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PSYCHOLOGICAL BARRIERS IN THE FOREIGN EXCHANGE MARKET

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ABSTRACT

Psychological Barriers in the Foreign Exchange Market

This paper undertakes an empirical analysis of the existence of psychological barriers in the dollar/DM and the dollar/yen exchange markets. Psychological barriers occur when agents attach some special importance to the last trailing digits of the price of an asset or a currency. Our empirical results indicate that psychological barriers exist and are significant in the dollar-yen market. Market exchange rates tend to resist movements towards numbers such as 130, 140, ... yen per dollar etc. In addition, once these barriers have been crossed, exchange rates accelerate away from them. The evidence of psychological barriers in the dollar/DM market is less clear-cut.

JEL classification: F30, G14, G15
Keywords: exchange rate, psychological barriers, market efficiency

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NON-TECHNICAL SUMMARY

In the financial press the movements of major currencies' exchange rates are routinely described in terms of 'resistance levels' and 'psychological barriers'. Exchange rates are often said to resist a movement towards some rounded number such as 150 yen for the dollar, or 2 DM for the dollar. Once these levels are transgressed, the movements of the exchange rates are said to accelerate. That is, certain values of the exchange rates (mostly rounded numbers) appear to have an important influence on the dynamics of the market, at least if the descriptions in the popular financial press are taken seriously.

On the whole academic economists have ridiculed these ideas. The concept of a psychological barrier contradicts the ideas of rationality and market efficiency. In particular, the fact that an exchange rate ends with a zero, or any other number, should be irrelevant information. After all, an exchange rate can always be multiplied by some arbitrary number, so that previously rounded numbers become unrounded. This irrelevance should be stronger in the foreign exchange market than in the stock markets, because (unlike the stock market index) an exchange rate can always be defined in two ways, one being the inverse of the other. Thus, if the dollar/DM rate is say 3.00 (a rounded number), the corresponding DM/dollar rate is 0.333333... (an unrounded number).

The existence of psychological barriers in the foreign exchange market is therefore important. If the existence of such barriers is confirmed, this may cast doubts on whether the efficient market hypothesis is a correct representation of the functioning of the foreign exchange market. Donaldson (1990) has recently confirmed the existence of psychological barriers in the movements of stock market indices in a number of major countries. This paper undertakes a similar analysis for the foreign exchange market.

Psychological barriers occur when agents attach special importance to the last trailing digits of the price of an asset or currency. Specifically, a psychological barrier is said to exist if traders are hesitant to pass such a number, and if, once the 'barrier is broken', the movement away from it accelerates through overbuying or overselling. We employ the following research strategy to determine whether such psychological barriers exist. We use daily quotations of the dollar/DM and the dollar/yen exchange rates, together with their inverses during the sample period of 1 January 1980 to 12 December 1990. These daily observations are classified in 100 classes according to the last two digits. We test for the existence of 'unit' and 'decimal' psychological barriers. In the case of unit psychological barriers only the first two digits after the decimal point are taken into account to construct 100 classes. In the case of 'decimal' barriers, we classify all observations in 100 classes according to the second and third digit after the decimal point. In this case psychological barriers occur when the second

and third digit after the decimal point are zeros, e.g. 1.100, 1.200, 1.300 and 1.400.

The existence of a psychological barrier implies that significantly fewer daily closing prices in the neighbourhood of the psychological barriers will be observed. Our empirical results indicate that psychological barriers exist and are significant in the dollar/yen market. Market exchange rates tend to resist movements towards numbers such as 130, 140, ... yen per dollar, etc. In addition, once these barriers have been crossed, the rate accelerates away from the barrier. We also find that the inverted quotations of the dollar/yen exchange rate (say 0.5 US cents per yen) do not trigger these psychological effects in the market.

The evidence of psychological barriers in the dollar/DM market is less clear-cut. We find some weak evidence that rounded numbers such as 2 or 3 Deutschmarks per dollar act as psychological barriers. We did not find evidence that numbers such as 1.4, 1.5, 1.6 ... have these psychological effects. Again, the inverted quotations appear to have no psychological impact.

These results raise issues concerning the efficiency of the foreign exchange markets. Why should irrelevant information influence agents' willingness to buy and sell foreign currencies? In addition, there is the issue of why these agents select one particular method for quoting foreign exchange rates rather than its inverse.

Defenders of market efficiency can of course claim that psychological barriers may not necessarily lead to exploitable profit opportunities. If this is the case, the existence of psychological barriers may not contradict market efficiency. It is likely, however, that profitable exploitation of these psychological barriers is possible. Transactions costs in the foreign exchange markets are now so low that it is difficult to conceive how they would prevent rational agents from exploiting the irrational behaviour of other agents. The continued existence of psychological barriers indicates that profit taking by rational agents is a weak force in the market.

1. INTRODUCTION

In the financial press the movements of the exchange rates of the major currencies are routinely described in terms of resistance levels and psychological barriers. Exchange rates are often said to resist a movement towards some rounded number like 150 Yen for the dollar, or 2 DM for the dollar. Once these numbers are transgressed, the movements of the exchange rates are said to accelerate. In other words, certain values of the exchange rates (mostly rounded numbers) appear to have an importance in influencing the dynamics of the market, at least if one takes the descriptions in the popular financial press seriously.

On the whole, academic economists have scoffed at these ideas. There is a good reason for this. The concept of a psychological barrier appears to contradict the idea of rationality and of market efficiency. In particular, the fact that an exchange rate ends with a zero or any other number should be irrelevant information. After all, one can always multiply an exchange rate by some arbitrary number, so that previously rounded numbers become unrounded. In the foreign exchange market the irrelevance of rounded numbers appears to be even stronger than in the stock markets, for the simple reason that (contrary to the stock market index) an exchange rate can always be defined in two ways, one being the inverse of the other. Thus, if the dollar/DM rate is say 3.00, a rounded number, the corresponding DM/dollar rate is 0.333333..., an unrounded number.

