RESERVE BANK OPERATIONS IN THE FOREIGN EXCHANGE MARKET: EFFECTIVENESS AND PROFITABILITY

Robert Andrew and John Broadbent

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ABSTRACT

Since the float of the Australian dollar in December 1983, the Reserve Bank has intervened in the foreign exchange market in order to exert a stabilising influence. Whether this intervention has been stabilising cannot be directly observed since the behaviour of the exchange rate in its absence cannot be known. However, there are a number of ways of assessing it indirectly. The best known is the Friedman "profits test". Friedman (1953) argued that a central bank which was stabilising the exchange rate would tend to buy foreign exchange when its price was low, and sell when its price is high, and hence its operations would be profitable. This paper applies the profits test to the Bank's foreign exchange operations since the exchange rate was floated. The main conclusion is that over this period the Bank's foreign exchange operations have produced total profits of around $A3.4 billion, suggesting that intervention has tended to be stabilising. Other statistical tests developed by Wonnacott (1982) and Mayer and Taguchi (1983), also presented in this paper, support this conclusion.

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1. INTRODUCTION

When the Australian dollar was floated in December 1983, the Reserve Bank noted that it would retain discretion to intervene in the foreign exchange market. The Bank's operations in the market were very light for the first 18 months or so of the float but became more substantial towards the end of 1985. By the latter half of 1986, the Bank had significantly stepped up its intervention in the face of sharp downward pressure on the exchange rate.

Since then, the Bank has continued to intervene in the market. At times this has involved undertaking relatively small amounts of intervention to slow the movement in the exchange rate or to slowly rebuild reserves. At other times, when the exchange rate had moved a long way from what was perceived to be a sustainable rate over the longer term, the Bank has sought to prevent further movement or even reverse some of the earlier movement.[1]

An obvious question arises: *Has this intervention been successful in having a stabilising influence on the exchange rate?* This question has no direct answer because we cannot know how the exchange rate would have behaved in the absence of the Bank's foreign exchange operations. As a consequence, we need to turn to various indirect measures. Probably the best known and appealing to a participant in the market is the profits test, first proposed by Milton Friedman in 1953. Other tests, which look at deviations of the exchange rate from a long-term trend, have been suggested by Wonnacott (1982) and by Mayer and Taguchi (1983).

This paper briefly reviews the literature on the effectiveness of foreign exchange intervention and then applies some of the tests discussed in this literature to the Reserve Bank's intervention over the floating rate period. While there can be

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[1] For fuller explanations of the Bank's foreign exchange operations, see Fraser (1992) and Macfarlane (1993).

shortcomings in the use of profits as a test of effectiveness of intervention, we argue that the existence of profits over long periods provides a strong case for the view that central bank intervention has been effective in stabilising the exchange rate. The paper shows that the Bank has made significant profits over the post-float period, though, as would be expected, profits have not been made in all sub-periods. Other tests carried out in this study support the finding that intervention has tended to stabilise the exchange rate over the period the currency has been floating.

It should be noted that the tests relate to what is often referred to in the literature as sterilised intervention. Academic discussion often makes much of the distinction between sterilised and unsterilised intervention (the latter leading to a change in financial conditions due to the effect of intervention on the monetary reserves of the banking system) but in reality central banks virtually always sterilise their intervention. To the extent that central banks want to undertake a change in monetary policy to influence the exchange rate they would do this through their usual means, which in most cases is operations in the domestic money market, rather than waiting for it to happen as a by-product of foreign exchange intervention.[2]

The paper is organised as follows. Section 2 discusses whether profitability can be used to assess the effectiveness of intervention and examines some of the empirical results from studies for other countries. Section 3 gives a broad overview of the Bank's foreign exchange operations, discusses the data and details our methodology. Section 4 summarises the empirical results on profitability for Australia. Section 5 provides some additional evidence, based upon tests first proposed by Wonnacott, that the Bank's operations have stabilised the exchange rate. The final section provides some concluding thoughts.

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[2] One reason for this is that intervention only impacts on domestic monetary reserves with a lag, as foreign exchange transactions are settled two days after being undertaken. A central bank whose currency was under threat to such a degree that it would consider raising interest rates would not want to wait for two days to achieve this monetary tightening through its failure to sterilise its intervention.

2. PREVIOUS PROFITABILITY STUDIES

2.1 The Connection Between Profits and Stabilising Intervention

In 1953 Friedman noted that "speculation can be destabilising in general only if speculators on the average sell when the currency is low in price and buy when it is high".[3] Conversely, profitable speculation would be stabilising because, to make profits, speculators would need to buy low and sell high, thereby reducing variability in the exchange rate. As a central bank intervening in the market acts (in some respects) much like an ordinary speculator, Friedman suggested that its success or failure in stabilising the rate be judged on the basis of an ordinary speculator - "there should be a simple criterion of success - whether the agency makes or loses money".[4]

This simple criterion elicited many articles examining the link between profitability and the effectiveness of foreign exchange intervention. The research focussed on:

(a) the extent to which central bank foreign exchange operations had been profitable; and

(b) the possibility that profitable intervention may not be stabilising or that stabilising intervention may not be profitable.

2.2 The Profitability of Intervention

There have been several empirical studies on the profitability of intervention for major countries. One of the first was that published by Taylor (1982), which examined nine industrial countries early in the floating period, from the early 1970s to the end of 1979.[5] According to his estimates, central banks lost more than $US11 billion over the whole period. Losses varied substantially for individual countries and, more importantly, as the period over which the calculation was carried out was altered.

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[3] Friedman (1953), p.175.

[4] ibid, p.188.

[5] The United States, Japan, Germany, United Kingdom, France, Italy, Canada, Switzerland and Spain were included in his study.

Subsequently, several authors challenged Taylor's results, reworking his calculations using several refinements. By lengthening the sample period and taking account of the interest differential between investing in foreign currencies and the local currency, Argy (1982), Jacobson (1983), and the Bank of England (1983) found that these large losses were in fact profits. For the US, for instance, Jacobson estimated that losses totalled around $US500 million for the 1973-79 period, but over the entire 1973-1981 period, net profits amounted to almost $US300 million. Moreover, including a measure of net interest earnings increased profits by up to $US470 million over the longer period.

Many of these studies suffered from the fact that they were based on data which only approximated the exchange rate at which transactions occurred. For example, they used published data which were often on an end-of-month basis. Given significant intra-month movements in exchange rates, this is not a good basis for reliable studies, as the rates at which a central bank deals in the market can be very different from the published series.

A later paper by Leahy (1989) on the profitability of US intervention sought to reduce some of the aggregation problems by using daily rather than monthly observations. Over the entire study period, from 1973 to early 1988, profits amounted to almost $US5.5 billion when interest income was included and $US3.8 billion when excluded. Again, however, Leahy noted the sensitivity of his calculations to using shorter periods, pointing to sub-periods when the authorities incurred large losses on intervention operations.

