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IN THE FOREIGN EXCHANGE MARKET

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A Simple Model of the Welfare Effects of Central Bank Intervention
in the Foreign Exchange Market

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Since the breakdown of the Bretton Woods system of adjustable peg exchange rates in early 1973, a continuing debate has taken place concerning the appropriate role of central bank intervention under the existing ad hoc system of managed floating exchange rates. Most people would agree that the primary purpose of such intervention should be to increase economic welfare. And since most economists have long accepted the proposition that if speculators as a group make profits, they increase economic welfare,^{1/} some have argued that central banks should also attempt to make profits in their intervention activities.^{2/}

But this last conclusion skips over a crucial step in the reasoning chain. Just because profitable speculation by speculators as a group increases welfare, does it necessarily follow that profitable speculation by an individual speculator, or profitable intervention by a central bank, will also increase welfare? Is it not possible that these activities might induce a perverse offsetting or reinforcing response on the part

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of other speculators? And, with or without such a perverse response, is it not possible that profitable speculation by an individual might decrease the profits (or increase the losses) of all speculators, and might this not lead to a reduction in welfare?

These are the questions that are investigated in this paper. To shed some light on them we will employ a simple two-period model, and will use the crude but useful concepts of consumers' and producers' surplus to measure welfare.

Speculators will be defined as agents who buy (sell) in one period with the expectation of making a profit by selling (buying) in the next period at a higher (lower) price. (We will abstract from interest rate or storage cost considerations in this analysis.)

Non-speculators will be defined as agents who produce to sell and purchase to consume, and whose decisions in each period are based solely on the price in that period; in particular their decisions are not based on the expectation that prices in the next period will be either higher or lower.

We will first consider the welfare effects of speculation by a group of speculators; then the response of speculators to central bank intervention; and finally the welfare effects of central bank intervention.

1. Welfare Effects of Speculation

In Figure 1 [which is adopted from Johnson (1976)] the demand curve for non-speculators is the same in periods 1 and 2, and the supply curve for non-speculators is higher in period 2 than in period 1. In

the absence of speculation the prices at t_1 and t_2 would be P_1 and P_2 respectively.

If speculators as a group purchase, net, a quantity x at t_1 and sell it at t_2 , they would drive the prices to P_1' and P_2' . At t_1 the producer surplus is increased by P_1cbP_1' and the consumer surplus is reduced by P_1caP_1' , producing a net welfare gain of the triangle abc . At time t_2 the consumer surplus is increased by $P_2'efP_2$, and the producer surplus is decreased by $P_2'dfP_2$, producing a net welfare gain of the triangle def . Thus the total welfare gain of non-speculators is the sum of the two triangles abc and def . And the speculators' welfare gain is the profit they make, $x(P_2' - P_1')$.

Now let us investigate how the non-speculators' welfare gain, the speculators' welfare gain, and the total welfare gain change with different amounts of speculation. Solely for convenience of illustration, let us assume that the supply and demand curves of non-speculators are straight lines with slopes of 2 and -2 respectively,^{3/} which makes the heights of triangles abc and def equal to their bases. Then the non-speculators' welfare gain is:

$$(1) \quad \text{NWG} = \text{areas of } abc \text{ and } def = (1/2x) (x) (2) = x^2$$

And the speculators' welfare gain is:

$$(2) \quad \text{SWG} = x (P_2' - P_1') = x (y - 2x) = yx - 2x^2$$

Hence the total welfare gain is:

$$(3) \quad \text{TWG} = x^2 + yx - 2x^2 = yx - x^2$$

Note that these relationships hold whether x is positive or negative, i.e., whether speculators buy or sell in period 1.