The irrevelance of rounded numbers can also be deduced from neo-classical demand theory. A basic result of that theory is that the demand functions are homogeneous of degree zero in all prices. This means that if we multiply all prices by the same number, thereby leaving relative prices unchanged, the demand of the different goods should remain unchanged. The existence of psychological barriers is in contradiction with this result. It implies that multiplying the exchange rates of one currency, say the dollar, by an arbitrary constant, (a procedure that leaves the relative prices of all currencies in terms of the dollar unchanged), affects the structure of the demand for these currencies.

The issue of whether psychological barriers exist in the foreign exchange market, therefore, is an important one. If confirmed, it can lead to doubts about the efficient market hypothesis as a correct representation of the functioning of the foreign exchange market[1].

Recently Donaldson (1990) has confirmed the existence of psychological barriers in the movements of stock market indices in a number of major countries. A similar study has, as yet, not been undertaken in the foreign exchange market. The purpose of this paper is to undertake such an empirical analysis.

The paper is organized as follows. In section 2 the research methodology, owed to Donaldson (1990), is described. In section 3, the empirical results are presented. Finally, in section 4 some conclusions are formulated.

2. RESEARCH METHODOLOGY

Psychological barriers occur when agents attach some special importance to the last trailing digits of the price of an asset or a currency. This happens when an exchange rate ending with 00 or 0 gains some special importance. More specifically, a psychological barrier is said to exist if traders are hesitant to pass such a number, and if, once the "barrier is broken", the movement away from the barrier accelerates through overbuying or overselling.

The research strategy employed to find out whether such psychological barriers exist is the following. We use daily quotations of the dollar/DM and the dollar/yen exchange rates, together with their inverse, during the sample period from Jan 1, 1980 to Dec. 12, 1990. These daily observations are then classified in 100 classes according to the last two digits. We will test for the existence of "unit" and for "decimal" psychological barriers. In the case of unit psychological barriers only the first two digits after the decimal point are taken into account to

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1 Recent empirical studies of the serial dependence of returns have led to doubts about market efficiency. Most of these studies analyze stock markets. See Campbell and Shiller (1988), Fama and French (1988) and Barsky and DeLong (1989). See also Frankel and Froot (1987) and Cutler, Poterba, and Summers (1990) for the foreign exchange market. For a recent survey relating to the foreign exchange market see MacDonald and Taylor (1991).

construct 100 classes. For example, in the case of the dollar/DM we have observations like 1.00, 1.01, 1.02, ...1.10, 1.11 ..... and the psychological barriers are 1.00, 2.00, 3.00, etc. . Each observation falls in one of the 100 classes depending on the two digits after the decimal point (00, 01, 02, ...98, 99). We call these classes the M-values. In the case of "decimal" barriers, we classify all observations in 100 classes depending on the second and third digit after the decimal point. In this case psychological barriers occur when the second and third digit after the decimal point are zero's, e.g. 1.100, 1.200, 1.300, 1.400. The M-values are defined in the same way.

In the case of the dollar/Yen the dimension of the quotations is typically something like 135.67. We devide these exchange rates by 100, and proceed in the same way as in the case of the dollar/DM. When analyzing the inverse Yen/dollar rate (which is a small number like 0.0076074) we multiply by 1000 and proceed likewise.

The existence of a psychological barrier implies that we will observe significantly less daily closing prices in the neigborhood of the psychological barriers. Thus, if the M-values are not distributed uniformly, and more specifically if we observe a lower frequency of M-values around the psychological barriers, one can say that there is statistical evidence for the existence of psychological barriers. In an efficient market this should not be the case. If markets are efficient we should not be able to reject the hypothesis that the M-values are uniformly distributed, i.e. that the probability of an observation to fall in one of the 100 classes (M-values) is the same.

Figures 1 to 8 (in appendix) present the frequency distributions of the M-values. Since there are 100 M-values, the probability of observing a particular M-value is 1 percent, if the frequency distribution is uniform. Thus, if the market is efficient the frequency distribution should be a horizontal line at 1. It can already be seen that for some exchange rates this may not be the case.

Our formal testing procedure was as follows. In a first step we performed a χ^2-test to check for uniformity of the frequency distribution of the M-values. We split the M-values in ten categories, i.e. 00-09, 10-19,...,90-99, and computed the χ^2-statistic using a goodness of fit test. We did this for both the unit and the decimal psychological barriers. The results are shown in table 1. It can be seen that in all

cases where we express exchange rates as amounts of Yen (DM) per dollar the hypothesis of uniformity can be rejected with a high degree of confidence. This is not the case with the inverted exchange rates (amount of dollars per Yen (DM)). In two of the four cases (decimal barriers) we cannot reject uniformity.

Table 1 : Tests of uniformity of the distribution of the M-values (χ^2 test)

Unit psychological barrier	$\chi^2(9)$	Uniformity rejected at
\$/DM	534.6	99.5 %
\$/Yen	2111.2	99.5 %
DM/\$	32.5	99.5 %
Yen/\$	150.0	99.5 %
Decimal psychological barrier	$\chi^2(9)$	**Uniformity rejected at**
\$/DM	49.9	99.5 %
\$/Yen	84.1	99.5 %
DM/\$	6.8	50.0 %
Yen/\$	12.5	90.0 %

Source : Computed from daily closing prices obtained from Reuters, (Jan 1, 1980 to December 12, 1990).

3. REGRESSION ANALYSIS OF THE FREQUENCIES OF M-VALUES

Our next step in the empirical test of the existence of psychological barriers consisted in setting up the following regression experiment. We regressed the frequencies of the M-values on a constant term and on a dummy variable which takes the value 1 when the M-value is in the "neighbourhood" of the psychological barrier, and zero otherwise. If there is a psychological barrier we should find that the M-values neighbouring the psychological barrier occur less frequently

than M-values far away form the psychological barrier. We use two alternative definitions of neighbouring M-values. More formally, the following regression equation was estimated :

$$P(M_i) = \alpha + \beta D + U_i \qquad (i = 1 \ldots, 100) \qquad (1)$$

where $P(M_i)$ is the observed frequency of the M-value i (M_i); D is a dummy variable which is defined in two alternative ways :

(a) D = 1 when $M_i \geq 90$ and $M_i \leq 09$ and zero otherwise;
(b) D = 1 when $M_i \geq 75$ and $M_i \leq 24$ and zero otherwise.