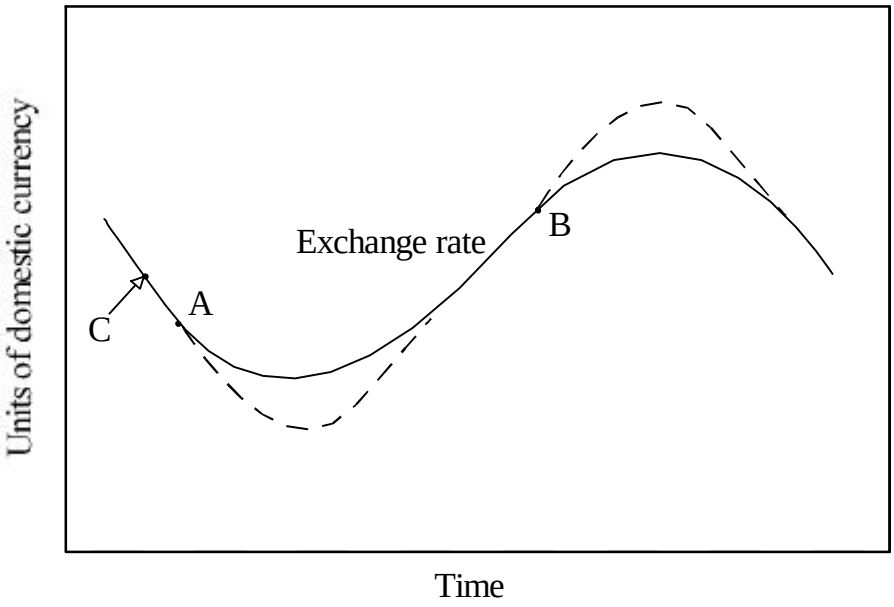
Murray, Zelmer and Williamson (1990) from the Bank of Canada applied Leahy's basic analysis to the Canadian experience. Unlike many earlier studies, however, they used actual data on the amount and the rate at which daily interventions were undertaken. Over the full sample, from mid 1975 to mid 1988, profits from intervention amounted to about $C1.6 billion ($US1.2 billion), with most of that coming from net interest earnings. Like other studies, the calculation of profits varied among sub-periods. Although profits were relatively large over the period as a whole, substantial trading losses were realised during some sub-periods.

2.3 The Relationship Between Profitability and Effectiveness

In making his claim that stabilising intervention would be profitable, Friedman might have had in mind a situation such as that depicted in Figure 1. The exchange rate is expressed here as the price of the foreign currency - i.e. as the amount of domestic currency required to buy one unit of foreign currency. This is the way most countries quote their exchange rate. A low reading indicates that foreign currency is cheap (the value of the domestic currency is high) and a high reading indicates that foreign currency is dear (the value of domestic currency is low). For those readers who are used to working mostly with Australian dollar exchange rates, this definition of the exchange rate may, unfortunately, be confusing as the Australian dollar is quoted in foreign exchange markets in reciprocal form (e.g. US70 cents per Australian dollar). The more widely accepted definition is used in this paper to be consistent with international usage and to simplify the understanding of the algebra used later in the study.

In terms of Figure 1, a central bank which bought foreign currency at point A and sold at point B would make a profit, since it bought when the price was low and sold when the price was high. It is also likely that by buying foreign currency at point A, the central bank would have tempered the domestic currency's appreciation (so that the exchange rate followed the path traced by the solid line rather than the dotted line) and, by selling it at point B would have reduced the local currency's depreciation.

Figure 1: Price of Foreign Currency



In this example, there is a very clear relationship between profitable and stabilising intervention. However, many researchers did not see this as proving that there was a link between profitable and stabilising intervention. They went on to examine cases where there was no relationship between the two.

Some argued that a central bank's operations might be profitable, but have little impact on the exchange rate and therefore not be stabilising. Referring again to Figure 1, this would be the case if the central bank bought at A and sold at B, but the exchange rate followed the dotted line. This is theoretically possible, but unlikely. While a central bank might be able to conduct its operations in such a low key way that it would have no impact on the exchange rate, it is hard to think of reasons why it would do this on a continuing basis, unless its operations were always aimed at something other than stabilising the exchange rate.

More recent researchers[6] have pointed to the possibility that profitable speculation could lead to more, rather than less, exchange rate variability. In these models, a group of speculators is aware that some market participants tend to buy as the price rises and sell as it falls. Initially, these "knowledgeable" speculators push the price away from equilibrium, knowing that the price will move even further away as the latter group enters the market. At this point, they turn their positions and the price moves back towards its equilibrium. While such a model may reflect the behaviour of some private speculators, who are trying to induce instability into the rate, it makes little sense for central banks which are trying to stabilise the rate. Therefore, while the situations outlined by these researchers are theoretical possibilities for private speculators, for all practical purposes they can be put aside.

Others[7] argued that a central bank's operations may be stabilising but not be profitable. Again, it is not hard to find illustrations of this. They fall into two broad categories. One involves measuring profitability over very short periods. For example, if a central bank had bought foreign currency but the price of foreign currency fell further soon after, then over that time span, those operations would not have been profitable. Central banks, however, would not normally judge the success of their operations over a short time frame. They would be looking to see whether their activities had a net stabilising effect over a period as long as an

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6 See Shleifer and Summers (1990).

7 See Bank of England (1983).

economic cycle; for example, did it contribute to reducing the degree of overshooting at the trough and at the peak. The effectiveness of intervention, and its profitability, therefore need to be measured over a time frame consistent with the central bank's objectives.

Second, central banks are not profit maximisers; they do not wait until the exchange rate reaches the bottom before buying (even if they knew where the bottom was). A central bank that was aiming to stabilise its exchange rate would start to buy foreign currency a long way before the exchange rate reached its probable low point. Unless the domestic currency immediately stops appreciating when the central bank starts buying foreign exchange, something which is unlikely, the central bank's operations are likely to show a loss for some time. In terms of Figure 1, a central bank might start to buy foreign currency at point C. By the time the foreign currency had depreciated against the domestic currency at point A, those operations would be showing a loss. It is not until the price of foreign exchange started to move back up that the operations would show a profit. In short, if a central bank has a longer term objective in mind, the success of those operations can only be assessed over the span of a complete cycle. At various points along the cycle, operations are likely to show a loss, even though they may have been stabilising.

Another situation in which stabilising intervention may not be profitable is if the exchange rate is on a consistent upward or downward trend. Drawing on Mayer and Taguchi, this is illustrated in Figure 2.[8] The exchange rate fluctuates around a downward trend. A central bank which bought foreign currency at point A and sold it at point B may be stabilising the exchange rate (in the sense of reducing the variation around the trend) but those operations would not be profitable as the rate at which the currency was bought would be higher than the rate at which it was sold.

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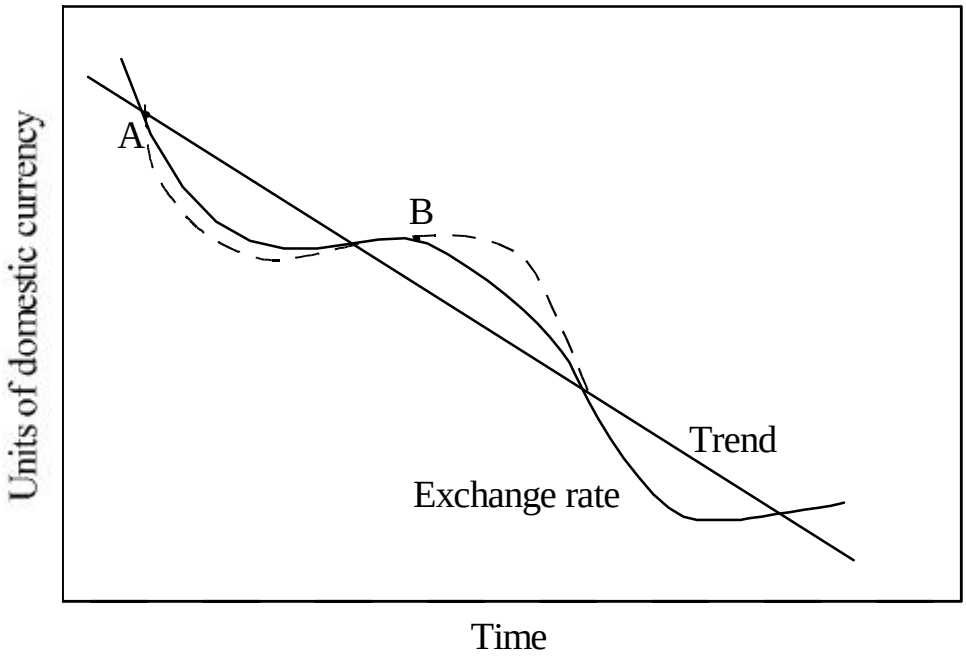
[8] See Mayer and Taguchi (1983), Diagram 3 on page 15.