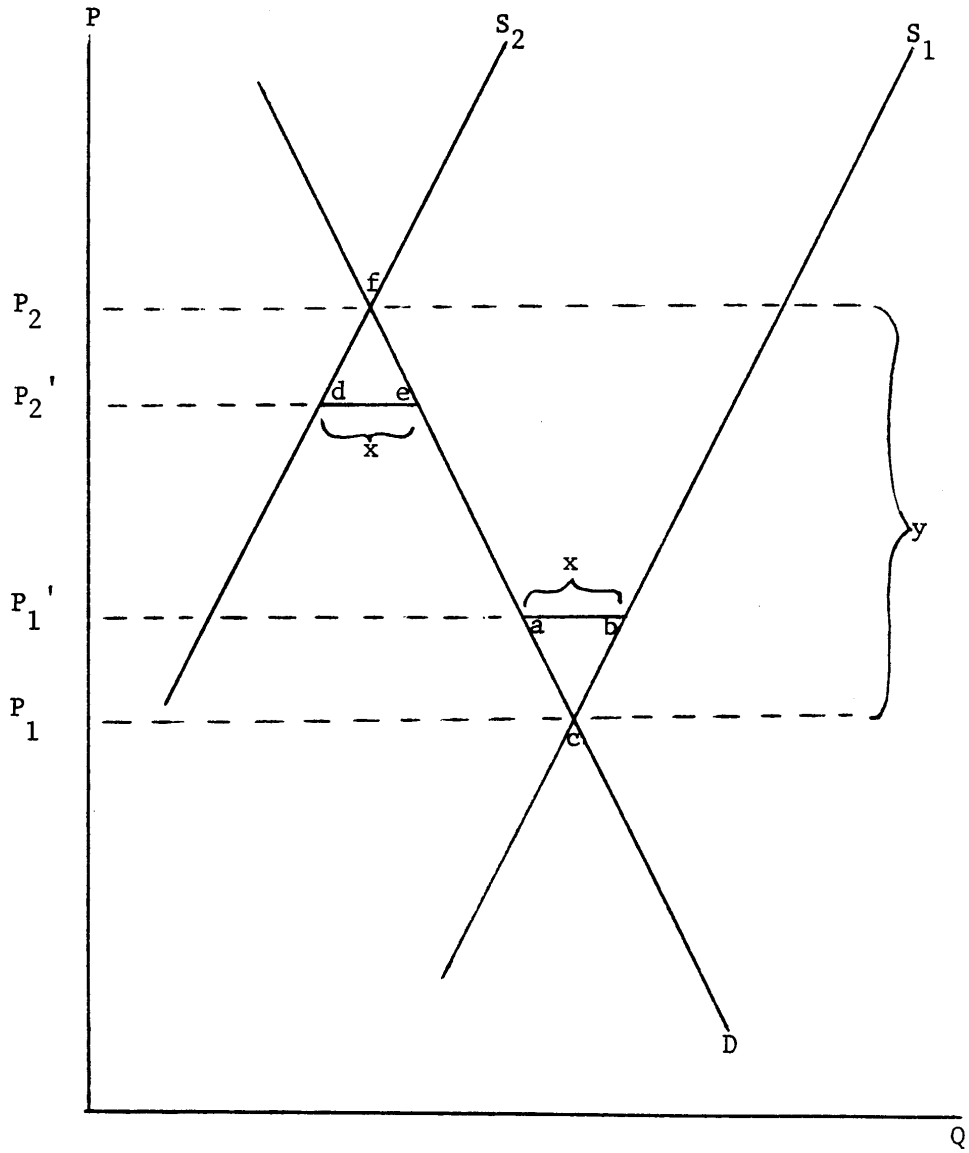


Figure 1

The plots of NWG, SWG, and TWG against x are drawn in figure 2.^{4/} They are symmetric about $x = 0$, $x = y/4$, and $x = y/2$, respectively.

Note that the welfare of non-speculators increases as the square of the speculative purchases or sales, i.e., they benefit whether speculators are right or wrong as long as they speculate.

Note also that the profits of speculators are zero at $x = 0$ and $x = y/2$; are positive for $0 < x < y/2$; are negative for $x < 0$ and $x > y/2$; and reach a maximum at $x = y/4$.^{5/}

Note also that the total welfare gain is zero at $x = 0$ and $x = y$; is positive for $0 < x < y$; is negative for $x < 0$ and $x > y$; and reaches a maximum at $x = y/2$.^{6/}

Table 1 summarizes the relationships between the profits of speculators as a group and the effect on total welfare for the different regions of figure 2. Note that when the speculators as a group make profits they increase total welfare (Region II in figure 2).^{7/}

However, this is not the same thing as saying that profitable speculation by an individual speculator or profitable intervention by a central bank will increase welfare. To show the latter, the analysis must be carried two steps further.

2. Speculators' Response to Central Bank Intervention

Whether profit-making intervention by a central bank increases or decreases welfare depends crucially on how speculators react. Let us denote the net amount purchased by speculators in period 1 by s , and the intervention purchases of the central bank by i , (hence $x = s + i$).

