988, 92)

These huge profits wouldn't have been possible without considerable speculation - foreign exchange market is operationally probably the most efficient in the world and the spreads are really small. A typical $10 million trade with a customer could make $2000-3000 to the bank.

7.4 Speculation.

In this context speculation can be defined as position taking in the foreign exchange market, i.e. taking either long or short position in one or several currencies. Position can be taken in the spot or forward market, it can also be created via currency options or futures. Most of speculation takes place in the spot market, where open positions are usually closed very fast, rather within seconds than minutes. The banks report that their speculation does not take place in the forward market. Rather the banks take very short-term open positions in the spot market. Apparently their consider the taking of long-term open positions based on fundamentals, or of any sort of position in the forward market, as too "speculative" and risky. The banks are willing to trust their spot exchange traders to take large open positions, provided they close most of them out by the end of the day, because these operations are profitable in the aggregate. Each trader's limit depends on the bank's aggregate limits and on the trader's previous track record in achieving trading profits by taking positions. Usually traders are given freedom to act according to their own individual views about the course of the currencies in which they are trading. A bank may have a separate considered view about the likely development of certain currencies, but the bank's "official" position is adopted, monitored and accounted separately from individual traders' positions. It can be quite common that trading book position and bank's own position are opposite.

Individual spot trader's position may at any given time largely reflect the balance of buy/sell orders that he has received from

customers. By definition, a market-maker is obliged to quote a bid/offer price and be prepared to deal up to the normal market size of deal upon request (in Bank of England's survey in 1989 the average size of the spot deal in the broker market was estimated to be slightly less than $5 million). Thus market-maker's open position depends partly on the stochastic order flows. However, in efficient and low-transaction cost spot foreign exchange market, the trader can adjust his book extremely rapidly by dealing in the interbank market. Eventually trader's open position depends on the trader's own view about the subsequent movements in the spot rate; when his position changes due to a customer transaction, he can run his new position, or revert it, depending on his view. (Goodhart 1987)

In the description of Goodhart a typical spot trader does not buy and sell on the basis of any model, but rather trades on the basis of knowledge as to which other traders are offering what deals at a given time, and a feel for what their behaviour is likely to be later in the day.
Normal strategy for a trader can be plus 10, minus 5 basis points rule, which means that profits are realized when exchange rate has moved favorably 10 basis points and loss is realized when price has moved against the trader 5 basis points. Steady access to an information-rich flow of customer orders mainly hones trader's tactical, minute-by-minute profit prospects. This trading pattern can yield small profit slices continuously and when accumulated in the end of the day, the total profit is big. More risky, longer-term highly leveraged position taking can be a gold mine. Because foreign exchange markets do trend, the primary risks with this strategy come in missing big turns in trends. In a study by McKinsey & Co. (during the mid-1980s) in roughly two thirds of the cases the dollar went up or down for three months against a basket of industrial currencies before turning. Once there is a trend, a trader just gets behind it and makes profits. The dollar's steady swoon from March 1985 to early 1988 may have been a unique profit opportunity in a foreign exchange trader's lifetime.

The banks' public posture about speculation varies dramatically. Citicorp acknowledges that only about half of its foreign exchange trading is on behalf of its customers, while Chase Manhattan says majority of their business to be customer driven. Bankers Trust refuses to reveal the specifics of its trading strategy, though a source "close to the firm" says that less than 2 percent of its

foreign exchange trading reflects customer service. (Institutional Investor June 1988, 91)

The firmly maintained view in the market is that short-term, largely intra-day, speculation is large in scale and on balance profitable. It is claimed that traders consistently make profits from their position taking (and those who do not, get fired), over and above their return from straight dealing owing to bid/offer spread.

How is it possible to make consistent speculative profits in an efficient market? It is possible if one has better information than others in aggregate. This "better information" does not certainly mean better information about longer-term economic fundamentals. In theory all agents in a market should be equally informed but in practice bank market-makers and traders do have informational advantage, they have the continuous order flow from their customers.

It is interesting to ask that who are the losers, investors who get a worse deal? Earlier certain bank traders had better access to public economic information, when only few bank's trading desks had Telerate/Reuters screens. These traders could exploit their informational advantage and make more money before new news had reached all investors in the market. The current foreign exchange market is informationally efficient, at least what comes to the public news, since all market participants have similar access to public information through Telerate/Reuters screens. Another source of informational advantage to the traders is their access to, and trained interpretation of, the information they receive from the order flow. One can present several examples of this advantage. Market makers and traders follow continuously what other banks and traders do. Some market actions may indicate central bank involvement and an experienced trader can anticipate and react to the potential effects of central bank intervention earlier than his customers. Some banks have a reputation of being good at trading certain currencies and their perceived operations may cause others to follow their lead. This kind of "bandwagon" behaviour can lead to temporary, or in some cases to longer lasting speculative, self-feeding trends. "Technical" correction in this kind of trend takes place when the initial buyers take some or all of their profits by selling the appreciating currency. Each market maker also knows the enquiries and orders he has received from his customers during the course of the day. From these signals he tries to figure out the positions of

others in the market and overall market developments as these positions unwind. Because market makers are in the centre of the market, they can react very quickly and sensitively to the incoming market information. Presumably, the losers are the outside customers. Once the customers try to react to changing information and make enquiries about terms for a large order (this enquiry provides important information for the market-maker, and he can very quickly change his own position prior to answering the enquiry), the market will already have moved, at least partly, against them. An outside customer has less information about the good terms than a market maker. When the customer asks around the market, he improves his own knowledge about the good terms, but he may simultaneously turn the market marginally against himself (i.e. market-makers, being aware of this potential order, marginally change their bid/ask quote to their own advantage).

