THE CLUSTERING OF BID/ASK PRICES AND THE SPREAD IN THE FOREIGN EXCHANGE MARKET

by

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Abstract

Following Lawrence Harris' (1989b) study of price clustering in stock prices, we examine the same phenomenon in the forex market. The pattern of clustering in the final digit of bid/ask prices depends on the desired degree of price resolution. The selection of spreads also involves clustering, but this is driven by a different behavioural pattern, consistent with the pure 'attraction' hypothesis. The combination of the two patterns can explain the differing frequencies of final digits in the bids as compared with the asks.

1. Introduction

Lawrence Harris (1989b, p.1) notes that the phenomenon of price clustering on round numbers is pervasive. In his study on 'Stock Price Clustering, Discreteness and Bid/Ask Spreads', he notes that "Stock prices cluster. Integers are more common than halves, halves are more common than either of the odd quarters, and odd quarters are more common than any of the odd eighths. The phenomenon is remarkably persistent through time and across stocks". Indeed, "The prices of almost all assets cluster on round numbers".

While this feature of asset prices has been noted for some time, and questions raised on its consistency with the random walk hypothesis and on its relevance when analyzing the effects of price discreteness on estimators (Osborne 1962; Niederhoffer, 1965; Harris 1989a), only more recently have there been attempts to give behavioural explanations of this pattern. Perhaps the simplest possible explanation might be called the 'attraction' theory, or round number syndrome. Suppose that discrete trading prices, eg bids and asks, are obtained from continuously distributed underlying values by rounding to the nearest available final unit, as hypothesized by Gottlieb and Kalay (1985), but that, in addition, nearest does not only depend on linear distance, but also on the basic attraction of each particular round number. Then, in a price system based on eighths, one would expect to see the ranking of the distribution of prices with respect to the final fraction, 0, 1/2, (1/4=3/4), (3/8=5/8), (1/8=7/8). In a price system with integers as final units, one would expect to see the following ranking, 0, 5, (7=3), (8=2), (4=6), (1=9).

An alternative theory, which has more behavioural content, has been developed by Ball, Torous and Tschoegl (1985) and amplified by Harris (1989b), and suggests that clustering is a consequence of the achievement of the optimal degree of price resolution. Thus no-one would find the extra time and effort of specifying the bid price of, say, the spot Dm/$ rate to eight places of decimals worthwhile, eg 1.71465238, (simply writing it down makes the point). On the other hand three places of decimals might be too coarse, 1.715. Indeed as it happens, the Dm/$ spot rate is conventionally traded to four decimal places, (and if that did not achieve the optimal degree of price resolution, the convention would change). But there is no reason to expect that all traders want exactly as much resolution as provided by the full set of decimals in that final unit (.0001 to .0009). Some may not need any resolution beyond the third decimal and leave the final, fourth decimal always at zero. Some would be happy with halves (ie .0000 to .0005 to .0010); some would ideally like quarters but cannot obtain .00025 or .00075, and so will choose either .0000; .0002/.0003, .0005, .0007/.0008 or .0010. Others may appreciate the narrower resolution provided by the complete range of the final decimal place; and those who would prefer an even tighter resolution have to make special arrangements, eg Ginzie trading, as mentioned by Harris (1989b, p.9). If such price resolution theory were correct, one would

find that the ranking of the final decimal units would be, 0, 5, (2=3=7=8), (1=4=6=9). Thus there is a testable difference in predictions.

Harris (1989b, p.8) finds that the attraction theory is not supported on his data set, since, according to it, there "should be less density observed on the first and seventh eighths, which are adjacent to the whole number, than on the third and fifth eighths, which are adjacent to the half. The data, however, provide no support for these implications. There are no systematic differences in density among the various eighths". Harris then goes on to estimate the factors causing the desired resolution to become more coarse, and hence the extent of clustering to increase. These are that price clustering increases with price level (eg if the Dm/$ went from 1.7000 to 10.7000, fewer traders would need to use the fourth decimal place), and with asset price volatility (ie make your bid quick and simple when prices are wildly fluctuating), and decreases with the average size of the transaction involved (ie you want a finer resolution when buying $10bn Dm than $100 Dm), and with the extent of competition and dealing frequency (Harris 1989b, pp. 10-11).