Figure 2: Price of Foreign Currency



Various researchers, however, have pointed out that in the circumstances outlined above, if profitability calculations take into account not only the trading profits on foreign exchange operations but also the differences in net interest earnings as a result of the switch from foreign to domestic assets (or vice versa), then the relationship between stabilising foreign exchange operations and profitable operations could be restored.

Taking account of net interest earnings will in most cases add to the profitability of central bank intervention as long as there is some tendency towards uncovered interest parity, i.e. as long as interest rates on the depreciating currency tend to be higher - on average - than on the appreciating currency. For example, if the central bank whose currency is depreciating sells foreign currency to buy its own currency, it would increase interest earnings on its assets as it moved from foreign to domestic assets. Similarly, for a country whose currency is appreciating, central bank purchases of foreign currency would result in trading losses in the short term but higher interest earnings. Instances where intervention has a negative effect on net interest earnings are confined mainly to periods when the domestic currency is appreciating due to tight monetary policy and the central bank is intervening to slow the appreciation.

In summary, we would conclude from the results of the available research that, while there can be instances where stabilising intervention is not profitable and profitable intervention is not stabilising, it is likely that they would be exceptions rather than the rule. Such cases tend to occur when measurement is over a period that is relatively short or when the exchange rate has a strong trend over the long term. In the latter case, allowing for net interest earnings can help. In general, however, particularly when measured over reasonably long periods (covering at least one complete economic cycle) evidence that foreign exchange operations are profitable would suggest that those operations are also stabilising. On this analysis, the profit criterion as set out by Friedman remains a reasonable test of the effectiveness of central bank foreign exchange operations in stabilising the exchange rate.

3. THE PROFITABILITY OF RESERVE BANK INTERVENTION

3.1 Overview of the Bank's Operations

The Bank's operations in the foreign exchange market can be thought of as comprising two main components. The first is pure intervention, over which the Bank has discretion as regards to size and timing. The second is client business, which consists of meeting the foreign exchange needs of its clients, principally the Commonwealth Government.[9] The timing and size of sales to clients is determined by the clients themselves, and therefore might be thought of as not at the Bank's discretion. However, the Bank chooses when to enter the market to restore the reserves of foreign exchange it has sold to clients. The second leg of the client business is therefore at the Bank's discretion.[10] Because client business involves a discretionary element, it should therefore be added together with pure intervention

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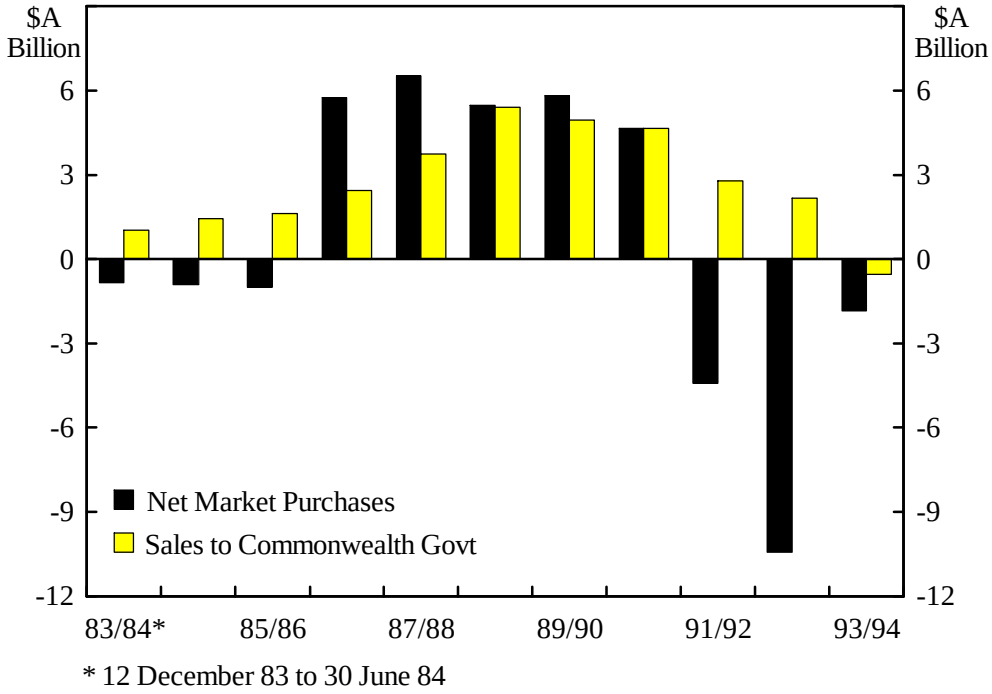
[9] There is a third form of Reserve Bank operation in the foreign exchange market which involves changing the foreign currency position of reserves. For example, the Bank may sell US dollars to buy yen. Since these transactions are in "third currencies", i.e. they do not involve an Australian dollar leg, they do not affect the value of the Australian dollar and are not included in these calculations.

[10] If the Bank chose to purchase in the market, at the time of receiving the client order, the exact amount of the order, then the Bank would exert no discretionary effect on the market. The outcome would be the same as if the client had gone directly to the market to meet its foreign exchange needs.

to calculate the total effect of the Bank's actions on the exchange rate. All the following calculations are based on figures which aggregate the two components.

Figure 3 shows the Bank's net purchases of foreign currency in the market and the net amount of foreign currency sold to the Government in each financial year since the float. Both are defined as positive numbers to facilitate comparison between the Bank's transactions in the market and client needs. Only in two years - 1988/89 and 1990/91 - did transactions in the market offset client needs. In the early post-float period, the Bank sold foreign currency in the market and sold to the Government. The consequential fall in reserves was reversed in the late 1980s when purchases in the market ran well ahead of sales to the Government. In more recent years, the Bank has reverted to being a seller both in the market and to the Government.[11]

Figure 3: Reserve Bank Foreign Exchange Transactions



* 12 December 83 to 30 June 84

Figure 4 shows the cumulative net foreign currency position of the Bank resulting from its transactions with the market and with clients since the float. It is measured in terms of US dollars - a positive number shows the Bank has bought more foreign currency from the market and/or its clients than it has sold. As noted, in the three