7.5 Determination of currency values

As new players have entered the market old guidelines for determining currency values - trade flows, purchasing power parities etc.- have become obsolete, replaced by rank speculation. As commented by Mr. Lowell Bryan, a McKinsey & Co. director and foreign exchange expert,"what determines FX prices is what traders think is important, period. Trading psychology rules in the short term; trade flows take years to have effect. In August (1987) the dollar moved down 6 % in two days based on the July trade figures. But it wasn't the real trade flows in July that did that ;it was the release of the information and trader's reactions (Dornbusch 1987, 25). This comment is consistent with the conclusions made by the researchers in the field. Economic fundamentals do not enter into most traders' behaviour, even if fundamentals must win out in the long run. Most traders are so young, and have been in their current job so short a time, that they may not even remember the preceding major upswing or downswing four years earlier. This short-term perspective need not be irrational from the viewpoint of the individual bank. Allowing its traders to take a sequence of many short-term open positions in the spot market may be the bank's only way of learning which traders can make money at it and which cannot.

Anyone with access to a Reuters screen can notice by reading the market commentaries that the market is rather emotionally than rationally driven, at least in the short run. Currency prices react

very fast when knew "market information" is released. This information can range from monthly US trade figures or employment figures to changes is base rate in the UK or to results of elections. For instance, during 1988's dollar appreciation against other major currencies (May - August), currency markets reacted positively to the improved US trade figures and seemed to forget the fact that rising dollar makes it more difficult to cut the deficit. The release of worsened July's trade figures in September 1988 turned the market bearish against the dollar. Finally, when the results of the presidential elections in the US were clear, Reagan's administration admitted that the economy is faced with serious problems because of the double deficits and that dollar has to fall significantly to improve the situation. Currency markets reacted immediately, the "terrible twins" caused dollar do plummet and only the joint central bank interventions in December 1988 could prevent continuous fall.

7.6 Central banks and the market.

Central banks intervene in the foreign exchange market whenever in their opinion their own currency deviates too much from the desired level or when their currency appreciates/depreciates too sharply (Here we take into account only floating currencies, like the U.S. $, £, Yen and DM). It is important to distinguish between different types of intervention. "Unsterilized" intervention means that central bank's foreign exchange intervention is not offset by an equivalent money market operation and the money supply adjusts fully to reflect the intervention. This change in the money supply becomes a change in the monetary policy and will tend to have a lasting effect on exchange rates. In "sterilized" intervention central bank offsets the impact of its intervention in the foreign exchange market on the money supply by means of domestic money market operation. Since sterilized intervention does not involve any underlying alteration to monetary policy it usually has only temporary effects on currencies. If central banks use sterilized intervention as a signalling mechanism of future policy changes this may have an effect on exchange rates. Intervention's potential signalling role is based on assumption that central bank has "inside" information about its own future policy and it can signal this to the market through an intervention.

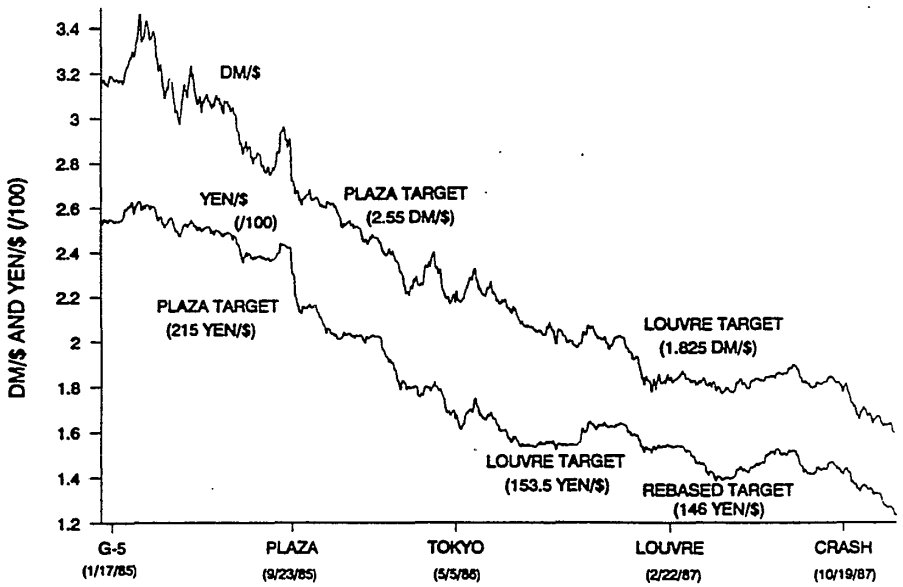
Central bank interventions can be unilateral or coordinated. Coordinated intervention is a simultaneous (same day), usually sterili-

zed, intervention operations by more than one central bank in support of (or against) the same currency (Dominguez 1989, 42). For example, a coordinated intervention to support dollar would involve the purchase of dollar denominated assets with foreign currency denominated assets by more than one central bank.