In the definition (a) we consider a narrow neighbourhood around the psychological barrier, in definition (b) we consider a wide neighbourhood.

The test of the existence of psychological barriers reduces to a t-test on the coefficient β. If a psychological barrier exists, this coefficient will be significantly negative.

We present the results of estimating equation (1) in tables 2 to 5. We observe that in the case of the Dollar/Yen (see table 2), the β-parameter is significantly negative, whether we use narrow or wide neighbourhoods around the psychological barriers. This means that there are significantly less observations of M-values close to the psychological barriers. This result holds true both for the tests of unit and decimal psychological barriers. In other words, we cannot reject the hypothesis that psychological barriers exist in the dollar-yen market. These psychological barriers appear to be both values like 200, 300 yen per dollar (unit psychological barriers) and values like 110, 120, 130, 140, ...yen per dollar (decimal barriers). In addition, the size of the β-parameter is quite large. For example, in the first row of table 2 we observe a β-parameter = -0.91. Given the α-parameter (1.18), this implies that the probability of observing an M-value in the classes between 90 and 09 around unit barriers is only 0.27 percent (1.18-0.91), whereas in the other classes it is 1.18 percent.

The results for the dollar/DM market are less clear-cut (see table 3). We find evidence for unit psychological barriers (2, 3 or 4 DM per dollar) when we use a narrow neighbourhood around these barriers (model (a)). There is no evidence,

however, of decimal psychological barriers. That is, values like 1.2, 1.3, 1.4, .., do not seem to work as psychological barriers in the dollar/DM market.

The evidence concerning the inverted exchange rates of these currencies (tables 4 and 5) is unambiguous. In no case do we find evidence of psychological barriers. All the β-parameters are insignificantly different from zero, except in two cases where they have the wrong sign. Thus, rounded numbers like 0.5 US cents per yen, or 40 US cents per DM do not play any role as psychological barriers.

From the preceding results one can conclude that the phenomenon of psychological barriers only plays a role in the dollar exchange markets when quotations are expressed in the form of amounts of DM per dollar, or amounts of Yen per dollar. This is quite a surprising result. It raises the question why a particular way of quoting exchange rates obtains a special "psychological" meaning, while another way of quoting the same exchange rate does not obtain such meaning.

Table 2 : Regression of equation (1) : Dollar/Yen

Test of Unit psychological barriers			
Model (a) :	α	β	R^2
	1.18 (1.75)	-0.91 (-3.91)	0.13
Model (b) :	α	β	R^2
	1.63 (5.83)	-1.26 (-8.24)	0.41
Test of Decimal psychological barriers			
Model (a) :	α	β	R^2
	1.04 (1.54)	-0.22 (-3.45)	0.11
Model (b) :	α	β	R^2
	1.11 (3.37)	-0.23 (-4.76)	0.19

Note : The numbers in brackets are t-statistics. The t-statistics of the α parameters test for the significance of the difference from 1. The t-statistics of the β parameters test for the significance of the difference from 0.

Table 3 : Regression of equation (1) : Dollar/DM

Test of Unit psychological barriers			
Model (a) :	α	β	R^2
	1.06 (1.04)	-0.31 (-2.32)	0.05
Model (b) :	α	β	R^2
	0.98 (0.29)	0.04 (0.41)	0.0
Test of Decimal psychological barriers			
Model (a) :	α	β	R^2
	1.02 (0.67)	-0.10 (-1.51)	0.02
Model (b) :	α	β	R^2
	0.96 (1.02)	0.07 (1.44)	0.02

Note : The numbers in brackets are t-statistics. The t-statistics of the α parameters test for the significance of the difference from 1. The t-statistics of the β parameters test for the significance of the difference from 0.

Table 4 : Regression of equation (1) : Yen/Dollar

Test of Unit psychological barriers			
Model (a) :	α	β	R^2
	0.92 (2.36)	0.41 (5.29)	0.22
Model (b) :	α	β	R^2
	0.86 (3.11)	0.28 (4.40)	0.16
Test of Decimal psychological barriers			
Model (a) :	α	β	R^2
	1.00 (0.02)	0.00 (0.05)	0.00
Model (b) :	α	β	R^2
	0.99 (0.19)	0.01 (0.26)	0.00

Note : The numbers in brackets are t-statistics. The t-statistics of the α parameters test for the significance of the difference from 1. The t-statistics of the β parameters test for the significance of the difference from 0.

Table 5 : Regression of equation (1) : DM/Dollar

Test of Unit psychological barriers			
Model (a) :	α	β	R^2
	0.98 (0.63)	0.08 (1.42)	0.02
Model (b) :	α	β	R^2
	1.01 (0.45)	-0.03 (-0.63)	0.00
Test of Decimal psychological barriers			
Model (a) :	α	β	R^2
	1.01 (0.62)	-0.07 (-1.38)	0.02
Model (b) :	α	β	R^2
	1.02 (0.73)	-0.04 (-1.03)	0.01

Note : The numbers in brackets are t-statistics. The t-statistics of the α parameters test for the significance of the difference from 1. The t-statistics of the β parameters test for the significance of the difference from 0.

4. ADDITIONAL TESTS

As explained in the introduction, an implication of the existence of psychological barriers is that these barriers tend to repulse the exchange rate : When below a barrier, the exchange rate "hesitates" to move towards it. Once it passes the barrier it accelerates away from it. An alternative way to test the psychological barrier hypothesis, therefore, is to test whether the frequency with which the exchange rate **passes through** various M-values is uniform across all M-values. If uniformity is rejected, we can test whether the frequency with which the exchange rate passes through various M-values is less dense around the psychological barrier. If so, we have additional evidence of the existence of psychological barriers.

The methods used to estimate the frequencies and to perform the tests are identical to those discussed above but now we take as dependent variable the frequency of **passing** M-values. These we obtain by counting the number of times the exchange rate moves through a given M-value. For example, when the exchange rate moves from 1.4113 to 1.4154 between two consecutive days, it passes through the M-values 12, 13, 14 and 15 (in the decimal barrier test). We record the number of times this happens in these M-values. We call this the frequencies of "passing" M-values.