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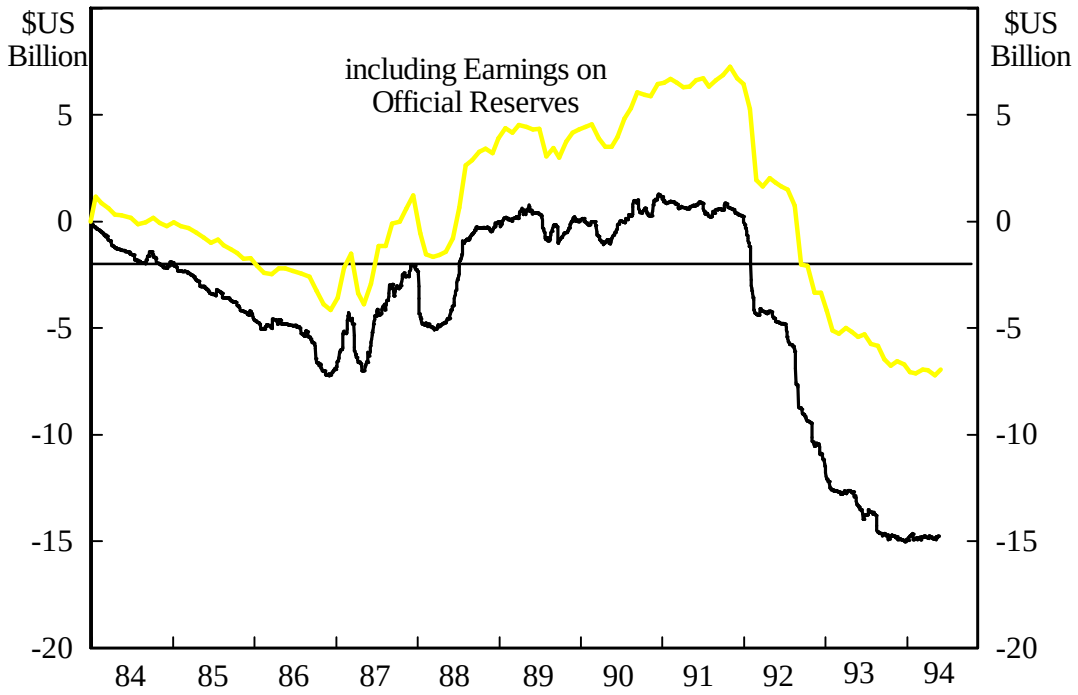
[11] Note that in 1993/94, the government was a net seller of foreign currency to the Bank, reflecting its program of swapping Australian dollar liabilities into US dollar liabilities.

years immediately following the float, the Bank was a net seller of foreign currency with the "short" position reaching around $US7 billion by the latter half of 1986. Soon after, the Bank switched to being a purchaser of foreign currency reflecting, first, a desire to rebuild reserves, and then intervention aimed at resisting the extent of the Australian dollar appreciation. By late 1988, the Bank's net foreign currency position had returned to square. The position fluctuated around zero for a time, before the sharp depreciation of the Australian dollar around the end of 1991 saw the Bank's sales of foreign exchange increase significantly. As at end-June 1994, the Bank had a cumulative "short" position totalling $US14.8 billion.

These calculations of the Bank's foreign exchange position only reflect the 'discretionary' element, i.e. the purchases and sales of foreign exchange. Throughout the period, however, there was another important influence at work, namely, the earnings on official reserves. These amounted to around $US8 billion in total and accrued continuously over the period. The dotted line in Figure 4 shows what the total foreign exchange position would be if these inflows were included. For the purposes of calculation of profit and loss, however, it is the 'discretionary' element given by the solid line that is important.

Figure 4: Cumulative Net Purchases of Foreign Exchange



3.2 Methodology and Data

3.2.1 Sample Period and Data

This study uses data on the actual deals undertaken by the Bank (volumes and exchange rates). The sample period runs daily from 12 December 1983 to 30 June 1994.

The bulk of the Bank's intervention involves buying or selling US dollars against the Australian dollar on a spot basis; as a consequence, the analysis measures foreign exchange transactions in US dollars.[12] Where the Bank undertook a transaction with either the market or a client that involved the exchange of Australian dollars for a foreign currency other than the US dollar, this was recalculated in equivalent US dollars using an appropriate exchange rate. In some cases this was the actual foreign currency/US dollar exchange rate at which the deal was undertaken as deals are often crossed through the US dollar. Where the foreign currency/US dollar rate was not known for individual transactions it was proxied using the average exchange rate at which other deals were carried out on that day, or if that was not available, the exchange rate at 4.00 pm on that day. Outright forward transactions were rare throughout the period, though where they were identified, the forward rate was adjusted for the effect of interest rate differentials to arrive at a comparable spot rate.

3.2.2 Net Interest Income

As noted above, many argue that a full assessment of the profitability of foreign exchange intervention requires that the effect on net interest income be taken into account. Since it is a cost of holding one currency instead of another, it is clearly one of the variables which determines profitability. On the other hand, it can be argued that the effects on net interest income are purely incidental for a central bank which aims to exert a stabilising influence on its exchange rate. They should not, in any way, impinge upon the decision of whether to intervene, and therefore, should be excluded from the profit calculation. This argument has some merit to the extent that profits should not affect a decision to intervene.

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[12] Spot transactions are settled within 2 business days from the day they are arranged; forward deals are those transactions which are arranged more than 2 business days before settlement.

In our view, there is not a clear answer to the question of whether interest earnings should be included in profit calculations. To our knowledge, most central banks intervene with the main objective of stabilising their exchange rate; they do not take portfolio considerations into account. In this respect, the most appropriate test of whether they met these objectives is to focus solely on trading profits. On the other hand, it could be claimed that net interest earnings should be taken into account to put central banks on the same footing as private sector speculators who have to take portfolio funding decisions into account.

In what follows, we present the figures for profits both including and excluding net interest income. It is worth repeating the earlier point, however, that taking account of net interest income usually works in the central bank's favour. Contrary to popular perceptions, therefore, the "trading profits" test is normally a harder one to pass than one that looks at total profits including net interest earnings.

The effect on net interest income is measured using the difference between the rate on an Australian 13-week treasury note and a US 3-month treasury bill rate. These are reasonable proxies for the interest rates available to the Bank as, at least until recently, the Bank tended to hold mainly short-term assets. The interest differential is applied to the net open currency position held by the Bank as a result of its foreign exchange operations.

3.2.3 Methodology

We have followed a similar procedure to that used by Murray, Zelmer and Williamson in their study of profitability for the Canadian experience. Profits from the Bank's foreign exchange operations at any point of time are calculated by:

$$\Pi_t = \sum_{i=1}^{t} m_i \left[e_i - s_i \right] + \left\{ \sum_{i=1}^{t} \left(v_i - m_i \right) \left(e_t - s_t \right) \right\} + \sum_{i=1}^{t} e_i \left[\left(r_i^* - r_i \right) \sum_{j=1}^{i} \left(v_j - m_j \right) \right]$$

where:

v_i is the addition to an existing US dollar position, with $v_i > 0$ for purchases of US dollars in a long position and $v_i < 0$ for sales of US dollars in a short position;

m_i is the reduction in an existing US dollar position, with $m_i > 0$ for sales of US dollars in a long position and $m_i < 0$ for purchases of US dollars in a short position;

e_i is the exchange rate at which a transaction is made in terms of the number of Australian dollars per US dollar;

r_i and r_i^* are the short-term interest rates on Australian dollar and US dollar assets respectively; and

s_t is the weighted average exchange rate at which the position is acquired and, for period *t*, is calculated as:

$$s_t = \frac{s_{t-1} \sum_{1}^{t-1} \left(v_{j-1} - m_{j-1} \right) + v_t e_t}{\sum_{1}^{t-1} \left(v_{j-1} - m_{j-1} \right) + v_t}$$

The three components on the right hand side of the above formula can be interpreted as follows:

- the first calculates the realised trading profit during the period;
- the second is a measure of the unrealised trading profit. It simply revalues any existing US dollar position using the exchange rate at the end of the period; and
- the third is a measure of net interest earnings from holding a long US dollar (short Australian dollar) position compared with holding the equivalent in Australian dollars.