7.6.1 Central bank interventions in the 1980s

From March 1981 until December 1984 the U.S. did not intervene in the foreign exchange market. The U.S. administration's view was that a strong dollar was a sign of a strong U.S. economy. By January 1985 pressure from the U.S. exporting industries as well as Germany and Japan led to a reversal of the U.S. nonintervention policy. From the early 1980s until February 1985 dollar had appreciated in nominal terms by over 40 percent against the DM and over twenty percent against the Yen. (FNYQR 1985, 58-60)

Figure 8
Spot DM/$ and YEN/$ exchange rates between January 1985 - November 1987



Source: Dominguez 1989

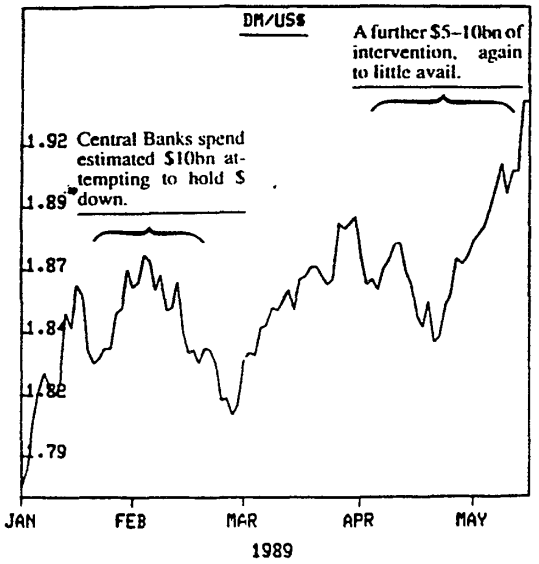
In mid-January 1985 the G-5 countries, for the first time since 1981, agreed to undertake coordinated intervention in the markets. During this first episode of intervention coordination Bundesbank sold a total of $3.5 billion from January through March 1985. Over the same period Japan and the U.S. entered the market on a much smaller scale, the U.S. sold some $600 million. In this period spot DM/$ and Yen/$ rates began their decline as can be seen from figure 8. Bundesbank's perception was that interventions started the down-

ward path of the dollar, Japan and the U.S. reportedly concluded that market forces had begun the dollar's descent.
The G-5's second coordinated intervention round took place after Plaza Agreement on September 22, 1985. At the Plaza meeting, central banks agreed to conduct coordinated sales of up to $18 billion over a six-week period, the aim was a 10 to 12 percent depreciation of the dollar relative to Yen and DM. The post-Plaza intervention operations were more equally shared across the central banks than earlier on in 1985.

After the Plaza agreement G-5 central banks did not commit coordinated interventions until early 1987. In late February 1987 the G-7 countries produced the Louvre Accord which stated that nominal exchange rates were "broadly consistent with underlying economic fundamentals" and should be stabilized at their current levels. The U.S., Japan and European countries agreed to spend up to $4 billion on intervention operations through early April in order to stabilize the DM and Yen with-in a five percent band around 1.825 marks per dollar and 153.5 Yen per dollar. During the first quarter of 1987 the Bank of Japan purchased $16 billion against Yen, but in spite of interventions Yen-dollar Louvre target had to be rebased to 146 Yen per dollar to reflect current market conditions. In order to maintain the Louvre mark-dollar target, the Fed and Bundesbank intervened to support the DM for the first time since Plaza in August 1987. In late 1987 and early 1988, after the global stock market crash, the G-3 central banks intervened to support the dollar by purchasing nearly $7 billion. Bundesbank backed up its intervention operations with a half percent discount rate cut on December 9th 1987. This dollar supportive intervention round is considered to be the most successful coordinated central bank intervention operation in the 1980s. Dollar rebounded from turn of the year lows and was then rather stable until the spring of 1988. (Dominguez 1989, 20)

Since 1988 central banks have made several coordinated interventions mainly to keep the DM/$ and Yen/$ rates in line with the Louvre target levels. The estimated size of the interventions against the dollar during the first half of 1989 was $15-20 billion, but as figure 9 shows, interventions could not stop the up-trend of the dollar. (Goldman Sachs 1989, 8)

Figure 9 The DM/$ spot rate between January - May 1989



Source: Goldman Sachs 1989

7.6.2 Central bank interventions' effectiveness

K.Dominguez examined market responses to official sterilized central bank policy over the period 1985 through 1987 (Dominguez 1989). She found that even though daily intervention data are not published, market participants were generally able to contemporaneously observe the source and magnitude of central bank intervention operations. The market overall is aware of central bank interventions when they occur. Dealers, who are contacted by central banks, report the level, at which central banks intervene, to Reuters immediately. Reuters inputs this information to its screens and central bank intervention becomes public. Dominguez's econometrical test used Bundesbank's confidential daily intervention data (daily central bank interventions data are not publicly available). Regression results indicated that coordinated intervention operations over the three-year period being studied consistently influenced longer-term market expectations. Unilateral interventions influenced market expectations in some periods.