We first present the χ^2-tests for uniformity of the frequencies of the passing M-values. This is done in table 6. In general, we are able to reject uniformity, except in the case of the (inverted) Yen/$ rate.

Table 6 : Tests of uniformity of the distribution of the passing M-values (χ^2 test)

Unit psychological barrier	$\chi^2(9)$	Uniformity rejected at
$/DM	222.0	99.5 %
$/Yen	1800.0	99.5 %
DM/$	172.5	99.5 %
Yen/$	187.7	99.5 %
Decimal psychological barrier	**$\chi^2(9)$**	**Uniformity rejected at**
$/DM	201.7	99.5 %
$/Yen	243.7	99.5 %
DM/$	53.2	99.5 %
Yen/$	14.3	90.0 %

Next we perform a similar regression analysis as in the previous section. We estimated equation (1) where $P(M_i)$ is now defined as the frequency with which the exchange rate passes through the M-value i. If the β-parameter is significantly negative, there is evidence that the frequency with which the exchange rate passes through various M-values is less dense around the psychological barriers. Put differently, a significantly negative β-parameter can be interpreted as evidence of the existence of psychological barriers. The results are presented in tables 7 to 10.

Once again we observe that in the Dollar/Yen market there is strong evidence of the existence of psychological barriers. We find that the β-coefficients are significantly negative both when we test for unit and for decimal barriers (see table 7). In other words, rounded numbers like 130, 140, 150 etc., seem to work as resistance levels in that market.

In the dollar/DM market (table 8) we find no evidence of psychological barriers. The β-coefficients are either insignificant or positive, albeit very small.

Finally, the evidence concerning the inverted exchange rates are presented in tables 9 and 10. In the case of the Yen/Dollar (table 9), all the β-coefficients have a positive sign, rejecting the hypothesis that rounded numbers tend to repulse the exchange rate. In the case of the DM/Dollar we find negative and significant β-coefficients. However, the size of these coefficients is very small. For example, when we find a β-coefficient of -0.04 and an α-coefficient of 1.01, this means that the frequency with which the M-values are passed in the neigborhood of psychological barriers is 0.97 % versus 1.01 % when the exchange rate is far away from the barriers. This is certainly a very small difference. It also contrasts with the results of table 7 for the dollar-yen market where some of the coefficients imply very large differences in frequencies.

To conclude, the results concerning the passing M-values tend to confirm those obtained in the previous section. In the dollar-yen market there is strong evidence of psychological barriers. The dollar-yen rate plays the role of "repulsing" the exchange rate. This is not the case for the inverted quotations in that market. In the dollar-DM market the evidence of rounded quotations to perform this psychological repulsing effect is weak.

Table 7 : Regression of equation (1) : Dollar/Yen (Passing M-values)

Test of Unit psychological barriers			
Model (a) :	α	β	R^2
	1.19 (1.85)	-0.96 (-4.14)	0.15
Model (b) :	α	β	R^2
	1.62 (5.57)	-1.24 (-7.88)	0.39
Test of Decimal psychological barriers			
Model (a) :	α	β	R^2
	1.02 (2.00)	-0.11 (-4.47)	0.17
Model (b) :	α	β	R^2
	1.06 (4.71)	-0.12 (-6.66)	0.31

Note : The numbers in brackets are t-statistics. The t-statistics of the α parameters test for the significance of the difference from 1. The t-statistics of the β parameters test for the significance of the difference from 0.

Table 8 : Regression of equation (1) : Dollar/DM (Passing M-values)

Test of Unit psychological barriers			
Model (a) :	α	β	R^2
	1.01 (0.22)	-0.04 (-0.49)	0.00
Model (b) :	α	β	R^2
	0.93 (1.32)	0.14 (1.87)	0.03
Test of Decimal psychological barriers			
Model (a) :	α	β	R^2
	1.00 (0.22)	0.01 (0.50)	0.00
Model (b) :	α	β	R^2
	0.98 (1.37)	0.03 (1.94)	0.04

Note : The numbers in brackets are t-statistics. The t-statistics of the α parameters test for the significance of the difference from 1. The t-statistics of the β parameters test for the significance of the difference from 0.

Table 9 : Regression of equation (1) : Yen/Dollar (Passing M-values)

Test of Unit psychological barriers			
Model (a) :	α	β	R^2
	0.93 (4.19)	0.35 (9.38)	0.47
Model (b) :	α	β	R^2
	0.88 (5.28)	0.25 (7.47)	0.36
Test of Decimal psychological barriers			
Model (a) :	α	β	R^2
	1.00 (0.79)	0.01 (1.77)	0.03
Model (b) :	α	β	R^2
	0.99 (2.04)	0.01 (2.88)	0.08

Note : The numbers in brackets are t-statistics. The t-statistics of the α parameters test for the significance of the difference from 1. The t-statistics of the β parameters test for the significance of the difference from 0.

Table 10 : Regression of equation (1) : DM/Dollar (Passing M-values)

Test of Unit psychological barriers			
Model (a) :	α	β	R^2
	0.97 (1.17)	0.13 (2.62)	0.07
Model (b) :	α	β	R^2
	1.04 (1.46)	-0.08 (-2.07)	0.04
Test of Decimal psychological barriers			
Model (a) :	α	β	R^2
	1.01 (2.84)	-0.04 (-6.35)	0.29
Model (b) :	α	β	R^2
	1.02 (5.92)	-0.04 (-8.38)	0.42

Note :The numbers in brackets are t-statistics. The t-statistics of the α parameters test for the significance of the difference from 1. The t-statistics of the β parameters test for the significance of the difference from 0.

CONCLUSION

In this paper we have studied the existence of psychological barriers in the foreign exchange market. These barriers are said to exist when particular values of the exchange rate, usually rounded numbers, appear to have an importance in influencing the dynamics of the market.

Our empirical results indicate that psychological barriers exist and are significant in the Dollar-Yen market. Numbers like 130, 140, ... Yen per dollar, etc. influence the behaviour of the market, in that the market exchange rates tend to resist movements towards these numbers. In addition, once these barriers have been crossed, there appears to be an acceleration away from these numbers. We

also found that the inverted quotations of the Dollar/Yen exchange rate (say 0.5 US cents per Yen) do not trigger these psychological effects in the market.