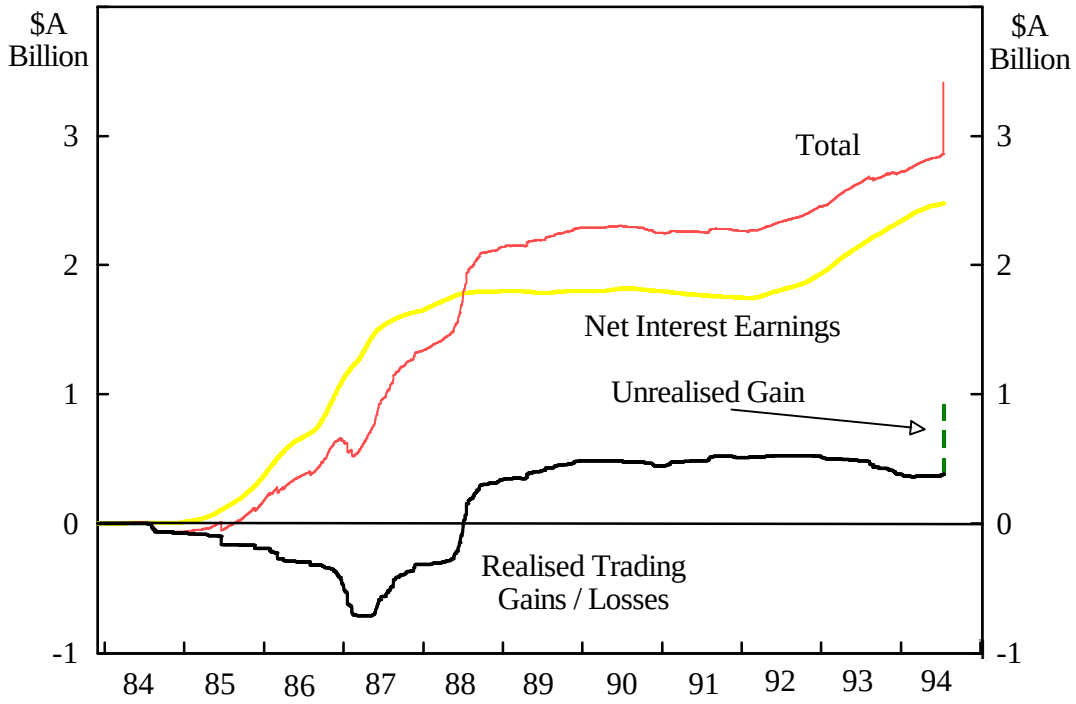
Note that there is a distinction made between a transaction that adds to an existing US dollar position, v_i, and a transaction that partially reverses a position, m_i. If a transaction adds to an existing US dollar position, the average exchange rate at which that position was acquired is recalculated so as to include that new transaction. At that point, there is no effect on profits. It is only when the position is reversed that trading profits or losses are realised. Realised profits/losses are calculated by comparing the exchange rate at which these US dollars are bought/sold to close out a position with the average exchange rate at which the position was acquired. At the end of the period, the unrealised profit or loss on the remaining open position can be measured by comparing the cost of establishing that position and the prevailing exchange rate.

A simple example best illustrates. Suppose the Bank initially purchases foreign currency and builds up a long US dollar position. As it continues to buy US dollars, the average exchange rate at which its long position has been acquired is recalculated. (In this case, the average exchange rate is an average purchase price.) Profits or losses are realised only when the position is reversed by selling US dollars. If the exchange rate at which the US dollars are sold is higher than the average cost at which they were acquired, then there is a realised profit on this transaction. If selling of US dollars is sustained, it gradually reverses the long US dollar position, resulting in profits/losses being realised until the position is fully closed out. Once closed out, further sales of US dollars open a short US dollar position and the average exchange rate at which this position has been acquired is an average selling price. Profits/ losses are realised on this short US dollar position only when US dollars are purchased. Finally, at the end of the period, unrealised profits on the outstanding US dollar position are calculated using the end-of-period exchange rate.

4. EMPIRICAL RESULTS

Figure 5 shows the accumulation of total profits and its components - realised trading profits, the sum of realised and unrealised trading profits and net interest earnings - between the float and June 1994.

Figure 5: Cumulative Profits of Foreign Exchange Operations



In the first few years of the float, realised trading losses were made. The Australian dollar depreciated sharply through this period. The Bank was mainly a seller of foreign exchange but it did also make some purchases from time to time. The cost of these purchases was on average higher than the price at which the Bank was selling, thus realising trading losses.[13] This process continued until end 1986. Thereafter, as the Australian dollar appreciated, the Bank became a net buyer of foreign currency and started to close out the net short position built up in the previous three years. The price at which the Bank was buying through this period was below the average price at which the short position had been established, so profits were realised. By October 1988, when the US dollar short position was finally closed out, realised trading profits stood at $A306 million, with a further $A1.9 billion in net interest earnings.

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[13] These trading losses contrast with the accounting profits reported in the Bank's accounts at this time. Most of the intervention the Bank undertook immediately post float involved the sale of foreign exchange which had been acquired prior to the float when the Australian dollar was stronger and the cost of foreign exchange therefore lower. The sale of this foreign exchange, at prices which were above cost, realised profits in the Bank's accounts. In this study, which looks only at operations since the float, the cost of foreign exchange acquired before the float is not taken into account; it compares receipts from sales of foreign exchange only with the cost of purchases of foreign exchange since the float.

Over the next few years, the exchange rate moved within a relatively narrow band and the Bank built up a small long position. Realised profits through this period were relatively modest. Subsequent sales of foreign currency have once again opened up a short foreign currency position amounting to $US14.8 billion at June 1994. This has not had much impact on realised profits; at June 1994, cumulative realised profits since the float stood at $A382 million.

Realised gains are one component of profits from intervention. As shown in Table 1, another component is unrealised gains. At June 1994, the short foreign currency position the Bank was holding had resulted in substantial unrealised gains amounting to $A553 million. These reflect the difference between the average exchange rate at which the short position was accumulated (US71.10 cents) and the exchange rate at end June (US73.04 cents) which is used to revalue the position. The other component of profits - net interest earnings - have also been substantial in recent years, and the cumulative total of such earnings since the float is $A2478 million. Adding all three components, total profits from intervention since the float have amounted to $A3414 million.[14]

Table 1: Reserve Bank Profits from Intervention
12 December 1983 to 30 June 1994
$A million

Realised gains	382
Unrealised gains	553
Net interest earnings	2478
Total	3414

[14] These profits represent only the revenue earned by the Bank as a result of intervention. The Bank also earns regular interest income on its holdings of reserves. Over the period since the float, total earnings on reserves have amounted to around $US8 billion.