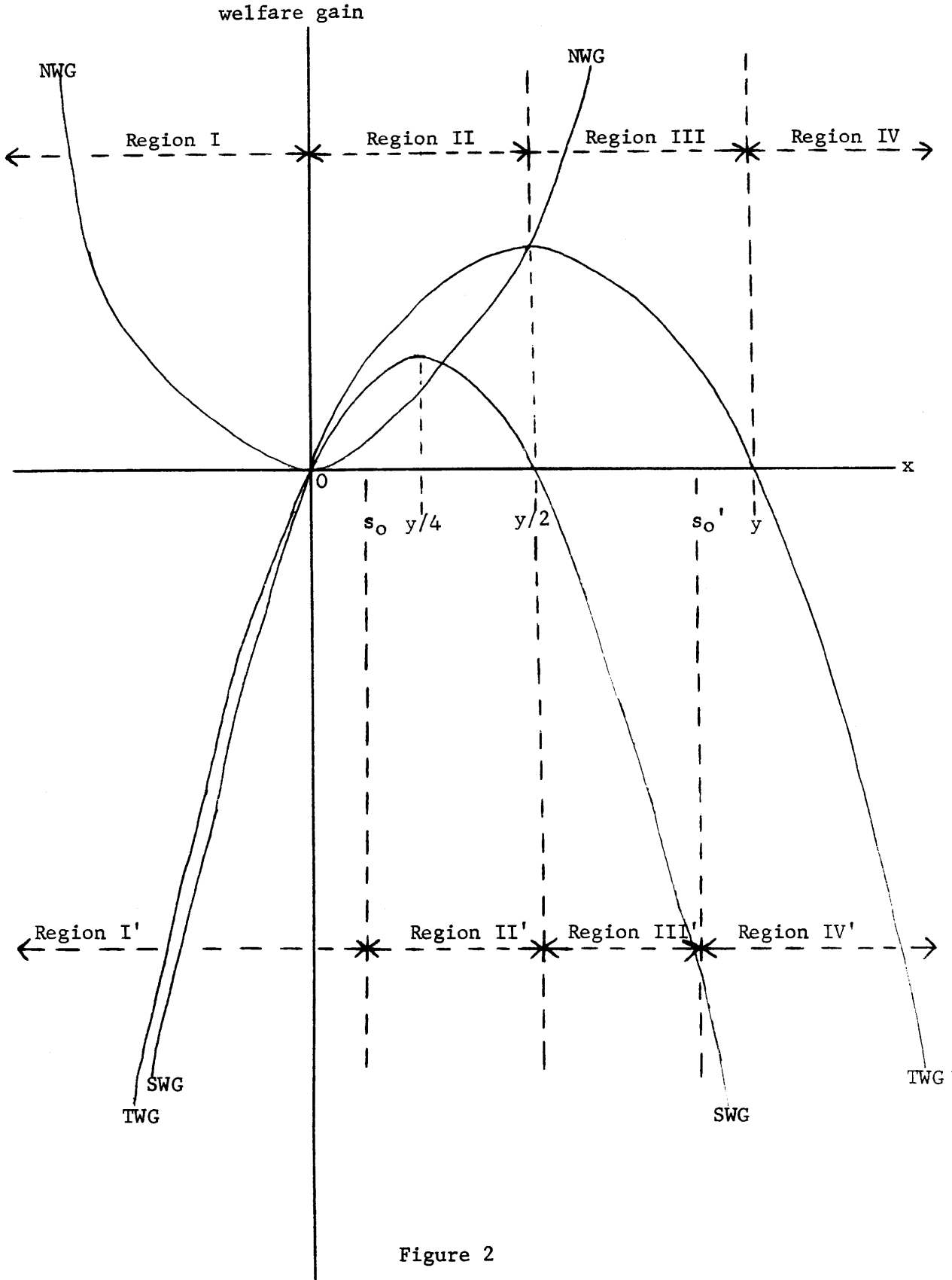


Figure 2

Table 1

| | Net Purchases by Speculators | Effect on Specu- lators as a Group | Effect on Total Welfare |
|---|---------------------------------|---------------------------------------|----------------------------|
| Region I (Speculation in "Wrong" Direction) | $x < 0$ | suffer losses | decreases welfare |
| Region II ("Under-speculation" in Right Direction) | $0 < x < y/2$ | make profits | increases welfare |
| Region III (Slight "Over-speculation" in Right Direction) | $y/2 < x < y$ | suffer losses | increases welfare |
| Region IV (Serious "Over-speculation" in Right Direction) | $x > y$ | suffer losses | decreases welfare |

The demand by speculators is normally considered to be an increasing function of the difference between the expected price in period 2 and the current price in period 1, i.e.,

$$(4) \quad s = f \left[E(P_2') - P_1' \right], \quad f' > 0$$

Now if a central bank makes intervention purchases in period 1, it will affect the demand of speculators in several ways.