The evidence of psychological barriers in the Dollar-DM market is less clear-cut. We found some weak evidence that rounded numbers like 2, or 3 mark per dollar act as psychological barriers. We did not find evidence that numbers like 1.4, 1.5, 1.6 ... have these psychological effects. Here also the inverted quotations have no psychological meaning.

These results lead to issues about the efficieny of the foreign exchange markets. The question arises why irrelevant information influences agents' willingness to buy and sell foreign currencies. In addition, there is the issue of why these agents select one particular way of quoting foreign exchange rates and not its inverse.

Defenders of market efficiency can, of course, claim that psychological barriers may not necessarily lead to exploitable profit opportunities. If this is the case, the existence of psychological barriers may not contradict market efficiency. It is doubtful, however, that these psychological barriers cannot be exploited profitably. Transactions costs in the foreign exchange markets are now so low that it is difficult to conceive how they would prevent rational agents from exploiting irrational behaviour of other agents. The fact that psychological barriers continue to exist indicates that profit taking by rational agents is a weak force in the market.

REFERENCES

Barsky, Robert, and DeLong, Bradford, Why have Stock Prices Fluctuated ?, mimeo, Harvard University, 1989.

Campbell, John, and Shiller, Robert, Stock Prices, Earnings, and Expected Dividends, *Journal of Finance*, 43, July 1988, pp. 661-76.

Cutler, David, Poterba, James, and Summers, Lawrence, Speculative Dynamics, NBER Working Paper, No. 3242, January 1990.

Donaldson, Glen, International Evidence on Psychological Barriers in Asset Prices and the Efficient Market Hypothesis, Financial Research Center Memorandum, No. 116, Princeton University, June 1990.

Fama, Eugene, and French, Kenneth, Dividend Yields and Expected Stock Returns, *Journal of Financial Economics*, 22, 1988, pp. 3-27.

Frankel, Jeffrey, and Froot, Kenneth, Using Survey Data to Test Standard Propositions Regarding Exchange Rate Expectations, *American Economic Review*, 77, 1987, 133-53.

MacDonald, Ronald, and Taylor, Mark, International Parity Conditions, in A. Courakis, and M. Taylor, (eds.), *Private Behaviour and Government Policy in Interdependent Economies*, Clarendon Press, Oxford, 1990