In this exercise, we shall look at the evidence on price clustering in the foreign exchange market. We describe the data set that we use in Section 2. We will show then in Section 3 that there are two different kinds of clustering in these data, which interact. The first is a price resolution mechanism, as outlined above, which, once again, proves superior to an attraction hypothesis; but the second is a separate, distinct form of clustering for the choice of the spread itself, which does depend on the attractiveness of certain key numbers. We argue that the psychology is quite different. When deciding which final fourth decimal unit to choose, ie 1.7014 or 1.7015, the final number has no resonance in itself; but the situation is different when deciding on the number to use for the size of the spread itself, as will be seen.

2. The Data

Between April 9th and July 3rd 1989, Goodhart (assisted by R.Lloyd) made a record of every single foreign exchange spot price exhibited on Reuters' FXFX and FXFY screens. This represents a massive data set, (available on request to other research workers). The busiest market is that for the Dm/$ for which there are approximately 5000 new quotes exhibited on Reuters screens each working day, thus making for a consecutive time series of about 1/4 million, irregularly spaced, observations. Goodhart, in conjunction with Demos, is producing a series of papers describing the characteristics of these series (1990 a and b).

The last quote of Dm/$ on Sunday April 9th, 1.8780/90, was made by BQ Worms in Hong Kong, at 23-59-29 (quotes recorded to nearest second). All quotes for spot rates on Reuters screens, including the DM/$, are in this form, with first the lower number, at which the bank will sell Dm for $s (we call this here the bid price), and then the higher number, (the ask),

at which the bank will sell $s for Dm. The markets on Saturdays and Sundays, although open, notably in mid-Eastern centres (eg Bahrain), are thin, at least until about 22.30 GMT on Sundays when the Antipodean markets come into full activity, so we shall ignore week-end price quotes in this exercise.

The price quotes exhibited on Reuters screens are indicative; the actual trading is done by telephone, and (apart from occasional Central Bank surveys, eg as described in Press Releases by the Bank of England, Federal Reserve Bank of New York and Bank of Japan on Sept 13, 1989) there are no regular data available on actual transaction prices or volumes. There are, however, pressures to prevent banks from quoting false prices on Reuters (ie at which it would not subsequently be prepared to deal), in the hopes of stampeding the market. Dealers' and banks' reputation would suffer, and Reuters itself keeps a watchful eye to prevent misuse of its information system. Indeed, and this will become important later on, practitioners have regularly told us that price resolution in the subsequent telephonic dealing is generally finer (within) that quoted on the screens.

The Reuters system works as follows (with thanks to M. Jones of Reuters for assistance). Those banks which are linked into Reuters system display their own individual bid/ask prices for a selection of spot and forward rates on their own individual electronic page, which can be accessed by anyone on the Reuters FX network. Whenever one such bank changes its bid/ask quote for a spot rate (exhibited on FXFX for the eight main currencies, all bilateral with US$, ie Dm, £, Yen, FrFr, SwFr, NLG, Itl, XEU (Ecu), and on FXFY for a larger number of minor currencies), the new quote is not only shown on its own individual page, but is also flashed up on the FXFX (or FXFY) screen[1]. Thus the FXFX price series provides a series of consecutive individual bank price revisions[2].

For this exercise we shall look at all the prices quoted on the weekdays of the first week of our sample for the DM/$ spot rate, a set of about 20,000 observations from over 200 banks[3]. This is a small selection of our over-all sample for all currencies over 12 weeks, but, with one exception (described further below), statistically sufficient for our present purpose.

3. Results

In Table 1a below we record the percentage of observations with which the final digit in the low (bid) price took on each numerical value, from 1 to 0, over 5 trading days, and for the whole sample. The extent of clustering is clear: 0 is regularly somewhat more frequent than 5, but not by much; the

1 The entry procedure to FXFX and FXFY takes a fraction of a second, but, if a second bank revises its quote while the first bank is still having its quote entered, the second bank's quote will not appear on the screen.

2 It is not the 'touch', ie the finest bid or ask available at any time, nor would it be possible to estimate the 'touch' from these data.

3 In this exercise, branches of the same bank, which are located in different centres, are considered as different banks.

frequency of 2, 3, 7 and 8 is broadly similar, though 8 appears noticeably more frequent than 7, and 3 slightly more frequent than 2, (n.b. the former is contrary to the 'attraction' hypothesis). Next, the frequency of observations of final digits, 1, 4, 6 and 9 again form a set with a broad similarity, though 1 appears rather more frequent than 4, 6 and 9, in contradiction to the pure 'attraction' hypothesis.