5. ALTERNATIVE TESTS OF STABILISING INTERVENTION

5.1 Wonnacott's Criterion

5.1.1 Methodology

Another test of whether exchange rate intervention is stabilising is if it acts to reduce the variance of the exchange rate around its equilibrium. This definition, however, has a major shortcoming in that it requires an exchange rate model to determine what the equilibrium rate should be, something which continues to elude the economics profession.

Wonnacott (1982) argued that a more practical definition is that intervention is stabilising if it reduces the variance of the exchange rate around its trend; this long-term trend is approximated with a centred moving average. The deviation of the exchange rate from its moving average is given by:

$$DMA = \frac{e_i - MA_k}{MA_k} * 100$$

where:

MA_k is a centred moving average over k periods.

Wonnacott's test involves measuring whether the direction of intervention is consistent with pushing the exchange rate back towards its long-run moving average. If DMA is greater than zero, so that the exchange rate is above its long-term trend, intervention that is working in the right direction would involve the Reserve Bank selling foreign currency to the market. Similarly, intervention would be stabilising if the Bank purchased foreign currency from the market when DMA is negative. The performance of the monetary authority can be measured by the ratio of the number of days when intervention was in a stabilising direction to the number of days when intervention took place.

This success ratio is given by:

$$SR = \sum_{i=1}^{t} \left(d_i\right) / \sum_{i=1}^{t} \left(D_i\right)$$

where:

d_i = 1 if intervention was in the right direction (and zero otherwise); and,

D_i = 1 if intervention took place (and zero otherwise).

Alternatively, the success ratio can be weighted according to the dollar value of intervention so as to account for the relative intensity of the intervention:

$$SR(\$) = \sum_{i=1}^{t} \left(n_i d_i\right) / \sum_{i=1}^{t} \left(n_i D_i\right)$$

where:

n_i is the absolute amount of foreign currency purchased or sold in period i.

This pragmatic approach rests upon a number of assumptions. First, the moving average is a reasonable proxy for the equilibrium rate, given that this equilibrium cannot be otherwise quantified. Large and discrete one-off movements in fundamentals could require an abrupt shift in the equilibrium rate, something which cannot be picked up by a simple moving average. Second, intervention has no discernible impact on the longer run trend in the exchange rate. If intervention has some impact in the longer-term, then the centred moving average exchange rate would not be an exogenous parameter for the monetary authority, but would be endogenous to its own policies. Whilst these assumptions are fairly restrictive, we would suggest that violations to them have probably not been too great throughout the period; as a consequence, the success ratios (SR and SR($)) should allow us to reasonably determine whether intervention was working in the right direction[15].

An underlying theme of Wonnacott's test is that intervention is more likely to be working in the right direction the larger the deviation of the exchange rate from its moving average. As a consequence, we have also calculated the success ratios using a restricted sample that excludes those observations which lie within an x per cent band of the moving average. Two alternative band widths were chosen: 1½ per cent and 3 per cent either side of the moving average. This is also more realistic because it allows the central bank some latitude in assessing where the

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[15] The success ratios measure whether the direction of intervention is correct. They do not test whether intervention influences the level of the exchange rate.

longer-term exchange rate is likely to lie. In addition, because the lag length of the moving average is also somewhat arbitrary, the success ratios were calculated using 3-month, 6-month, and 12-month moving averages.[16]

5.1.2 Empirical Results

Table 2 sets out the results for the total post-float period, for the various combinations of moving averages and band widths. The way these can be interpreted is as follows: row 3, for instance, shows results where a three-month moving average and a 3 per cent band width are used. The statistics show that over the whole period the exchange rate deviated from its moving average by more than 3 per cent on 139 days. On 94 of these days (i.e. 68 per cent) the Bank intervened in the foreign exchange market. Of these interventions, 80 per cent (91 per cent when weighted by the size of intervention) were in a stabilising direction. The final column shows that the average daily value of intervention that was in a stabilising direction was $A66 million.

Success ratios are all in excess of 50 per cent, which indicates that the Bank's intervention on average was in a stabilising direction on this test. If intervention had been random, success ratios would not have been significantly different from 50 per cent.[17] The success ratios are significantly higher when weighted according to the size of intervention, suggesting that large interventions had a greater propensity to be in the right direction than smaller ones. Intervention tended to occur more frequently the further the exchange rate deviated from its moving average and the success ratios also tended to be higher in these cases.

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[16] The tests were performed on series that contain 6 months fewer observations than the original series in order to allow for the calculation of a 12 month centred moving average.

[17] Given the sample size, any value more than 2 per cent away from 50 per cent would be significantly different from a random outcome.

Table 2: Moving Average Test for Stabilising Intervention
(for whole post-float period)

	Total No. Days	No. of Days Intervened	Percentage of Days Intervened	% of Intervention in Stabilising Direction		Average Dollar Value of Intervention in Stabilising Direction ($A mil)
				No. of Days SR	Dollar value SR($)	
3-Month Moving Average						
All Days	2703	1546	57	55	68	65
/DEV/ >1½ per cent	745	428	57	71	85	66
/DEV/ >3 per cent	139	94	68	80	91	66
6-Month Moving Average						
All Days	2703	1546	57	55	66	64
/DEV/ >1½ per cent	1205	695	58	64	81	63
/DEV/ >3 per cent	419	266	64	76	92	64
12 Month Moving Average						
All Days	2703	1546	57	56	65	63
/DEV/ >1½ per cent	1804	1056	59	55	71	62
/DEV/ >3 per cent	932	598	64	60	80	59

The style of the Bank's intervention has changed during the period since the float. Up to late 1985, intervention was light. The average amount dealt on the days when the Bank intervened was about $A12 million, with the largest being on 8 November 1985, when the Bank purchased $A90 million. In 1986, the scale of intervention started to become bigger. The catalyst for the change in approach was recurring episodes of extreme foreign exchange market instability. Around the middle of the year, as the exchange rate had already fallen a long way and looked undervalued in relation to economic fundamentals, the Bank intervened heavily to provide a solid foundation. On several days, purchases of Australian dollars from the market approached $A250 million, and for July 1986 as a whole, net purchases amounted to $A1.2 billion. Through the second half of the 1980s, the Bank maintained a frequent presence in the market, intervening on 76 per cent of days. The average

size of daily intervention was about $A50 million. In the 1990s, the frequency of intervention fell sharply to 26 per cent of days, though the average size increased to about $A110 million.

It is possible to split the floating rate period into three broad sub-periods, corresponding to different phases in the Bank's intervention:

- from the float until late 1985, when intervention in the market was very light;
- from late 1985 to early 1991, when the Bank intervened frequently in the market with moderate volumes; and
- since early 1991, when the Bank has been in the market less frequently but has dealt in large amounts when needed.

The results for these three sub-periods are shown in Table 3. These results show that the success rate of intervention, as measured by SR and SR($), was a little higher in the second sub-period than in the first period, but increased noticeably in the latest sub-period when the Bank intervened less frequently but in larger amounts. Most success ratios in this last period were above 70 per cent and some were 100 per cent. This suggests that the Bank was most successful when it entered the market less frequently but on a significant scale.