Figure 1 : USD/YEN

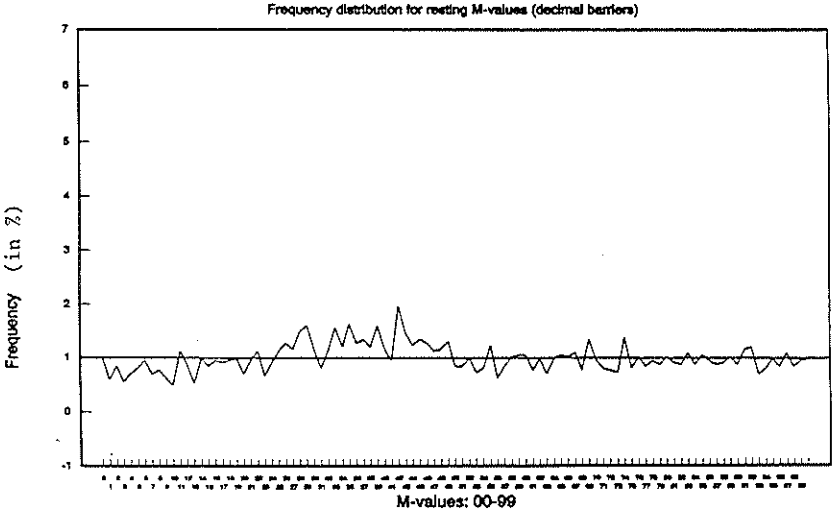

Figure 2 : USD/YEN

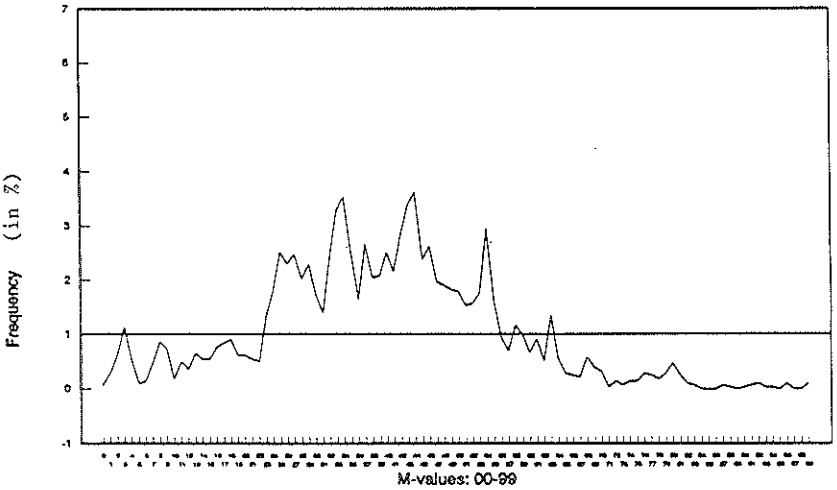

Figure 3 : USD/DEM

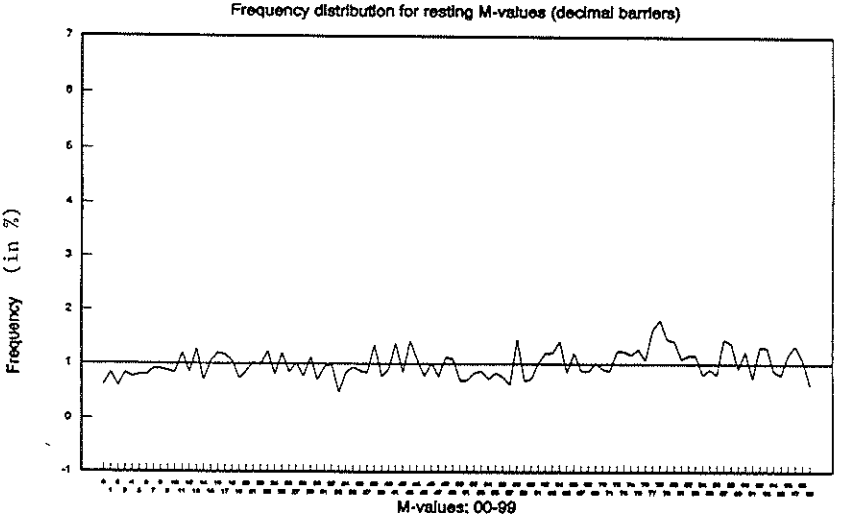

Figure 4 : USD/DEM

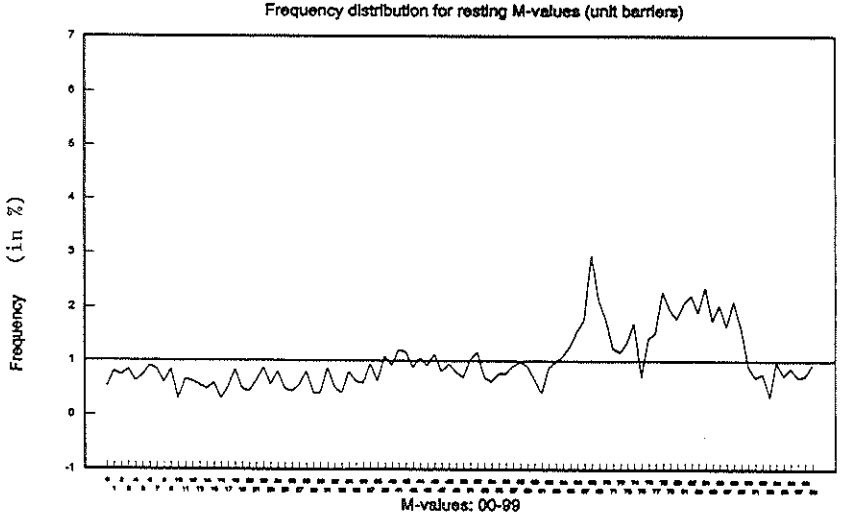

Figure 5 : YEN/USD

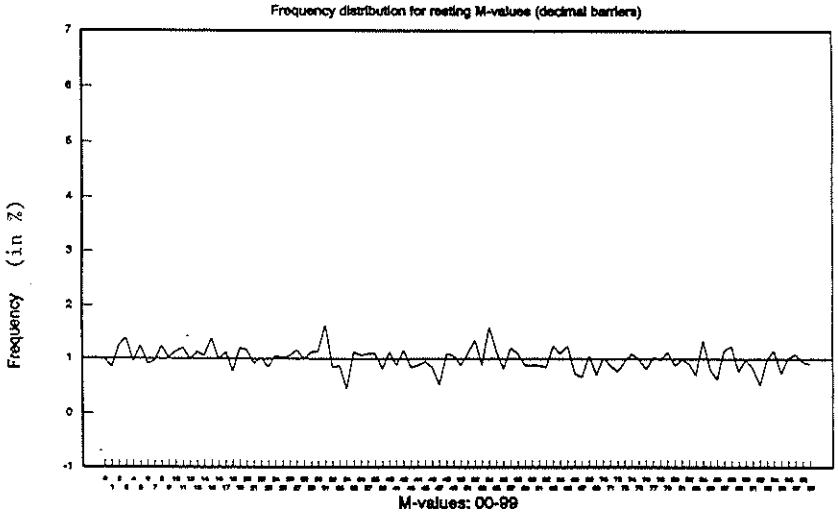