Then in Table 1b we examine the associated distribution for the higher (ask) price. The main characteristics, ie the division into three groups (0,5; 2,3,7,8; 1,4,6,9), remain the same, but the distribution in the second group shifts, thus now 7>8 and 2>3, whereas the inequalities had the reverse sign in Table 1a.

Naturally, when we take all price quotes, both bids and asks, in Table 1c, the results average out. As expected 0>5: otherwise the frequencies in the other two groups are quite closely similar (2=3=7=8 and 1=4=6=9) except for the higher value of 8.

We test now the equality of the frequencies in the three groups, having noted that the variance in the % frequencies from day to day is greater than that consistent with an identical multinomial distribution for the 5 days. This suggests that the same model with identical percentages for all digits is not valid for the whole sample; we should keep this in mind when interpreting the statistical tests.

In Table 2 we test the equality of the frequencies of 5=0, 2=3=7=8 and 1=4=6=9, for Table 1, first for the whole sample, and then independently for each day, using a X^2 test. Note that the main reason for rejecting 2=3=7=8 in Tables 1a and 1c is the surprisingly high frequency of finding a final 8 digit.

In order to throw more light on some of the above findings we turn to an examination of the size of the spreads (between the bids and asks) quoted by the banks.

In Table 3 we report the percentage of observation of all spreads in our sample. This Table suggests the presence of clustering of a different type than the one found in Table 1. Here, though, we are concerned with a measure of size, the spread, rather than a final digit and there are no reasons to suppose that the spread should be distributed uniformly in any interval[4].

The spread allows banks to recoup its expenses composed of transaction costs and inventory costs, and is affected by the extent of informational asymmetries and the degree of competition. Different banks may have different cost structures and these could be responsible for the distribution in Table 3. Our data set contains information on the bank which quoted each price, so we are able to investigate the matter in more detail.

4 We would like to thank an anonymous referee for drawing our attention on this point.

In order to have a reasonable number of observations for each bank with which to estimate the distribution of the spread, we have selected the ones which quoted more than 100 prices during the week of our sample. These are 56 banks out of 212 and account for over 3/4 of the observations. With regard to the choice of the spread, these banks behaved quite differently, with some of them always quoting the same spread, while others chose 2 or more different spread sizes throughout the week. We have therefore subdivided the banks according to the minimum number of different spreads used in at least 90% of their quotes. The distribution is given below

N. of Spreads	1	2	3	4	5	6
N. of Banks	26	18	8	2	1	1

Among the 26 banks using only one spread, the size adopted was 5 in 9 cases, 7 in 2 cases and 10 in the remaining 15 cases.

The remaining 30 banks use at least 2 spreads in most of their quotes, so we can infer something about the distribution of the spread. Banks change their quoted spreads because of changing costs and conditions in the market; there is no theory, though, on how the these should evolve, and in general, we would not expect the spread to follow a random walk process. Nevertheless, the following observations strongly suggest the presence of clustering in the spread.

The most used spreads of the 18 banks using mainly 2 spreads are never adjacent, with spreads of 4, 6, and 9 never among them; the 8 banks using mainly 3 spreads always have 5 and 10 among them, but never 6, 8, or 9; a spread of 5 and/or 10 is always present among the most used spreads of all 30 banks (both in 17 cases), while 6, 8, and 9 are present respectively only twice, once, and never. These observations suggests that clustering is present in the choice of the spread, but, in contrast with the bid and ask prices, the pattern of clustering is consistent with the pure 'attraction' hypothesis.

We now combine our findings of price resolution in the final digits with pure 'attraction' in the choice of spread. Assume that the trader starts with the choice of the lower bid price; 0 and 5 are the most common. But related to these, a spread of 7 dominates 8 (to a far greater extent than 3 dominates 2). So in the asks (higher price), we should expect to see 2 (given by 5+7) and 7 (given by 0+7) more frequent than 3 or 8. This is what appears in Table 1b. Next assume that the trader starts with the choice of the higher ask price: again the combination of 0 or 5 with 7 will imply that 3 (0-7) or 8 (5-7) will be greater than 2 or 7 in the bid price, as indeed appears in Table 1a. The combination of these two separate behaviour patterns can explain the major shifts between the results for these two Tables, except that the doublet (8 bid/5 ask) occurs more frequently than this line of analysis can readily explain.

