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Assessing the Impact of Central Bank Intervention on Exchange Rate: New Evidence from Transfer Function Modeling

تأثير تدخل البنك المركزي على سعر صرف العملات: دليل جديد بواسطة نموذج دالة التحويل

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Abstract

Recently, only econometric models like GARCH and EGARCH investigated the instant effects of central banks interventions. In this paper, extended study for investigating and analyzing the dynamic effects is conducted using transfer function modeling. We investigate the effect of the Reserve Bank of Australia on the \$US/\$A exchange rate in the period 1983 -1997, which can be broken into four distinct phases. Equally, we investigate the changing effectiveness of daily intervention into various separate components. We rely on a new strategy implied by the transfer function modeling that outperforms the traditionally used EGARCH one. This methodology is considered a very important tool; it leads to evaluating the instant and dynamic effects in long term and for avoiding future economic shocks. As far as our knowledge, this is the first study investigating the effects of foreign exchange market interventions on the exchange rate by using the transfer function modeling.

Key words: central bank intervention, dynamic effects, time series outliers, transfer function modeling.

ملخص

تم في الأبحاث الحديثة، فحص التأثيرات اللحظية لتدخل البنوك المركزية في سعر الصرف بواسطة نماذج في الاقتصاد القياسي كالنموذج العام لاختلاف التباين المشروط للانحدار الذاتي (GARCH). ولكن من خلال هذا البحث تم فحص وتحليل كل من التأثيرات اللحظية والديناميكية على حد سواء بواسطة نموذج دالة التحويل (Transfer Function modeling)، لقد تم فحص وتحليل كل من التأثيرات اللحظية والديناميكية لسياسة تدخل البنك المركزي الأسترالي في سعر الصرف للدولار الأسترالي بالنسبة لسعر صرف الدولار الأمريكي في الفترة 1983-1997 باستخدام أسلوب جديد وهو نموذج دالة التحويل. ولقد تم إثبات أن هذا الأسلوب الجديد كان أفضل من نماذج الاقتصاد القياسي المستخدمة في هذا المجال، حيث أن استخدام تلك المنهجية الجديدة يعتبر أداة هامة في تقييم التأثيرات على المدى الطويل مما يساعد على تجنب الهزات الاقتصادية التي قد تحدث في المستقبل. وحسب علمنا، تعتبر هذه الدراسة هي الأولى من نوعها التي تعالج قضية فحص وتحليل تأثير تدخل البنوك المركزية على سوق سعر الصرف الأجنبي بواسطة استخدام نموذج دالة التحويل.

Introduction

Previous literature concerned with measuring the effects of interventions has given various results. Baillie and Osterberg (1997) find little evidence that the different types of intervention have had much effect on the conditional mean of exchange rate returns and some evidence that intervention is associated with slight increases in the volatility of exchange rate returns. Kim, Kortian and Sheen (2000) conclude that the effects of intervention can be destabilizing, with purchases of Australian dollars being associated with leaning against the wind phenomenon of depreciation of the Australian dollar and also increases in volatility. Morana and Beltvatti (2000) conclude that the intervention is not particularly effective, with the spot rate only changing in the intended direction for 50% of the time and that usually intervention is associated with increases in volatility. Dominguez (1998) analyzes a long time series of daily data in the context of various GARCH "generalized autoregressive conditional heteroskedasticity" specifications to conclude that interventions have a significant effect on the volatility, but the sign changes over time. Sometimes, interventions stabilize and some other times destabilize the exchange rate. Chang and Taylor (1998) use high frequency data on exchange rates and interventions for their analysis and conclude that intervention has a very short effect on volatility (almost all the empirical work with high frequency data has found that the intervention on any day is positively correlated to the conditional variance of exchange rate change for that day, or else uncorrelated). Humpage (2000) starts with the premise that while intervention may not have an effect on fundamentals, it may however, influence expectations. On using a non-parametric test suggested by Merton (Journal of Business, 1981), Humpage finds some evidence that intervention has value as a forecast that the previous day's exchange rate movements will be dampened today.

While there are a few ways to investigate the effect of central bank intervention on the exchange rate, a useful tool to study the effects of central bank intervention should reflect the effects of intervention on both current and expected future exchange rate. This property is important because interventions can have opposite effects on current and expected future exchange rate.