Figure 6: YEN/USD

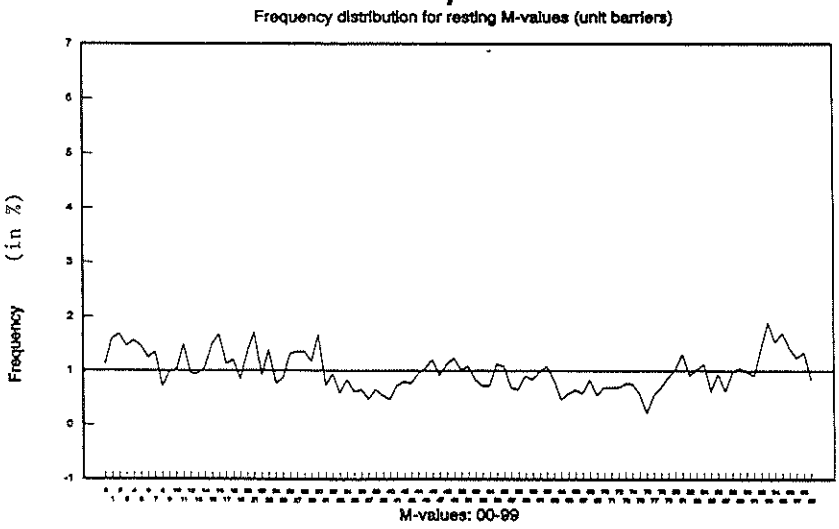

Figure 7 : DEM/USD

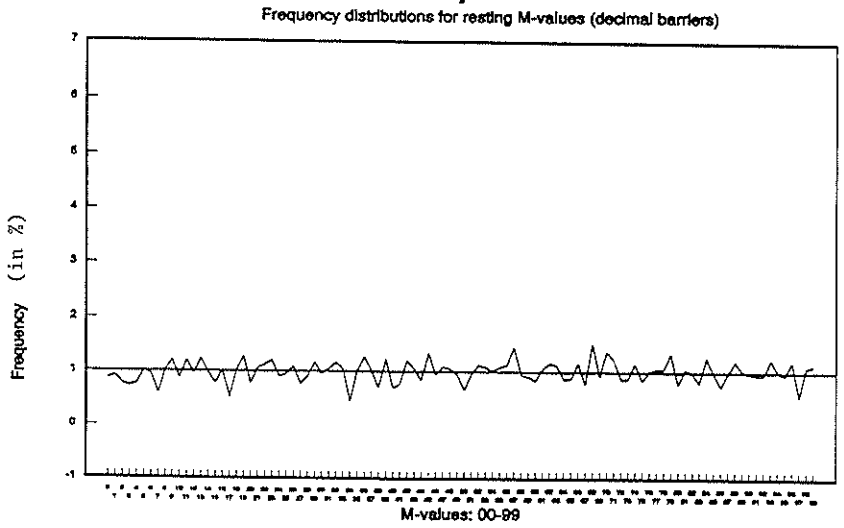

Figure 8 : DEM/USD

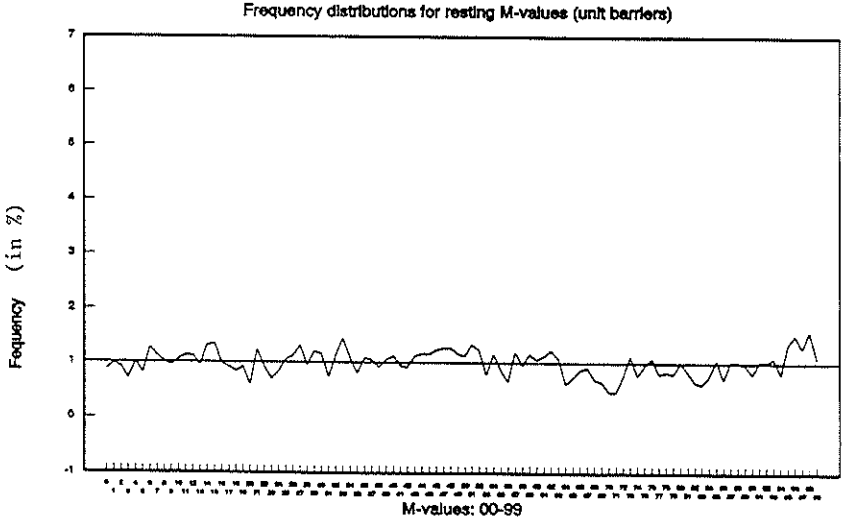

Figure 9 : USD/YEN

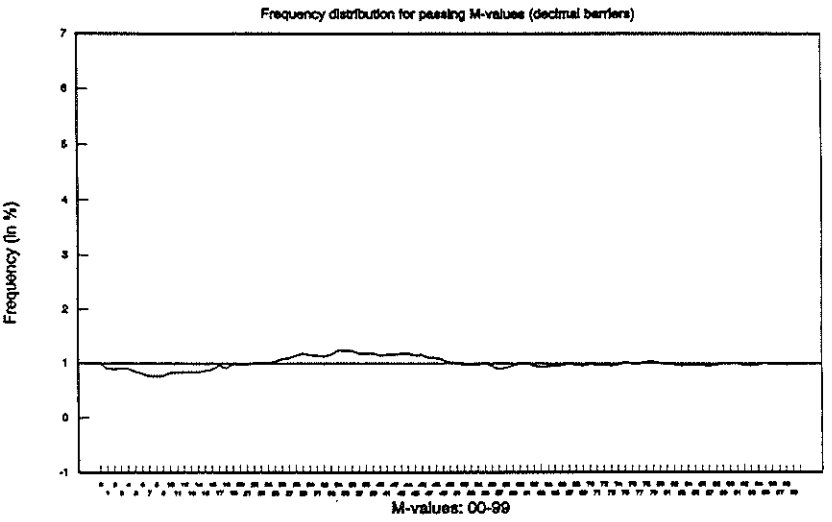

Figure 10 : USD/YEN

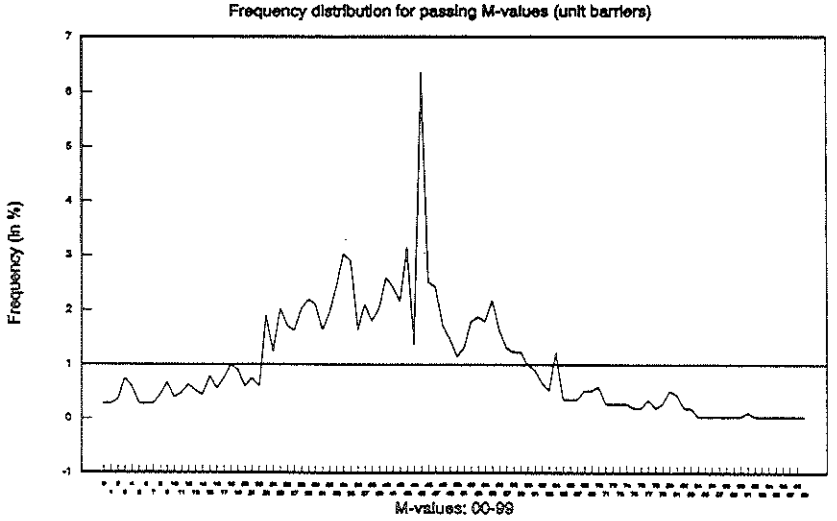

Figure 11 : USD/DEM