Table 3: Moving Average Test for Stabilising Intervention

	Total No. Days	No. of Days Intervened	Percentage of Days Intervened	% of Intervention in Stabilising Direction: No. of Days SR	% of Intervention in Stabilising Direction: Dollar value SR($)	Average Dollar Value of Intervention in Stabilising Direction ($A mil)
12 December 1983 to 31 October 1985						
3-Month Moving Average						
All Days	527	274	52	54	59	12
/DEV/ >1½ per cent	237	112	47	60	67	15
/DEV/ >3 per cent	64	31	48	74	83	19
6-Month Moving Average						
All Days	527	274	52	53	59	12
/DEV/ >1½ per cent	329	163	50	58	63	13
/DEV/ >3 per cent	148	76	51	66	78	16
12 Month Moving Average						
All Days	527	274	52	51	55	12
/DEV/ >1½ per cent	419	225	54	51	55	12
/DEV/ >3 per cent	289	157	54	53	59	13
1 November 1985 to 31 January 1991						
3-Month Moving Average						
All Days	1422	1075	76	53	62	64
/DEV/ >1½ per cent	377	279	74	72	82	68
/DEV/ >3 per cent	75	63	84	83	92	87
6-Month Moving Average						
All Days	1422	1075	76	53	62	62
/DEV/ >1½ per cent	614	463	75	63	75	60
/DEV/ >3 per cent	229	175	76	79	92	70
12 Month Moving Average						
All Days	1422	1075	76	54	63	62
/DEV/ >1½ per cent	951	723	76	55	68	63
/DEV/ >3 per cent	491	392	80	61	77	62

Table 3: Moving Average Test for Stabilising Intervention *(cont.)*

	Total No. Days	No. of Days Intervened	Percentage of Days Intervened	% of Intervention in Stabilising Direction		Average Dollar Value of Intervention in Stabilising Direction ($A mil)
				No. of Days SR	Dollar value SR($)	
1 February 1991 to 30 June 1994						
3-Month Moving Average						
All Days	754	197	26	71	80	126
/DEV/ >1½ per cent	131	37	28	95	97	162
/DEV/ >3 per cent	0	0	NA	NA	NA	NA
6-Month Moving Average						
All Days	754	197	26	69	79	127
/DEV/ >1½ per cent	262	69	27	84	98	163
/DEV/ >3 per cent	42	15	36	100	100	176
12 Month Moving Average						
All Days	754	197	26	68	72	120
/DEV/ >1½ per cent	434	108	25	74	85	129
/DEV/ >3 per cent	152	49	32	84	97	137

Studies of other major foreign exchange markets have come up with similar conclusions. Wonnacott (1982) applied his test to US intervention in Deutschemarks over the late 1970s, Mayer and Taguchi (1983) studied intervention by Germany, Japan and the United Kingdom between 1974 and 1982 while Murray, Zelmer and Williamson (1990) examined Canadian intervention over the period 1975 to 1988. Their results showed that intervention was helpful, at least on some simple tests. For example, the percentage of days when intervention occurred, the percentage of intervention that was in the right direction and the average value of intervention all tended to increase as the exchange rate moved further away from its moving average.

5.2 Hybrid Criterion

5.2.1 Methodology

A variant to Wonnacott's tests was proposed by Mayer and Taguchi (1983). They distinguished two exchange rate zones by fitting a band around the trend in the exchange rate. Outside this band, intervention is judged according to Wonnacott's criterion. Within the band, however, intervention is judged according to a "leaning against the wind" criterion, the so-called LAW criterion. Under this criterion, successful interventions push the rate towards the last observed level. In other words, the central bank should buy the local currency when it is falling and sell it when it is rising, *regardless of where it stands vis-a-vis the moving average trend.* Mayer and Taguchi argued that this hybrid criterion more accurately reflected central bank behaviour.[18] They suggested that if the exchange rate is a long way from its equilibrium level but is moving towards it, then Wonnacott's criterion should prevail. But as the exchange rate moves closer to its equilibrium level, then intervention should be assessed according to the LAW criterion. This is because the equilibrium level cannot be ascertained exactly, and there is the likelihood of misjudgment. Moreover, in order to obtain a "smooth landing" in the equilibrium zone, it might be advisable to lean against the wind to ensure that momentum does not build up to push the exchange rate through the equilibrium zone. Figure 6 provides a graphical comparison of these criteria.

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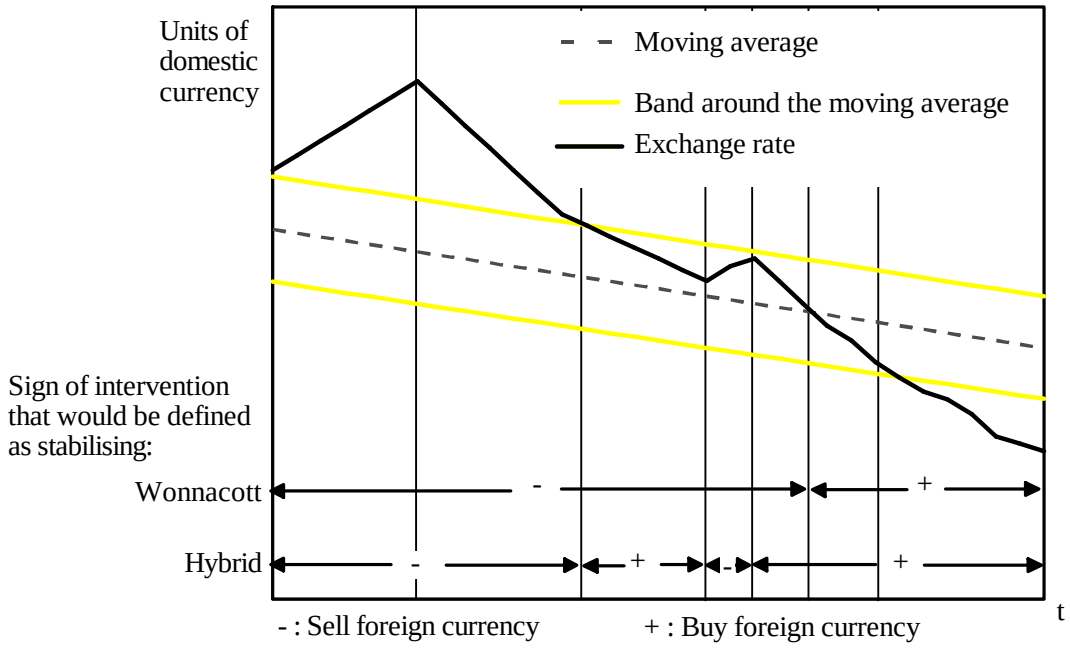
[18] Mayer and Taguchi argued that the LAW criterion made little sense applied to all exchange rate movements because it implied that the authorities always took the view that the prevailing exchange rate is the best one. Under this approach, therefore, all exchange rate movements should be dampened, if not suppressed.

Figure 6: Stabilisation Criteria



5.2.2 Empirical Results

In testing the Bank's intervention using the hybrid criterion, two bands were chosen around the long-run trend within which the stabilising impact of intervention was judged according to the LAW criterion; they are 1½ per cent and 3 per cent on each side of the moving average.