Central banks's main problem is that their resources are limited. The size of coordinated interventions is very small compared to the average daily $600 billion foreign exchange market turnover. Therefore there are very few circumstances under which even coordinated central bank intervention can reverse a currency's trend. Intervention can cause temporary deviations from a trend or exacerbate an existing trend. If fundamental market pressures are generally pointing in the opposite direction interventions tend to fail. The

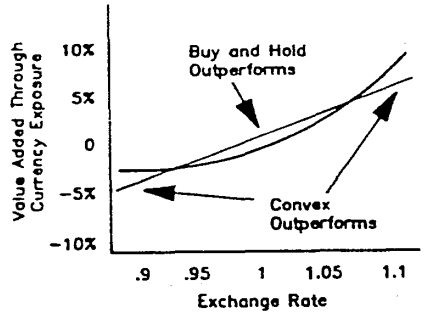
thinner the trading volume is, the greater are the central banks' chances to stimulate reversals. Central bank interventions are most successful over public holidays.

Central banks are more successful in cushioning violent currency movements with their interventions. Comments from the Federal Reserve Bank of New York, as reported in the New York Times on March 9, 1989, describes this intention: "In a clear confirmation of the strength of the effort by the U.S. to control the course of the dollar, the Federal Reserve Bank of New York said yesterday that it had bought $2.4 billion at the end of last year to support a decline in the currency. Then almost immediately, the bank turned around in January and sold $1.88 billion more to try to slow a rally".

7.6.3 Central bank interventions - implications

Do central bank interventions induce serial dependence in currency returns? Probably yes, since instead of reverting trends interventions usually only slow trends. This essentially means that without central bank interventions market adjustment process towards market's desired equilibrium level would be faster than with central banks intervening. Thus interventions effectively lengthen trends. Both parametric and non-parametric tests confirm the presence of serial dependence in currency returns (Kritzman 1989, 98). In a test period from 1977 to 1988 the significance peaked at intervals around two years, suggesting that the trends tend to last about two years on average. This serial dependence can be exploited by linear investment rules that produce convex payoff functions between exchange rates and currency returns.

Figure 10 "Buy and hold" investment strategy payoffs compared with convex investment strategy payoffs



Source: Kritzman 1989

This concept is illustrated graphically in figure 10. Figure compares a buy-and-hold payoff function to a convex payoff function. The horizontal axis is the exchange rate of a hypothetical foreign

currency relative to the dollar. The vertical axis represents the return of the two strategies for a given exchange rate. A convex payoff function results from a strategy of buying a currency as its exchange rate increases and selling it as its exchange rate declines.

While central bank interventions in a sense are stabilizing (they prevent the movement away from equilibrium level, although in this case the "equilibrium" level is defined by central banks, not by the market), they also stimulate speculation, because these interventions reduce the chances of loosing money. An intervention against trend just creates a good buying/selling opportunity for a trader who knows that market pressures are strong enough to absorb and ignore the intervention. Sometimes an unexpected, strong central bank intervention can burn speculators but more often central banks limit position taking risk and encourage bank traders to play with size. Few other investors enjoy government's long-term trading horizons and are willing to buy in panics and sell into booms in major currencies. During 1987 alone, central banks outside the U.S. increased their dollar reserves by $140 billion - hardly a profitable move with the falling dollar (Institutional Investor June 1988, 97).

Regular interventions have put "psychological limits" to traders subconsciousness. The market knows to predict an intervention when up- or downswing is big enough. The timing of the intervention is unpredictable - that is why traders are careful not to go too far. Without the central banks the foreign exchange market would be a zero-sum game and traders would be a lot more cautious. Market players view the central banks as general losers and this is partly true. As Scott Pardee, former trade desk chief at the New York Federal Reserve Bank, puts it "some of the foreign exchange profits are made from the general public" (Institutional Investor June 1988, 97).

7.7 Speculation in the future.

If the currency volatility will continue there is no reason for curbing speculation. The worst scenario for the foreign exchange players who make money would be the reestablishment of Bretton Woods agreement. Huge percentage of the trading volume would probably dry

up and specially the banks depending on their foreign exchange profits would face serious difficulties.

The three most common proposals for reducing the volatility of key-currency exchange rates are a system of target zones, the imposition of controls or taxes on international capital flows, and a strengthening of international coordination over economic policies (Frenkel and Goldstein 1989). We know that news are a key factor in the determination of exchange rates. We need to know what news are relevant, otherwise it is difficult to ascertain which sources of news could be influenced in a stabilizing way by policy actions.

Prior to framing proposals for improving the functioning of the exchange rate system it is logical to ask what is wrong with the existing system. The current size of the foreign exchange market overwhelms the size of central banks' reserves. The deregulation of the market was the primary factor behind market's colossal growth in the 1980s; the re-regulation of the foreign exchange market would seem to be the only way for authorities to reduce the volatility in the current market.

If central banks and governments don't manage to coordinate their macroeconomic policies any better than they have in the 1980s currency volatility and speculation will probably continue.

8 SUMMARY AND CONCLUSIONS

Structural exchange rate models have lost their ability to explain exchange rate movements in the 1980s, when exchange rates moved considerably. The proportion of exchange rate changes that can be explained ex post after observing the contemporaneous changes in macroeconomic determinants is very low. Exchange rates must be reacting then to economic variables that are unknown to the economist, or to some non-fundamental factors.