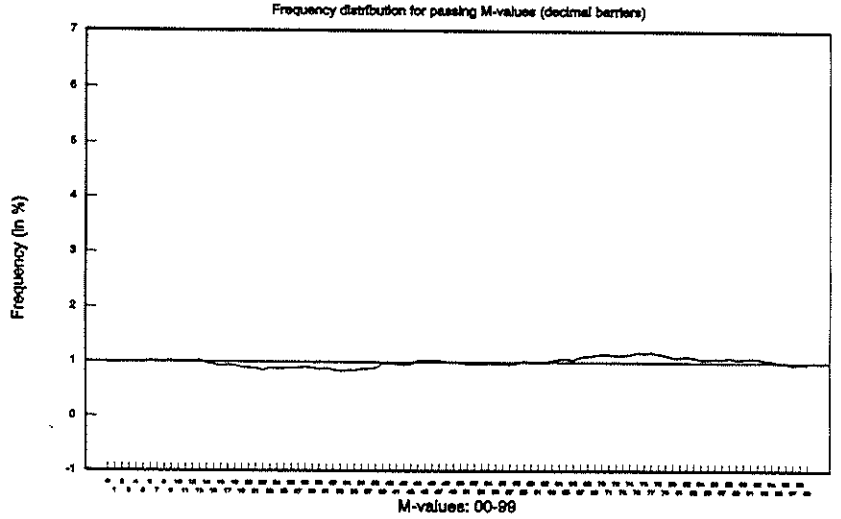

Figure 12 : USD/DEM

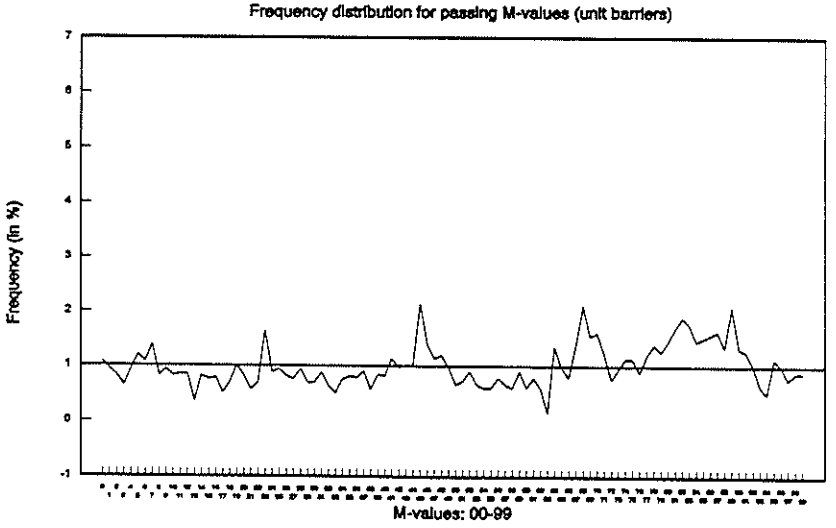

Figure 13 : YEN/USD

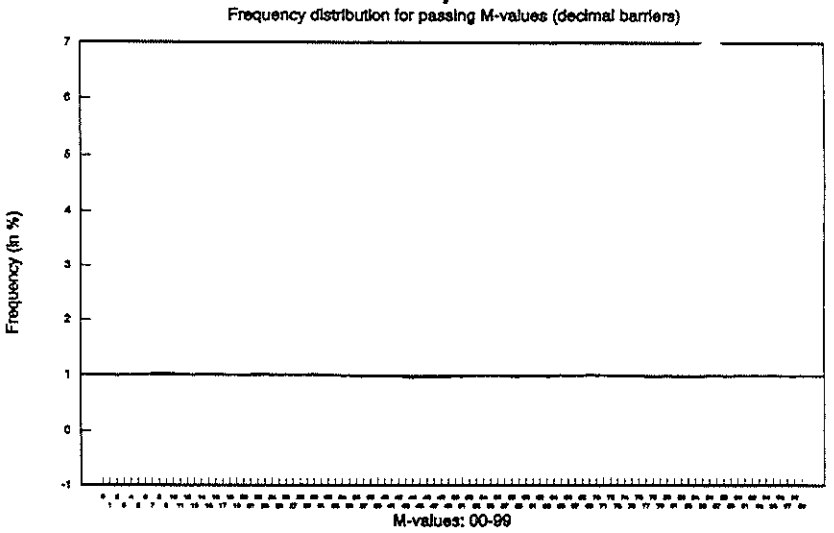

Figure 14 : YEN/USD

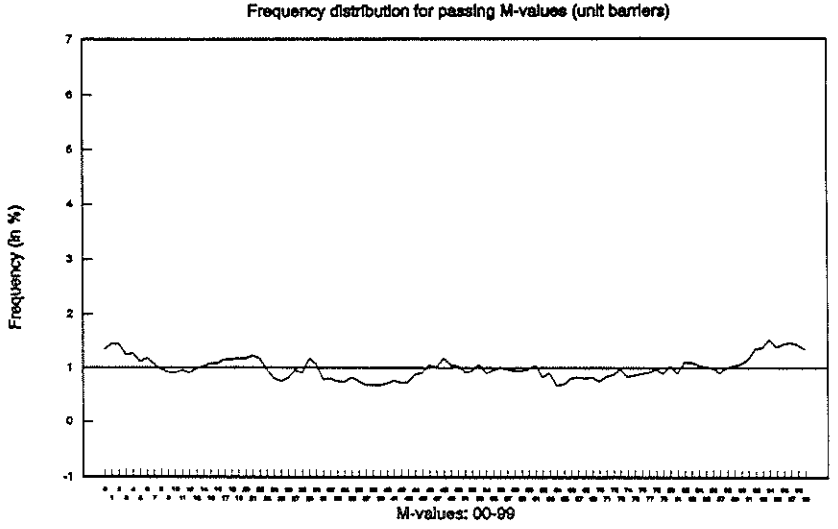

Figure 15 : DEM/USD

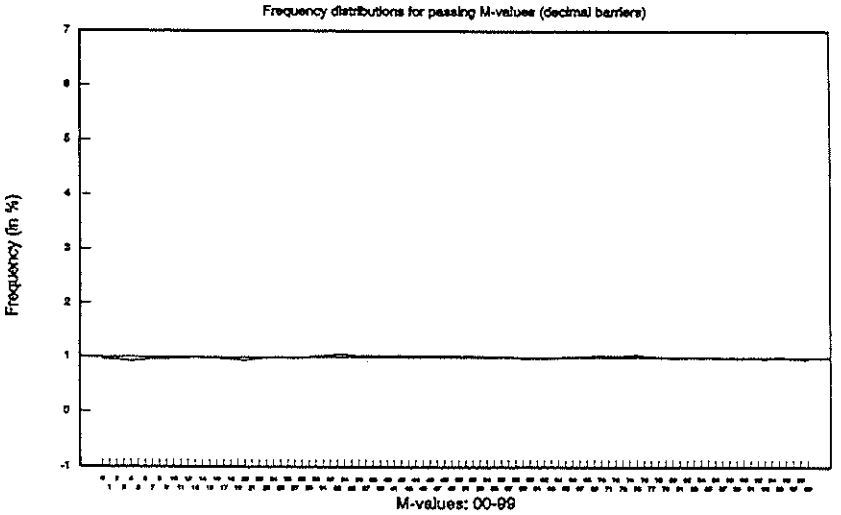

Figure 16 : DEM/USD