Table 4 shows results using this criterion for the total post-float period and for the three sub-periods. Qualitatively, these results are not very different from using Wonnacott's criterion:

- success ratios were again well above 50 per cent;
- in all periods, SR($) is higher than SR. This suggests that intervention for large amounts was more successful than intervention for small amounts. Partly this reflects the fact that large intervention tended to take place when the exchange rate was a long way from its long-term average (i.e. when the exchange rate was more likely to be out of line);
- intervention was generally more successful in the second sub-period than in the early period; and

Table 4: Results for Hybrid Criterion

		Percentage of intervention in Stabilising Direction	
		No. of Days (SR)	Dollar value SR($)
Whole post-float period	**3 Month Moving Average** width of band -		
	1½ per cent	63	76
	3 per cent	62	72
	6 Month Moving Average width of band -		
	1½ per cent	63	76
	3 per cent	63	73
	12 Month Moving Average width of band -		
	1½ per cent	58	70
	3 per cent	61	73
12 December 1983 to 31 October 1985	**3 Month Moving Average** width of band -		
	1½ per cent	58	69
	3 per cent	60	75
	6 Month Moving Average width of band -		
	1½ per cent	59	68
	3 per cent	60	75
	12 Month Moving Average width of band -		
	1½ per cent	51	57
	3 per cent	57	66
1 November 1985 to 31 January 1991	**3 Month Moving Average** width of band -		
	1½ per cent	64	73
	3 per cent	62	71
	6 Month Moving Average width of band -		
	1½ per cent	63	72
	3 per cent	63	72
	12 Month Moving Average width of band -		
	1½ per cent	57	68
	3 per cent	61	71

Table 4: Results for Hybrid Criterion *(cont.)*

		Percentage of intervention in Stabilising Direction	
		No. of Days (SR)	Dollar value SR($)
1 February 1991 to 30 June 1994	**3 Month Moving Average** width of band -		
	1½ per cent	65	84
	3 per cent	61	74
	6 Month Moving Average width of band -		
	1½ per cent	70	88
	3 per cent	63	76
	12 Month Moving Average width of band -		
	1½ per cent	70	77
	3 per cent	69	81

- the success ratio SR($) tends to be highest in the recent sub-period. In contrast, however, the success ratio, SR, is little different from the earlier periods and is well down compared with the success ratios measured using Wonnacott's criterion. This suggests that, in this period, the Bank's operations when the exchange rate was within the band were not characterised by the LAW criterion.

6. CONCLUSION

Over the floating rate period, the Reserve Bank's foreign exchange operations have been profitable. Realised trading profits have amounted to about $A382 million and unrealised gains were $A553 million at the end of June 1994. When net interest income is taken into account, total profits rise to about $A3.4 billion. While we acknowledge that there is not always a close link between profits and the effectiveness of intervention, the existence of profits over a long run of years suggests that the Bank, on balance, has bought foreign exchange when its price was low (i.e. the $A exchange rate was high) and sold when its price was high (i.e. the $A exchange rate was low). This would indicate that intervention has been in a stabilising direction. Alternative tests, such as those proposed by Wonnacott, provide support for this conclusion.

REFERENCES

Argy, V. (1982), "Exchange Rate Management in Theory and Practice", Princeton Studies in International Finance, No. 50, Princeton University.

Bank of England, (1983), "Intervention, Stabilisation, and Profits", Quarterly Bulletin 23: 384-391.

Baumol, W. (1957), "Speculation, Profitability, and Stability", Review of Economics and Statistics, Vol. 30: 263-271.

Corrado, C. and D. Taylor (1986), "The Cost of Central Bank Leaning Against a Random Walk", Journal of International Money and Finance, Vol. 5:303-314.

De Long, J. B., A. Shleifer, L.H. Summers and R.J. Waldman (1990), "Noise Trader Risk in Financial Markets", Journal of Political Economy, Vol. 98:703-738.

De Long, J. B., A. Shleifer, L.H. Summers and R.J. Waldman (1991), "The Survival of Noise Traders in Financial Markets", Journal of Business, Vol. 64:1-19.

Dominguez, K. (1989), "Market Response to Coordinated Central Bank Intervention", National Bureau of Economic Research, Working Paper No. 3192.

Feldstein, M. (1986), "New Evidence on the Effects of Exchange Rate Intervention", National Bureau of Economic Research, Working Paper No. 2052.

Flood, R. and R. J. Hodrick (1990), "On Testing Speculative Bubbles", Journal of Economic Perspectives, Vol.4: 85-101, Spring.

Fraser, B.W. (1992), "Australia's Recent Exchange Rate Experience", Reserve Bank of Australia Bulletin, June.

Frenkel, J. (1991), "The Making of Exchange Rate Policy in the 1980's", National Bureau of Economic Research, Working Paper No. 3539.

Friedman, M. (1953), "The Case for Flexible Exchange Rates", in Essays in Positive Economics. Chicago, University of Chicago Press.

Froot, K. and J. Frankel (1989), "Forward Discount Bias: Is It an Exchange Risk Premium", Quarterly Journal of Economics , Vol. 54: 139-161.

Humpage, O. (1991), "Central Bank Intervention: Recent Literature, Continuing Controversy", Federal Reserve Bank of Cleveland, Economic Review, Quarter 3: 2-13.

Humpage, O. (1984), "Dollar Intervention and the Deutschemark-Dollar Exchange Rate: A Daily Time Series Model", Federal Reserve Bank of Cleveland, Working Paper 8404.

Jacobson, L. (1983), "Calculations of profitability for U.S. Dollar-Deutsche Mark Intervention", Staff Study No. 131. Washington: Board of Governors of the Federal Reserve System.

Kearney, C. and R. MacDonald (1986), "Intervention and Sterilisation Under Floating Exchange Rates: the UK 1973 - 1983", European Economic Review, Vol. 30: 345 - 364.

Leahy, M. (1989), "The profitability of U.S. Intervention", International Finance Discussion Papers, No. 343. Board of Governors of the Federal Reserve System.

Macfarlane, I.J. (1993), "The Exchange Rate, Monetary Policy and Intervention", Reserve Bank of Australia Bulletin, December.

Mayer, H. (1982), "The Theory and Practice of Floating Exchange Rates and the Role of the Official Exchange Market Intervention", BIS Economic Papers, No. 5. Basel: Bank For International Settlements.

Mayer, H. and H. Taguchi (1983), "Official Intervention in Exchange Markets: Stabilising or Destabilising?" BIS Economic Papers, No. 6. Basel: Bank For International Settlements.

Murray, J., M. Zelmer and S. Williamson (1990), "Measuring the Profitability and Effectiveness of Foreign Exchange Market Intervention: Some Canadian Evidence", Bank of Canada Technical Report, No. 53.

Obstfeld, M. (1988), "The Effectiveness of Foreign Exchange Intervention: Recent Experience", National Bureau of Economic Research, Working Paper No. 2796.

Shleifer, A. and L.H. Summers (1990), "The Noise Trader Approach to Finance", Journal of Economic Perspectives, Vol. 4, No. 2: 19-33.

Spencer, P. (1985), "Official Intervention in the Foreign Exchange Market", Journal of Political Economy, Vol. 93: 1019-1024.

Taylor, D. (1982), "Official Intervention in the Foreign Exchange Market, or Bet Against the Central Bank", Journal of Political Economy Vol. 90: 356-368.

Telser, L. (1959), "A Theory of Speculation Relating Profitability and Stability", Review of Economics and Statistics Vol. 41: 295-301.

Weber, W. (1986), "Do Sterilised Interventions Affect Exchange Rates?" Federal Reserve Bank of Minneapolis, Quarterly Review, Vol. 10, No. 3: 14 - 23.

Wonnacott, P. (1982), "US Intervention in the Exchange Market for the DM, 1977-80", Princeton Studies in International Finance, No. 51, Princeton University.