Commonly used tools for investigating the effect of central bank intervention on the exchange rate, such as some non-parametric statistics and "generalized autoregressive conditional heteroskedasticity", or GARCH, estimates, are not forward-looking. The non-parametric statistics is computed using only past values of the exchange rates. GARCH estimates of intervention effects are also calculated using a time series of past exchange rate changes. As a result, neither measure captures what the effect of an intervention is expected to be in the future.

In this paper, we will investigate the empirical effects of central bank interventions on the short run dynamics of the exchange rate of the Australian dollar against the US dollar. To this goal, we will rely on a quite new strategy, the transfer function model that yields a more appropriate tool for investigating the effects of the interventions on the exchange rates than the traditional GARCH approach does. Transfer function model is forward-looking because it measures the market's forecast of future exchange rate movement. As a result, it can capture both the immediate and longer term effects of central bank intervention. The transfer function model implies a more realistic dynamics of the persistence of the intervention shocks and we will support that by the data over all the periods under investigation.

We didn't use the Australian case from our point of view but Kim, Kortian and Sheen (2000), examine the key characteristics of foreign exchange intervention by the Reserve Bank of Australia (RBA) in the period 1983-1997 as an example.

The purpose of this paper is to assess the effects of central bank interventions on the exchange rates using the Transfer Function Modeling. We compare the results with those of the literature and henceforth assess the importance of relying on a more appropriate tool for investigating the effect of central bank intervention on the exchange rate.

The paper is organized as follows. Section 2 recalls the technical background of Transfer Function model. Section 3 presents the data. Section 4 tests the effects of central bank interventions for the exchange rate of the Australian dollar against the US dollar. Section 5 concludes.

The Transfer function model

In many cases, we may able to relate the response (i.e., the observed value) of one series to its own past values, and also to the past and present values of other time series. So, we consider a time series Yt is an output time series whose values may be related to one or more input time series Xt, for example, sales may be related to advertising expenditures; daily electricity consumption may be related to certain weather variable series such as maximum daily temperature or relative humidity or both.

For a single explanatory variable, the transfer function model is

$$Yt = C + B1\ Xt + Nt$$

where Y_t represents a stationary ARMA process. If we assume that the input and output variables are both stationary time series, the general form of the single-input, single-output transfer function model can be expressed as

$$Yt = C + [\omega (B) / \delta (B)] Xt + Nt \quad (1)$$

where Nt follows an ARMA model (i.e., Nt $=[\theta(B)/ \phi (B)]$ at) and

$\omega (B) = \omega0 + \omega1(B) + \omega2(B)**2 +\ldots\ldots\ldots+ \omega [s-1] (B)** [s-1]$

and $\delta (B) =1 - \delta1(B) - \delta2(B)**2 -\ldots\ldots..- \delta r (B)**r$.

(Liu, & Hudak, 1992-2000).

In practice, the number of terms in $\omega(B)$ is small and the value for r is usually 0 or 1. We can also represent the rational polynomial operator $\omega(B) / \delta (B)$ with a linear operator $\nu(B)$, where $\nu(B) = \nu 0 + \nu1B + \nu2B**2 +\ldots\ldots\ldots\ldots\ldots$.

The polynomial operators are related according to $\nu(B)= \omega(B)/\delta(B)$

Since we assume the transfer function is stable, the coefficients $\nu0$, $\nu1$, $\nu2$, diminish to zero regardless the order of the $\delta(B)$ polynomial. If the linear operator $\nu(B)$ is used, the model in (1) can be written as :

$$Yt = C + \nu(B) Xt + Nt \quad (2)$$

In the event that $\delta(B) =1$ (i.e., r = 0), we have $\nu(B) = \omega(B)$ and $\nu(B)$ has a finite number of terms. In the case that $\delta(B) \neq 1$ (i.e., r > 0), then $\nu(B)$ has an infinite number of terms.

The representation in (1) can be extended directly to the case of multiple-input transfer function model as :

$$Yt = C + [\omega1(B)/\delta1(B)] X1t +\ldots..+ [\omega m(B)/\delta m(B)] Xmt + Nt \quad (3)$$

We can also use the linear form of the transfer function by writing (2) as:

$$Yt = C + \nu1(B) X1t + \nu2(B) X2t +\ldots\ldots\ldots\ldots\ldots\ldots+ \nu m(B) Xmt + Nt \quad (4)$$

The values $\nu0$, $\nu1$, $\nu2$, …. are either referred to as the transfer function weights or the impulse response weights for the input series Xt (see chapter 9 of Box and Jenkins, 1970). These weights provide a measure of how the input series affects the output series, and the weight given to each time lag. That is $\nu0$, is a measure of how the current response is affected by the current value of the input series; $\nu1$ is a measure of how the current response is affected by the value of the input series one period ago; ν2 is a measure of how the current response is affected by the value of the input series two periods ago; and so on. The sum of all weights, usually represented by g, is called the steady state gain and represents the total change in the mean level of the response variable if we maintain the input at a single unit increase above its mean level.