The current foreign exchange market is largely driven by agents who aim to profit by short-term trading in the spot market. Traders open speculative positions which are closed within very short time periods. Since most traders' trading horizon is so short, traders' short-term expectations about the future spot rate dominate over their longer-term expectations in the trading process. Short-term expectations tend to be regressive and explosive, when long-term expectations take economic fundamentals into account. Thus short-term speculative trading may generate accumulative exchange rate movements taking the real exchange rate far away from fundamentals.

Economic fundamentals are a key element in the exchange rate determination, but it is not clear how these fundamentals are related to exchange rates. Most large movements in the exchange rates, i.e. jumps, are caused by public news announcements. Since traders' expectations can be non-rational and heterogeneous it is difficult to quantify and model economic fundamentals' role in the exchange rate determination.

Any structural model that tries to explain exchange rate determination in the current foreign exchange market should take speculation and different expectations formation processes into account. It may be, however, impossible to construct a plausible exchange rate model in a world where speculative and fundamentalist views compete. The sharp turnaround in the U.S. dollar exchange rate in the early 1985 showed that shifts from speculative to fundamentals related expectations can be abrupt and unpredictable.

In addition to the longer-term trend volatility the foreign exchange market seems to be volatile over very short time horizons. The first order negative auto-correlation, i.e. the tendency for the spot rate to revert back directionally from its previous movement, is remarka-

bly high over the shortest time horizons. This price oscillation, caused by the "human element" in the market, can lead to operational inefficiencies which may offer excess returns to market participants. The most notable operational inefficiency in the foreign exchange market seems to be the "profit taking" phenomenon after large jumps.

The human element basically means that different agents in the market have asymmetrical, differing information sets and accordingly differing views about the "appropriate" equilibrium exchange rate. These differing opinions cause constant price revisions, oscillations around trends.

The growth of the foreign exchange market in the 1980s has been huge and the estimated net daily turnover exceeds $ 600 billion. Speculative interbank trading accounts for most of this turnover; the share of the turnover generated by international trade is exceedingly small. Unless the major industrial countries start to re-regulate the foreign exchange market, speculation and volatility will probably continue in the future.

Further study of the statistical properties of continuous exchange rate time series would be useful in identifying whether all major exchange rate movements are caused by public news. This kind of study could possibly reveal which public news matter most in exchange rate determination. Another area for further studies would be the foreign exchange trader's decision making process. Traders effectively determine the current spot rate at any given moment. Accordingly factors considered to be important by traders are important for the determination of the spot rate.

REFERENCES

Bank for International Settlements — Survey of foreign exchange market activity. Bank for International Settlements. Basle 1990.

Bank of England A — Charts and Fundamentals in the Foreign Exchange Market. Discussion Paper No 40. London 1989.

Bank of England B — The market in foreign exchange in London. BoE quarterly bulletin. London November 1989, 531-535.

Copeland, Thomas & Weston, J. Fred — Financial Theory and Corporate Policy.Addison-Wesley, third edition 1988.

Dominguez, Kathryn — Market responses to coordinated central bank intervention. NBER working paper no: 3192. MA 1989.

Dornbusch, Rudiger — Purchasing Power Parity. NBER working paper no: 1591. MA 1985.

Dornbusch, Rudiger — Exchange rates and macroeconomics: A selective survey. The Scandinavian Journal of Economics 90th anniversary symposium. Helsinki June 1988.

Dornbusch, Rudiger & Frankel, Jeffrey A. — Flexible exchange rate system: Experien ce and alternatives. NBER working paper no: 2464. MA 1987.

Euromoney — Forecasting game. Euromoney August 1987, 112-124.

Fama, Eugene — Efficient capital markets: a review of theory and empirical work. 1979.

Federal Reserve Bank of New York — Federal Reserve Bank of New York quar terly review. 1985.

Frankel, Jeffrey A. & Froot, Kenneth — Using survey data to test some standard propositions regarding exchange rate expectations. NBER working paper no: 1672. MA 1985.

Frankel, Jeffrey A. & Froot, Kenneth — Three essays using survey data of ex change rate expectations. Manuscript University of California. 1986a.

Frankel, Jeffrey A. & Froot, Kenneth — The dollar as a speculative bubble: a tale of fundamentalists and chartists. NBER working paper no: 1854. MA 1986c.

Frankel, Jeffrey A. & Meese, Richard — Are exchange rates excessively variable? NBER macroeconomics annual 1987, 117-153.

French, Kenneth & Roll, Richard — Is trading self-generating? University Of Chicago, working paper no:121. Chicago 1984.

French, Kenneth & Roll, Richard — Stock return variances: the arrival of information and the reaction of traders Journal of Financial Economics. North Holland, Amsterdam 1986, 5-26.

Frenkel, Jacob & Goldstein, Morris — Exchange rate volatility and misalignment: evaluating some proposals for reform. NBER working paper no:2894. MA 1989.

Froot, Kenneth — Exchange rate survey data: The roles of expectational errors, the risk premium and measurement error. University of California, Berkeley, 1985.

Froot, Kenneth & Ito, Takatoshi — On the consistency of short-run and longrun exchange rate expectations. Journal of International Money and Finance. Vol 8 no:4 December 1989, 487-511.