- a) First, it will tend to increase P_1' , which in turn will tend to decrease the quantity demanded by speculators.
- b) Second, if speculators know that the central bank is making intervention purchases in period 1, this will tend to lower the price that speculators expect to prevail in period 2, because they know the central bank will have to sell the same amount in period 2. This effect will also tend to decrease the speculators' demand.
- c) Third, if speculators know that the central bank is making intervention purchases in period 1, and if they have reason to expect that the central bank's intervention will usually be profitable (based perhaps on the bank's track record), then this will tend to raise their expected value of P_2' , and/or reduce the variance of their probability distribution of P_2' . Both of these effects will tend to increase the speculators' demand in period 1. On the other

hand if speculators have reason to expect that the central bank's intervention will usually be unprofitable, then, by the opposite reasoning, this will tend to decrease the speculators' demand in period 1.^{8/}

What is the net effect of these different influences? Although nothing can be said with certainty, it seems unlikely that speculators will take such comfort from the knowledge that the central bank shares their judgment, that they will increase their purchases in period 1.

And it seems extremely unlikely that speculators will reduce the quantity they demand in period 1 by more than the amount that the central bank purchases, because this would result in a price decline when the central bank purchases -- a rather counter-intuitive result.

Hence, it seems most likely that central bank intervention purchases will lead speculators to reduce the quantity they demand in period 1, but by a smaller amount than the central bank purchases. Thus the central bank's intervention will probably be partially (but not fully) offset by the response of speculators.

Therefore, we will assume that when the central bank makes intervention purchases in period 1, speculators will:

- a) (most likely) reduce the quantity they demand in period 1, but by less than the amount that the central bank purchases, or
- b) (less likely) increase the quantity they demand.

In either case the purchases by the central bank will cause the combined net purchases of the central bank and speculators, $x = i + s$, to be greater than the original quantity demanded by speculators, s_0 .

Now, under this assumption, let us proceed to analyze the implications of central bank intervention.

3. Welfare Effects of Central Bank Intervention

Consider two possible cases: when speculators, in the absence of central bank intervention, would purchase in period 1 an amount s_0 which is

- a) less than $y/2$
- b) greater than $y/2$

Consider first the case where net purchases by speculators would be an amount $s_0 < y/2$ (which could be negative). If the central bank intervenes to purchase foreign exchange in period 1, by our assumption the combined purchases of the central bank and speculators will be greater than s_0 . And as long as the central bank purchases do not cause $x > y/2$, the central bank will make a profit and it will increase total welfare (Region II' in figure 2).

If the central bank purchases are so large that they cause $y/2 < x < s_0'$ (where we assume s_0' is as far above $y/2$ as s_0 is below it), then the central bank will suffer losses, but it will still increase total welfare (given the symmetry of the TWG curve about a vertical line through $y/2$) (Region III' in figure 2).

However, if the central bank either sells foreign exchange in period 1, or buys so much that $x > s_0'$, then the central bank will suffer losses and it will decrease total welfare. (Regions I' and IV' respectively in figure 2.)

Table 2 summarizes the relationship between the central bank's profits and total welfare for this case.

Now consider the second case where net purchases by private speculators would be an amount $s_0' > y/2$. Then if the central bank intervenes to sell foreign exchange in period 1, it will, by our assumption, cause $x < s_0'$. And as long as the central bank does not sell so much foreign exchange that it causes $x < y/2$, the central bank will make a profit and it will increase total welfare (Region III' in figure 2).

If the central bank's sales are so large that it causes $s_0 < x < y/2$, then the central bank will suffer losses, but its actions will still increase welfare (Region II' in figure 2).

However, if the central bank either buys foreign exchange, or sells so much that it causes $x < s_0$, then it will suffer losses and it will decrease total welfare. Table 3 summarizes the relationship between the profitability of central bank intervention and total welfare for this case.

Thus for both cases (when private speculation would have been less than and greater than the welfare maximizing amount $y/2$ in the absence of any central bank intervention), we see that, if the central bank intervention is profitable, it will increase total welfare.

Table 2 ($s_0 < y/2$)

| | Net Purchases by Central Bank and Speculators ($x = i + s$) | Effect on Central Bank | Effect on Total Welfare |
|-------------|---|---------------------------|----------------------------|
| Region I' | $x < s_0$ | suffers losses | decreases welfare |
| Region II' | $s_0 < x < y/2$ | makes profits | increases welfare |
| Region III' | $y/2 < x < s_0'$ | suffers losses | increases welfare |
| Region IV' | $x > s_0'$ | suffers losses | decreases welfare |

Table 3 ($s_0' > y/2$)

| | Net Purchases by Central Bank and Speculators ($x = i + s$) | Effect on Central Bank | Effect on Total Welfare |
|-------------|---|---------------------------|----------------------------|
| Region I' | $x < s_0$ | suffers losses | decreases welfare |
| Region II' | $s_0 < x < y/2$ | suffers losses | increases welfare |
| Region III' | $y/2 < x < s_0'$ | makes profits | increases welfare |
| Region IV' | $x > s_0'$ | suffers losses | decreases welfare |

Generally speaking, the following relationships seem to exist in figure 2 between total welfare, speculation, and central bank intervention.