There are three assumptions of the model in (2) which describes the transfer function between Xt and Yt (either in a linear form or as a rational polynomial):

1. The input series can affect the response variable, but not conversely (i.e., the relationship between Xt and Yt is unidirectional).
2. The input series is assumed to be independent of the disturbance.
3. The model is stable; this is usually manifested as assuming the input and output series are stationary time series, and that the sum of the transfer function (TF) weights is finite.

The assumption that the output series does not affect the input series is often appropriate for physical or engineering processes. In these cases the input may be viewed as a controller mechanism that is used to maintain a certain level in the response variable. If we model economic and business data, we may wish to use more dynamic models that allow for bi-directional (or feedback) relationships. Examples of such models include simultaneous transfer function (STF) models, vector ARMA models. However, although the assumption of a unidirectional relationship may not be strictly true, transfer function models can still be effectively in modeling business and economic data.

Note: There are some special cases of the transfer function model shown in (3).

1. If there are no explanatory variables, then the transfer function is the ARIMA model.
2. The intervention models can be obtained directly if all input series are binary series (that is, series consisting of only the values 0 and 1). (Liu, & Hudak, 1992-2000).

Data

In Australia, the Federal Reserve Bank is responsible for conducting interventions on the $US/$A exchange rate, since the floating of the currency in December 1983.

Kim, Kortian and Sheen (2000), examine the key characteristics of foreign exchange intervention by the Reserve Bank of Australia (RBA) in the period 1983-1997. They chose Nelson (1991)'s Exponential GARCH (1,1), with Student's t-distribution for standardized residuals, modeling strategy to model the effects of the Reserve Bank of Australia's foreign exchange intervention.

We will pursue this study using transfer function modeling strategy to investigate such an intervention policy and to assess the effects of the RBA interventions on the $US/$A exchange rate as an example of intervention policy impact evaluation. Comparing the results with those in their article.

We used for the analysis the same data used by them {we are very grateful to Kim, Kortian and Sheen for kindly providing the data}, the data consists of 3558 daily observations of the $US/$A exchange rate and the related information over the period December 1983 to December 1997. The Scientific Corporation Associate statistical system (SCA) program is used to analyze the data.

The available variables are defined as the following:

Exchange: the exchange rate is defined as the $US price of one unit of $A.

Nmp: the RBA intervention proxied by net market purchases of foreign currency, measured in $A billions.

Nint: negative intervention dummy variable that takes the value of one if the intervention occurs, and zero otherwise.

Pint: positive intervention dummy variable that takes the value of one if the intervention occurs, and zero otherwise.

Rint: reported intervention dummy variable that takes the value of one for the days of known intervention proxied by a report of such in the Australian Financial Review of the following day, and zero otherwise.

H: holiday dummy that takes the value of one for the day immediately after public holidays.

Di,t: daily dummy that takes the value of one for day i and zero otherwise.

Sint: Official statements dummy that takes the value of positive (negative) one for days of official statement suggesting the value of the $A should rise (fall), and zero otherwise.

Since the nature and aims of the Australia's intervention policy has not been uniform, Kim, Kortian and Sheen broke the period 1983-1997 into five distinct episodes and provided some key summary statistics for each as the following:

Period I: December 1983 to June 1986

Interventions during this immediate post-float period were characterized as operations where the Reserve Bank was engaged in 'smoothing and testing' of the market. The frequency of intervention was the highest (85%) and fairly evenly divided between purchases and sales of Australian dollars, however the average magnitude of transactions undertaken by the Bank was modest ($A 8 million). On less than 2% of the intervention days, there were official statements from either the RBA or the Commonwealth government regarding the undesirability of prevailing conditions in the foreign exchange market.

Period II: July 1986 to September 1991

The most noticeable shift in policy was the marked increase in the magnitude of interventions. The average absolute value of transactions jumped to $A 63 million. The fact that the Reserve Bank was pursuing a 'leaning against the wind' intervention policy, attempting to moderate rises in the currency during 1988 and the latter part of 1990, is evident in that 84% of the transactions during this period involved sales of the

Australian dollar. Interventions in support of the currency while less frequent, were considerably larger in magnitude, with the average value of sales. The largest defense of the currency (a purchase of $A 1026 million) occurred at the time of the October 1987 worldwide stock market crash.