Goldman Sachs — The Limits of Foreign Exchange Intervention. The International Economics Analyst. Vol. 5 May 1989, S.1-S.11.

Goodhart, Charles — The foreign exchange market: a random walk with a dragging anchor. London School of Economics Discussion Paper no 7. 1987.

Goodhart, Charles — From hour to hour in the foreign exchange market. London School of Economics Discussion Paper no: 33. 1988A.

Goodhart, Charles — Every minute counts in the foreign exchange market. London School of Economics Discussion Paper no: 37. 1988B.

Goodhart, Charles — The geographical location of the foreig exchange market. London School of Economics Discussion Paper no: 38. 1988C.

Goodhart, Charles — "News" and the foreign exchange market. London School of Economics Discussion Paper no: 71. 1990.

Grossman, Sanford J. — An analysis of the implications for stock and futures price volatility of program trading and dynamic hedging strategies. NBER working paper no: 2357 MA 1987.

Hacche, Graham — The determinants of exchange rate movements. OECD working paper no 7. 1983.

Institutional Investor — The forex game. Institutional Investor June 1988, 89-97.

Ito, Takatoshi — Foreign exchange rate expectations: micro survey data. NBER working paper no: 2679. MA 1988.

Ito, Takatoshi & Roley, Vance — News from the U.S. and Japan: Which moves the Yen/$ exchange rate? NBER working paper no: 1853. MA 1986.

Kritzman, Mark — Serial dependence in currency returns: investment implications. The Journal of Portfolio Management. Fall 1989, 96-102.

Krugman, Paul — Is the strong dollar sustainable? NBER working paper no:1644. MA 1986.

Marrinan, Jane — Exchange rate determination: sorting out theory and evidence. New England economic review. Federal Reserve Bank of Boston Nov/ Dec 1989, 39-50.

Marris, Stephen — Deficits and the dollar: The world economy at risk. Policy analyses in international economics. Washington 1985.

Martin, Ian — Accounting in the foreign exchange market. Butterworths London 1987.

Martin, John & Masson, Paul — Exchange rates and portfolio balance. NBER working paper no: 377. MA 1979.

Meese, Richard & Rogoff, Kenneth — Empirical exchange rate models in the seventies. Do they fit out of sample? Journal of International Economics. Vol 14, no: 1/2 February 1983, 3-24.

New York Times — New York Times. March 9 1989.

Wheeler, Langdon — The oscillation of systems: the missing link between price volatility and market efficiency. Financial Analysts Journal. July/August 1989, 7-11.

APPENDIX 1 Expected depreciation over different time horizons

THE TERM STRUCTURE OF EXPECTED DEPRECIATION AND PREDICTION ERRORS
(in percent per annum)