With many of the bank traders exhibiting a spread of 5, the entry of a spread of 10 can, perhaps, be seen more as a general indication of a willingness to trade, rather than a commitment to those particular bid/ask quotes in subsequent

haggling over the telephone. Consequently one of us, Curcio, hypothesized that the extent of price clustering among those entries involving a spread of 10 would be significantly greater than those involving the lower value of 5. The results for spreads of 5, 7 and 10 are shown below, using bids plus asks

Frequencies of final digit

Spr.	1	2	3	4	5	6	7	8	9	0	Obs.
5	5.69	9.57	10.75	5.33	18.66	5.69	9.57	10.75	5.33	18.66	16754
7	3.32	12.47	10.20	5.18	17.24	2.27	15.23	10.05	4.01	20.03	5332
10	1.52	7.07	6.95	1.56	31.02	1.62	6.36	9.28	1.17	33.45	16630

Observe that in 64% of the prices quoted those using a spread of 10 remain at 0 or 5, compared with 37% for those using the lower spread of 5. Those with the larger spread (10) only quote the marginal numbers (1,4,6,9) on 5.87% of all quotes compared with 22% for those with a spread of 5. For those with the lower spreads (5 and 7), the sum of 2+3 and 7+8 is greater than either 0 or 5, while it is less than half in the case of those with the higher spread. The conclusion is that the desired extent of price resolution for those with the larger quote (10) is nearer to 1/2 than to 1/4, while it is less than 1/4 for those with the narrower spreads (5 and 7).

Finally, given our above conclusion that even those using the highest spreads desired a price resolution less than 1/2, it follows that there should be no clustering, at least from this source of influence, in the penultimate digit. We examine this in Table 4. This does reveal a complete absence of the kind of clustering exhibited in Table 1; indeed a number (1) that was marginal there is the most common here. However, the frequencies are not approximately equal. On some days, eg April 11, 12, 13 the extent of price movement in the market is so sluggish that there is a clear tendency for the digits to cluster around a given mean level. In view of this, one would either need some complex statistical adjustment process (as applied by Harris 1989b) or a longer series to establish that the expected frequency of all digits in the penultimate digit was equal. We leave that exercise for others to complete, being content with having established that the pattern apparent in numerical clustering in the final digit does not carry over to the penultimate digit.

4 Conclusions

We have shown that the pattern of numerical clustering in the final digit exhibited for forex spot bid and ask quote prices depends on the desired degree of price resolution by traders. Traders quoting larger spreads seek a coarser price resolution than those using finer spreads. The selection of spreads also involves clustering, but this appears to be driven by a separate behavioural pattern, which appears consistent with the pure attraction hypothesis. The combination of these two behaviour patterns can explain most of the difference between the numerical frequencies of the final digits in the bids as compared to the asks.

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TABLE 1

A) LOWER (BID) PRICE: FREQUENCIES OF FINAL DIGIT

DAY	1	2	3	4	5	6	7	8	9	0	OBS
10	4.60	9.03	9.93	3.58	20.29	3.03	8.77	11.54	4.30	24.94	4584
11	5.23	9.30	10.62	4.71	20.69	3.86	8.15	11.64	3.74	22.06	4012
12	4.78	8.50	7.44	2.62	21.67	4.76	8.82	14.12	4.27	23.03	3470
13	2.81	7.56	8.61	2.43	26.24	2.88	7.05	10.35	2.16	29.90	4482
14	3.47	7.05	9.84	2.85	25.83	2.75	6.92	9.51	2.56	29.22	3860
AVG	4.18	8.29	9.29	3.24	22.94	3.46	7.94	11.43	3.41	25.83	20408