Period III: October 1991 to November 1993

The Bank's presence in the market was considerably less frequent (approximately 1 out of or every 4 days), although the intensity of its intervention as measured by the average value of transactions ($A 145 million), was substantially higher. On 8.5% of its intervention days, the Bank put out a statement declaring its presence. The largest defenses occurred in August 1992. In the months leading up to that, the weakening world economy had reduced Australia's terms of trade, putting continuous downward pressure on the currency. The RBA preferred not to raise the cash rate in these circumstances (since real interest rates were perceived to be high, and the recovery of activity still nascent), and opted for intervention. This meant that the RBA needed to commit much larger volumes in defense of the currency.

Period IV: December 1993 to June 1995

In this time period RBA did not undertake any foreign exchange transactions and it constituted the longest period of inactivity for the Bank over the post-float period

Period V: July 1995 to December 1997

In July 1995, the Bank returned to the market undertaking foreign exchange transactions targeted specifically at retirement of the large swap positions built up during Period III (The RBA began to use, from the early 1990s, foreign exchange swaps as its main tool of sterilization so as to reduce disruptions in the domestic securities market, see Rankin, 1998). Thus, market transactions were motivated to take advantage of the strong $A to retire the bulk of its existing swap positions at favorable prices, rather than motivated by the aim to achieving specific goals. Accordingly, the frequency of official foreign exchange transactions undertaken in this period is not low, with nearly all the transactions involving moderate average sales ($A 40 million) of Australian dollars.

Transfer function modeling

Period I

From the plot of exchange series, ACF (autocorrelation function) of exchange decays exponentially, PACF (partial autocorrelation function) cuts off after one lag, and the EACF (extended autocorrelation function) of exchange series is considered. We concluded that the ARIMA model for exchange series is ARIMA (0,1,0), it fits the data, according to the results of ACF of residuals.

We used the linear transfer function method (LTF) to identify a transfer function model. Since there is no apparent seasonality in the data, we used an AR(1) approximation for disturbance term (Nt). We began the LTF method with 11 TF weights (i.e., the 0th through 10th lags inclusive), the model was

exchange t = C +[ν0 + ν1B +....+ ν10B**10]Nint t(binary,1)+[1/(1– ϕB)] at

When we estimated the model, our attention is drawn immediately to the estimate of the AR parameter. This value is 0.9978, approximately close to 1. Hence, we may conclude that we should employ differencing to achieve stationarity. We also confirmed this by computing the ACF of the estimated disturbance Nt, it was found decays exponentially. So, we considered the fitted model

(1-B) exchange t=C+[ν0+ν1B+......+ν10B**10]Nint t(binary,1)+[1/(1 –ϕB)]at

The constant term is insignificant (its t-value is -1.66).

Since the transfer function weights for the input variable negative intervention (nint) decays exponentially, therefore we need to incorporate the denominator polynomial δ(B) for the transfer function. Also when a set of estimated TF weights exhibits a die-out pattern, we can use the corner method to identify the orders in a corresponding rational transfer function ω(B)/δ(B), . Based on the corner method, we supported the idea that we need to incorporate the denominator polynomial δ(B). The EACF of the disturbance term is examined. Based of the above, we considered the model

(1-B) exchange t= ν0/(1- δB) Nint t(binary,1)+[1/(1 – ϕB)]at

This model has been estimated and fits the data, since all residuals sample autocorrelations are found within a 95% confidence limit of zero. This part of diagnostic checking reveals no model inadequacy. And the estimates are listed below (number in parentheses are the t-values of the estimates):

Table (1): Parameter estimates and t-values of the transfer function model for negative intervention in Period I.

Parameter	Estimate	Estimate with outlier adjustment
c	-0.0004 (-1.66)	-0.0002 (-1.15)
ν0	-0.0048 (-10.41)	-0.0040 (-12.11)
v1	-0.0058 (-9.81)	-0.0058 (-9.81)
v2	-0.0041 (-6.23)	-0.0026 (-5.39)
v3	-0.0031 (-4.38)	-0.0021 (-3.96)
v4	-0.0023 (-3.21)	-0.0014 (-2.64)
v5	-0.0015 (-2.04)	-0.0012 (-2.18)
v6	-0.0015 (-2.05)	-0.0012 (-2.29)
v7	-0.0013 (-1.90)	-0.0012 (-2.37)
estimated σa	0.0053	0.00383

From the estimation output with outlier and adjustment, the all types of outliers are detected at 30 positions: Additive Outlier, Innovational Outlier, Transient Outlier, and Level Shift (AO, IO, TC, and LS).