FORECAST HORIZON	SURVEY SOURCE	DATES	N	EXPECTED DEPRECIATION E[s(t+1)]-s(t) Mean	SD of Mean	t stat	SURVEY PREDICTION ERROR E[s(t+1)]-s(t+1) Mean	SD of Mean	t stat	FORWARD DISCOUNT f(t)-s(t) Mean	SD of Mean	t stat	FORWARD RATE PREDICTION ERROR f(t)-s(t+1) Mean	SD of Mean	t stat
1 WEEK															
TOTAL	MMS	10/84-9/85	183	-8.13	4.23	-1.92	-23.36	10.55	-2.21						
UK			46	-24.26	9.08	-2.67	-41.13	25.70	-1.60						
WG			46	-3.81	7.58	-0.50	-19.40	20.23	-0.96		NA			NA	
SW			45	-0.75	9.96	-0.07	-13.88	23.58	-0.59						
JA			46	-3.53	6.74	-0.52	-18.81	13.41	-1.40						
2 WEEKS															
TOTAL	MMS	1/83-10/84	187	4.22	1.26	3.36	16.57	3.38	4.91						
UK			47	-2.66	2.48	-1.07	13.49	6.77	1.99						
WG			47	5.08	2.59	1.96	20.28	7.51	2.70		NA			NA	
SW			46	6.09	2.54	2.40	19.95	6.49	3.07						
JA			47	8.40	2.21	3.79	12.63	6.32	2.00						
1 MONTH															
TOTAL	MMS	10/84-9/85	48	-10.25	2.88	-3.56	-23.80	7.76	-3.07	-0.16	0.87	-0.18	-13.71	7.49	-1.83
UK			12	-25.06	6.07	-4.13	-38.95	20.29	-1.92	-5.63	2.09	-2.69	-19.52	19.52	-1.00
WG			12	-6.91	6.10	-1.13	-19.91	14.82	-1.34	1.56	1.47	1.06	-11.44	13.93	-0.82
SW			12	-6.38	5.15	-1.24	-19.59	17.09	-1.15	1.99	1.52	1.31	-11.22	16.76	-0.67
JA			12	-2.66	3.65	-0.73	-16.76	8.84	-1.90	1.45	0.77	1.87	-12.65	9.95	-1.27
3 MONTHS															
TOTAL	MMS	1/83-10/84	187	7.76	0.38	20.53	18.53	2.89	15.52	3.75	0.17	21.52	14.51	2.87	5.07
UK			47	4.46	0.55	8.08	18.38	5.98	3.07	0.37	0.19	1.96	14.29	5.97	2.40
WG			47	8.33	0.62	13.45	22.01	5.96	3.69	4.68	0.14	34.37	18.36	6.05	3.03
SW			47	9.62	1.01	9.51	22.23	5.26	4.23	6.13	0.14	43.69	18.74	4.91	3.82
JA			47	8.68	0.54	15.95	11.58	5.20	2.23	3.85	0.16	23.77	6.75	5.02	1.35
TOTAL	ECONOHIST	6/81-8/85	165	10.03	0.63	15.80	15.54	2.75	5.64	2.47	0.36	6.82	7.98	2.59	3.09
UK			33	5.16	1.34	3.84	14.38	6.80	2.11	0.47	0.36	1.34	9.69	6.07	1.60
FR			33	5.57	1.08	5.17	15.88	5.80	2.74	-4.23	0.70	-6.07	6.08	5.42	1.12
WG			33	12.79	1.17	10.91	17.19	5.86	2.93	4.54	0.21	21.26	8.94	5.41	1.65
SW			33	12.96	1.11	11.68	16.16	6.95	2.33	6.39	0.33	19.30	9.58	6.63	1.45
JA			33	13.67	1.51	9.04	14.10	5.16	2.73	5.16	0.46	11.25	5.59	5.17	1.08
6 MONTHS															
TOTAL	ECONOHIST	6/81-8/85	165	9.88	0.45	21.76	18.07	2.47	7.30	2.47	0.35	7.16	10.24	2.44	4.20
UK			33	5.03	0.74	6.81	16.82	5.52	3.05	0.64	0.29	2.20	11.99	5.38	2.23
FR			33	4.77	0.80	5.95	17.98	4.97	3.61	-4.30	0.57	-7.54	8.45	4.84	1.75
WG			33	12.97	0.68	19.17	20.33	5.20	3.91	4.52	0.19	24.22	11.35	5.06	2.24
SW			33	12.77	0.70	18.12	19.35	6.58	2.94	6.27	0.28	22.65	12.47	6.26	1.99
JA			33	13.86	0.69	19.98	15.86	5.07	3.13	5.21	0.42	12.51	6.93	5.32	1.30
TOTAL	AMEX	7/81-8/84	20	8.03	0.90	8.88	13.01	3.34	3.89	3.89	0.93	4.19	8.88	3.13	2.84
12 MONTHS															
TOTAL	ECONOHIST	6/81-8/85	165	8.29	0.35	23.57	17.76	1.76	10.07	2.54	0.31	8.08	12.12	1.92	6.33
UK			33	4.05	0.56	7.22	16.72	4.08	4.10	0.78	0.22	3.49	13.81	4.21	3.28
FR			33	3.92	0.53	7.34	18.41	2.29	8.04	-3.83	0.43	-8.86	10.66	2.98	3.57
WG			33	11.25	0.39	29.03	19.90	3.29	6.04	4.38	0.15	28.93	13.02	3.32	3.92
SW			33	10.91	0.43	25.49	19.67	4.07	4.84	6.27	0.22	29.05	15.41	4.13	3.73
JA			33	11.31	0.53	21.18	14.10	4.59	3.07	5.08	0.34	15.05	7.70	5.04	1.53

Notes: Expectations are for four currencies against the dollar: UK=British Pound; WG=German Mark; SW=Swiss Franc; JA=Japanese Yen.

Source: Frankel and Froot 1986c.

APPENDIX 2 Prior forecasts and recorded results of main news between April 10-26 1989.