- a) Total welfare increases as the net speculative purchases increase until total welfare reaches a maximum at the optimum level of speculation, $x = y/2$. After that total welfare decreases.
- b) If speculators as a group make a profit, the amount of speculation is increased from 0 toward the welfare-maximizing amount.
- c) If the central bank makes a profit it increases total speculation (by private speculators and the central bank) toward the welfare-maximizing amount.

It should also be stressed that while profit-making central bank intervention increases total welfare, it does not necessarily increase the welfare of either non-speculators or speculators considered alone. For example, it can be seen in figure 2 that as central bank purchases increase total speculation from $y/4$ toward $y/2$, that the profits of speculators (which include the profits of the central bank) decline. Similarly, as central bank sales reduce total speculation from above $y/2$ toward $y/2$, the welfare of non-speculators declines.

It is particularly interesting to note that if, in the absence of central bank intervention, private speculators would either:

- a) over-speculate in the right direction ($s_0 > y/2$), or

b) speculate heavily in the wrong direction (say $s_0 < -y/2$), then central bank intervention that would drive total speculation to the optimal amount ($x = i + s = y/2$) would indeed cause total welfare to increase, but all of this gain, and then some, would accrue to speculators -- the welfare of non-speculators would actually decline.

This is noteworthy because central banks frequently justify their intervention on the grounds that speculators are causing an excessive movement of the exchange rate which is harming non-speculators. This analysis suggests the ironic possibility that such central bank intervention may benefit the speculators by saving them from themselves, but it may actually reduce the welfare of non-speculators.^{9/}

4. Conclusion

In this paper a simple two-period, consumer-producer surplus model of the foreign exchange market was used to determine if profitable intervention by an individual central bank (as opposed to profitable speculation by a group of speculators) necessarily increases welfare. The conclusion was that it does -- as long as the intervention is (a) only partially offset (most likely), or (b) reinforced (less likely), by private speculation. However, although profitable central bank intervention increases the total welfare of the society, it does not necessarily increase the welfare of either speculators or non-speculators considered alone. In particular, central bank intervention -- even when profitable -- may well reduce the welfare of non-speculators and increase the welfare of speculators, the exact opposite of the usually stated objective of the intervening central bank.

Footnotes

1/ Support for this proposition extends back for more than a century and a quarter. See John Stuart Mill (1848), Abba Lerner (1944), James Meade (1949-50), and Stephen Salant (1976).

2/ For example, see Milton Friedman (1978).

3/ This assumption is not essential to derive the general shape of the plots in figure 2, or to arrive at the general qualitative nature of our results.

4/ This figure was suggested by Steve Salant.

5/ $\frac{d(\text{SWG})}{dx} = y - 4x = 0 \Rightarrow x = y/4; \frac{d^2(\text{SWG})}{dx^2} = -4$

6/ $\frac{d(\text{TWG})}{dx} = y - 2x = 0 \Rightarrow x = y/2; \frac{d^2(\text{TWG})}{dx^2} = -2$

7/ Profitability of speculation is a sufficient but not a necessary condition for an increase in total welfare. If speculators as a group "slightly overspeculate in the right direction," total welfare will increase even though speculators as a group suffer losses.

8/ It might be noted that some observers have suggested that the net speculative demand is also a positive function of the rate of change of the price, i.e., that "bandwagons" occur.

Thorough investigation of stock and commodity markets has failed to detect such bandwagons.

Evidence for the foreign exchange market is thus far meager. Dooley and Shafer (1976) found that in the early quarters of managed floating, simple trading rules based on past exchange rate changes (so called filter rules) would have yielded substantial profits. This may have been due to speculative bandwagons, or to central banks slowing the adjustment of exchange rates to new levels dictated by economic fundamentals. Furthermore there was a tendency for the profitability of these rules to decline over time, perhaps because speculators became more familiar with the new system, or because the natural selection of speculators took place.

On the other hand Kemp (1976) and Giddy and Dufey (1975) found no evidence of bandwagons in the foreign exchange market.

9/ From a broader perspective it might be noted that if a central bank is out to do good, there is no obvious reason why it should be more concerned with the welfare of non-speculators than speculators, especially if, as in this paper, the latter term encompasses anyone whose decisions are influenced by the expectation that the price in the next period will be different from the present period -- which includes almost everyone.

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