Also, we checked the adequacy of the proposed model by the cross correlation function (CCF), which is a measure of association between the currently observed values (or residuals) of one series with the values of another series at current and prior time periods. It was found that there is no significant cross correlation between the residuals of the input series and the residuals of the transfer function model, except for those attributable to sampling variation.

From the transfer function model of the exchange rate obtained for the negative intervention, we conclude that there is a significant impact of the RBA intervention in the same day in which the RBA intervenes and this impact continues, it decreases in an exponential manner and disappears after 7 days.

From table (1), we notice the negative sign of the parameter estimates. This means that the exchange rate moves in the desired direction for the intervention, that is, a sale of $A depresses its value.

The same modeling steps where carried out for the positive intervention (Pint) and the estimates were as the following:

Table (2): Parameter estimates and t-values of the transfer function model for positive intervention in Period I.

Parameter	Estimate	Estimate with outlier adjustment
c	-0.0004 (-1.48)	-0.0002 (-0.13)
ν0	0.0045 (7.14)	0.0033 (8.38)
v1	0.0052 (6.38)	0.0040 (7.74)
v2	0.0026 (4.46)	0.0032 (5.44)
v3	0.0036 (3.5)	0.0021 (3.31)
v4	0.0028 (2.68)	0.0020 (3.08)
v5	0.00020 (1.83)	0.00014 (2.06)
v6	insignificant	0.0013 (1.94)
estimated σa	0.00558	0.0035

and the estimates of v7, v8,v9,v10 are insignificant.

From the transfer function model of the exchange rate that was obtained for the positive intervention, we conclude that there is a significant impact of the RBA intervention in the same day in which the RBA intervenes and this impact continues, it decreases in an exponential manner and disappears after 6 days.

For holidays (H), all the estimates are insignificant. So, there is no effect.

For (News), all the estimates are insignificant, except the estimate for v1 = 0.0041 (2.01).

To verify the existence of the trading days effects, we assumed the TF weights for each input involve only the contemporaneous term. All the estimates are found insignificant. So, there is no effect.

And for reported intervention (Rint), the estimates with outlier detection and adjustment were as the following:

Table (3): Parameter estimates and t-values of the transfer function model for the reported intervention in Period I.

Parameter	Estimate
c	-0.0001 (-0.87)
v0	0.0062 (6.13)
v1	0.0071 (5.85)
v2	0.0049 (3.72)
v3	0.0063 (4.58)
v4	0.0060 (4.32)
v5	0.0053 (3.84)
v6	0.0039 (2.88)
v7	0.0035 (2.60)
v8	0.0047 (3.63)
estimated σa	0.0042

and the estimates of v9,v10, are insignificant.

From the transfer function model of the exchange rate that was obtained for the reported intervention, we conclude that there is a significant impact of the RBA intervention in the same day in which the RBA intervenes and this impact continues, it decreases in an exponential manner and disappears after 8 days.

From table (2), we notice the positive sign of the coefficients. This means that the reported intervention had an opposite impact that may suggest the market in general was speculating against the RBA.

While for official statement (Sint), all the estimates are significant except the estimates of v8 = 0.0005 (1.31), c=-0.0001(-0.79), and σa is 0.00379.

This indicates that market participants do appear to pay attention to official statements regarding the current direction of the exchange rate level.

Concerning net market purchase (Nmp) time series, its fitted model is ARIMA(1,0,0). we applied the transfer function model.

(1-B) exchange t=C+[ν0+ν1B+....+ν10B**10](1-B)Nmp t+[1/(1–ϕB)]at

the estimates are listed below (t-values in parentheses):

Table (4): Parameter estimates and t-values of the transfer function model for the net market purchases intervention in period I.

Parameter	Estimate
c	-0.0004 (-1.73)
ν0	0.0002 (13.43)
v1	0.0002 (12.04)
v2	0.0001 (4.98)
v3	0.0001 (4.98)
v4	0.0000637 (2.95)
v5	0.0000515 (2.38)
v6	0.0000627 (2.98)
v7	0.0000527 (2.47)
v8	0.0000412 (1.98)
estimated σa	0.0050389

and, the estimates of v9,v10 are insignificant. Whereas all these estimates with outlier detection and adjustment are significant except the estimates of v10 = -0.000001 (-0.09), c = -0.0004 (-2.22), and σa = 0.00376. This means that the effect of net market purchase disappears after 9 days.