1989	GMT	COUNTRY	STATISTIC	REPORTED ON AAMM	FORECASTS REUTERS	MMS	TELERATE
APR 10		W.G.	COST OF LIVING	0.2		0.2	0.2
APR 10	1031	U.K.	PPI (OUTPUT)	0.3	0.4	0.4	0.4
APR 10	1031	U.K.	PPI (INPUT-SA)	1.4	0.9	1.3	0.7
APR 11	625	JPN	MACHINERY ORDERS	DROP		23	
APR 13	631	JPN	MERC TRADE (DLRS)	4.13	7.6	7.4	7.4
APR 13	1033	U.K.	AVERAGE EARNINGS	9.25	9	9	9
APR 13	1036	U.K.	UNEMPLOYMENT	-30.6	-35	-30	-37.5
APR 13	1230	U.S.	RETAIL SALES	0.1	0.3	0.3	0.2
APR 14	530	JPN	INDUSTRIAL PROD	-1.7		-1.4	
APR 14	650	FRA	CONSUMER PRICES	0.3	0.3		
APR 14	650	FRA	CONSUMER PRICES (Y/Y)	3.4	3.4		
APR 14	1230	U.S.	PRODUCER PRICES	0.4	0.5	0.5	0.5
APR 14	1231	U.S.	MERC TRADE (CUSTOMS)	-10.5	-10	-10.1	-10.2
APR 14	1231	U.S.	MERC EXPORTS			28.9	28
APR 14	1231	U.S.	MERC IMPORTS			39	38.3
APR 14	1315	U.S.	INDUSTRIAL PROD	0	0.2	0.2	0.2
APR 14	1328	U.S.	CAPACITY UTLSN	84	84.3	84.3	84.3
APR 14	1400	U.S.	BUS INVENTORIES	0.5	0.4	0.4	0.5
APR 17	1030	U.K.	MANFG OUTPUT	-0.6	0.1	-0.3	0.2
APR 17	1031	U.K.	RETAIL SALES	0	-0.1	0.2	0
APR 17	1031	U.K.	INDUSTRIAL PROD	-0.3	0.1	0.8	-0.1
APR 17	1036	U.K.	UNIT WAGE COSTS (3M)	2.9	2.9		
APR 18	1231	U.S.	BUILDING PERMITS	1.22		1.45	
APR 18	1231	U.S.	CONSUMER PRICES (Y/Y)		4.9		
APR 18	142	AUS	CURRENT A/C (ADLRS)		-1.2		
APR 18	528	JPN	HOUSEHOLD EXP	-2.1	1.8		
APR 18	801	JPN	M2 + CDS (Y/Y)	10.3	10.3	10.4	10.5
APR 18	807	JPN	WHOLESALE PRICES	STABLE	0.3	0.3	0.3
APR 18	1030	U.K.	PSDR	-2.3	-2.7	-3.3	-2.7
APR 18	1236	U.S.	CONSUMER PRICES	0.5	0.5	0.5	0.5
APR 18	1240	U.S.	HOUSING STARTS	1.4	1.5	1.55	1.45
APR 19	1007	FRA	INDUSTRIAL PROD	-0.7	0.3		
APR 19	1323	W.G.	PRODUCER PRICES	0.3	0.3	0.3	0.2
APR 20		U.K.	M4 (SA)		1.5		
APR 20	741	W.G.	M3 (PA)	6.2	7.1		
APR 20	1030	U.K.	M0 (SA)	0.5	0.5	0.4	0.5
APR 20	1032	U.K.	M4 LENDING (SA)	8	5.6	4.8	5.5
APR 21		U.K.	CYCLICAL INDICATORS		0.1		
APR 21	1030	U.K.	CONSUMER SPENDING	0.6		-0.5	0
APR 21	1818	U.S.	FEDERAL BUDGET	-35.78	-31.5	-29	-30
APR 24	631	JPN	WPI -1ST 10 DAYS	2.56		1.2	
APR 25	1456	FRA	UNEMPLOYMENT		10		
APR 25	538	JPN	DIFFUSION INDEX -LED. I	30		36.4	
APR 25	935	U.K.	BLDG SOC COMMITMENTS	4.25	3.9	4.25	3.75
APR 25	1230	U.S.	DURABLE SHIPMENTS	-0.7		1.7	
APR 25	1230	U.S.	DURABLE GOODS ORDRS	0.8	1.3	1.7	1
APR 25	1230	U.S.	EMPLOYMENT COST INDEX	1.2		4.7	
APR 26	1309	W.G.	CONSUMER PRICES		0.3		
APR 26	1309	W.G.	CONSUMER PRICES (Y/Y)		2.8		
APR 26	601	JPN	INDUSTRIAL PROD -SA,PRE	4.2			
APR 26	651	JPN	RETAIL SALES %YR	24.8			

Source: Goodhart 1990.

APPENDIX 3 Major observed Jumps and contemporaneous news between April - June 1989.

Date	(BST) Time Announcement	Jump%	Comment
1. Fri Apr 14th	13.30:13.31 US Producer Prices at 13.30 US Trade Figures at 13.31	Dm -0.24 Yen 0.00 £ -0.16	The first announcement was better, i.e. lower, than expected; but the trade figures were worse, i.e. higher, so an initial move on the Prices figures would then be immediately reversed.
2. Wed Apr 26th	11.30 UK Trade Figures	£ +0.015	Slightly better than feared
3. Fri May 5th	13.30 US Unemployment /Payroll figures	Dm -0.17 Yen -0.18 £ +0.19	Weaker than expected
4. Thurs May 11th	13.30 US Retail Sales	Dm -0.14 Yen -0.11 £ +0.09	Much lower than expected
5. Wed May 17th	13.30 US Trade Figures	Dm +0.42 Yen +0.45 £ -0.49	Considerably better than expected
6. Thurs May 18th	13.30 US Consumer Prices	Dm +0.10 Yen +0.07 £ -0.08	Higher than expected
7. Thurs May 25th	11.30 UK Trade Figures	£ -0.01	Worse than expected
8. Mon June 19th	02.31 Australian Current Account	Aus -0.61	Large and widening, but not as bad as feared
9. Wed May 24th	09.48 UK Interest Rates Rise	£ -0.45	Bank of England administers a 1% in base rates
10.Thurs June 15th	18.00-22.00 Attack on US $	Dm, Yen, £ } appreciate almost 2%	Intervention to reinforce technical $ weakness.

Source: Goodhart 1990.

BANK OF FINLAND DISCUSSION PAPERS

ISSN 0785-3572

1/91 RISTO PELTOKANGAS Usean faktorin korkorakennemallit ja immmunisaatio. (Multi-factor Models of the Term Structure and Immunization). 1991. 82 p. (ISBN 951-686-274-8)

2/91 ANTTI URVAS Volatile Exchange Rates and Speculation - Can the Dollar Movements of the 1980s Be Explained? 1991. 124 p. (ISBN 951-686-275-6)