B) HIGHER (ASK) PRICE: FREQUENCIES OF FINAL DIGIT

DAY	1	2	3	4	5	6	7	8	9	0	OBS
10	3.38	9.80	9.03	5.48	22.21	4.54	12.37	9.16	4.23	19.81	4584
11	4.16	10.34	9.25	5.06	19.62	5.08	10.59	9.50	4.71	21.69	4012
12	4.70	10.69	10.89	5.01	24.06	3.72	9.14	7.90	3.17	20.72	3470
13	2.90	8.95	8.05	2.92	26.53	2.63	9.42	8.41	2.79	27.40	4482
14	2.31	8.21	8.24	3.73	25.49	3.50	7.23	9.43	3.37	28.50	3860
AVG	3.49	9.60	9.09	4.44	23.58	3.89	9.75	8.88	3.65	23.62	20408

C) BID AND ASK PRICES: FREQUENCIES OF FINAL DIGIT

DAY	1	2	3	4	5	6	7	8	9	0	OBS
10	3.99	9.41	9.48	4.53	21.25	3.78	10.57	10.35	4.26	22.37	9168
11	4.70	9.82	9.93	4.89	20.15	4.47	9.37	10.57	4.22	21.87	8024
12	4.74	9.60	9.16	3.82	22.87	4.24	8.98	11.01	3.72	21.87	6940
13	2.86	8.26	8.33	2.68	26.38	2.76	8.23	9.38	2.48	28.65	8964
14	2.89	7.63	9.04	3.29	25.67	3.12	7.07	9.47	2.97	28.86	7720
AVG	3.84	8.94	9.19	3.84	23.26	3.67	8.84	10.16	3.53	24.73	40816

TABLE 2

TESTS FOR EQUALITY OF THE FREQUENCIES

	WHOLE SAMPLE			SEPARATE DAYS		
				NUMBER OF TIMES		
	X^2	DF	ACC OR REJECT	ACC AT 5%	AT 1%	REJECTED
5=0						
TABLE 1	37.3	1	Reject 0.1%	2	0	3
2	0.01	1	Accept	1	3	1
3	19.7	1	Reject 0.1%	2	1	2
2=3=7=8						
TABLE 1	157	3	Reject 0.1%	0	0	5
2	13.2	3	Reject 0.1%	2	0	3
3	43.9	3	Reject 0.1%	1	2	2
1=4=6=9						
TABLE 1	28.8	3	Reject 0.1%	2	0	3
2	27.8	3	Reject 0.1%	2	0	3
3	6.84	3	Accept	4	1	0

TABLE 3

FREQUENCY OF THE SPREAD

SPREAD/DATE *1000/	10	11	12	13	14	TOTAL OBS
<3	0.24	0.42	1.73	0.09	0.23	101
3	0.46	2.02	2.05	0.83	1.30	260
4	1.55	1.92	1.35	0.38	0.67	238
5	41.58	44.72	44.96	36.23	38.68	8377
6	0.37	0.62	0.29	0.27	0.13	69
7	17.10	14.11	11.73	12.29	9.27	2666
8	1.88	0.65	1.10	1.29	1.55	268
9	0.15	0.10	0.00	0.02	0.00	12
10	36.56	35.32	36.60	48.08	46.55	8315
11-14	0.02	0.02	0.03	0.04	0.03	6
15	0.04	0.10	0.09	0.42	1.04	68
16-19	0.00	0.00	0.09	0.00	0.00	3
20	0.02	0.00	0.00	0.04	0.36	17
21-24	0.02	0.00	0.00	0.00	0.00	1
25	0.00	0.00	0.00	0.00	0.00	0
26-29	0.00	0.00	0.00	0.00	0.00	0
30	0.00	0.00	0.00	0.00	0.18	7
TOTAL OBS	4584	4012	3470	4482	3860	20408

TABLE 4

LOWER (BID) PRICE: FREQUENCIES OF PENULTIMATE DIGIT

DAY	1	2	3	4	5	6	7	8	9	0	OBS
10	2.23	3.25	2.12	0.37	2.16	21.27	44.87	18.41	4.47	0.85	4584
11	43.99	24.25	4.54	2.92	7.10	4.26	0.15	0.00	0.10	12.69	4012
12	4.41	7.61	18.56	43.98	23.72	1.61	0.06	0.00	0.00	0.06	3470
13	28.34	25.08	3.19	0.56	0.18	3.08	7.72	5.06	7.79	19.01	4482
14	9.43	9.61	11.35	7.49	5.34	10.47	32.10	7.33	3.24	3.65	3860
AVG	17.91	14.12	7.37	9.67	6.96	8.55	17.89	6.63	3.35	7.56	20408