We employ STEPAR paragraph to check if exchange rate and net market purchase series could be contemporaneously correlated. Based on the residual correlation matrices of the stepwise autoregressive fitting, we found the exchange and nmp series are contemporaneously correlated. However, we cannot determine which series is contemporaneously influenced by the other. To clarify that, we consider the reduced-form modeling for the system of equations. The following linear transfer function model is employed for the determination of differencing orders and subsequently for the identification of the model equation:

exchange t=C+[ν0 + ν1B +......+ ν6B**6](1-B)Nmp t+[1/(1 – ϕB)]at

The ARMA component of the model is fixed to AR(1) because the data is non-seasonal. The results of the model estimation indicate that we have to employ the differencing operator (1-B) to achieve stationarity, since the AR parameter is 0.998. So, the model will be

(1-B) exchange t=C+[ν0 + ν1B +......+ ν6B**6](1-B)Nmp t+[1/(1 – ϕB)]at

The results of model estimation indicate that net market purchase series at lags 1 and 2 is positively related to exchange series.

The same modeling steps where carried out for the next equation

(1-B) nmp t=C+[ν0 + ν1B +......+ ν6B**6](1-B) exchange t+[1/(1 – ϕB)]at

The results of the model estimation indicate that exchange series is related to net market purchase series at lags 1 and 2.

We combined the two equations to be estimated jointly using STFMODEL paragraph and SESTIM paragraph.

Based on the summary for simultaneous transfer function model, the estimates of net market purchase series and their t-values show that net market purchase series is related to exchange series at lag 1 and exchange series is related to net market purchase series at lag 1. We performed diagnostic check by examining the cross correlation matrices of the residual series using CCM paragraph. From the output, we can see that the residuals are clean with only trace correlations at lags 1, 5, and 8 of the CCM. So, we can be sure that there is no large correlation remaining between the residual series.

Based on the reduced-form model building shown above, we found that net market purchase series is related to exchange rate series at lag 1 and also exchange series is related to net market purchase series at lag 1 when a contemporaneous relationship is not considered. As a result, it is more logical to think that exchange rate series may be influenced by net market purchase series contemporaneously.

To clarify that, we considered the structural-form model using the same procedures used in the reduced-form model. The model is:

(1-B) exchange t=C+[ν0 + ν1B +......+ ν6B**6](1-B) nmp t+[1/(1 − ϕB)]at

From the summary for simultaneous transfer function model, we found that there is indeed a contemporaneous relationship between exchange rate and net market purchase series. The cross correlation matrices of the residual series pass the diagnostic check although there is a spurious correlation at lag 1,5,8 .

Period II

The estimates with outlier detection and adjustment are as the following:

For negative intervention (nint):

Table (5): Parameter estimates and t-values of the transfer function model for the negative intervention in period II.

Parameter	Estimate
c	0.0009 (1.15)
ν0	-0.0041 (-11.45)
v1	-0.0053 (-12.46)
v2	-0.0042 (-9.31)
v3	-0.0032 (-6.53)
v4	-0.0020 (-5.77)
v5	-0.0020 (-3.97)
v6	-0.0019 (-3.78)
v7	-0.0011 (-2.20)
estimated σa	0.0032

and the estimates of v8,v9,v10 are insignificant.

For positive intervention (pint):

Table (6): Parameter estimates and t-values of the transfer function model for the positive intervention in period II.

Parameter	Estimate
c	0.0004 (3.55)
ν0	0.0020 (8.45)
v1	0.0024 (8.54)
v2	0.0019 (6.05)
v3	0.0009 (2.78)
estimated σa	0.00335

and all the rest of v 's are insignificant.

For holidays (H): all the estimates are found insignificant.

And for net market purchase (nmp):all the estimates of v's are significant, except the estimate of v10 =0.0000021 (1.83), it may be considered slightly significant according to its t-value, the estimate of c =0.0004 (4.32), the estimate of σa =0.00324.

From the estimation output with outlier and adjustment, the all types of outliers are detected at 65 positions (AO,IO,TC, and LS).

For (News), all the estimates are insignificant, except the estimates of v2 =0.0026 (2.22), v8 = 0.0028 (2.36), v9 = 0.0022 (2.12), c = 0.0004 (4.23),and σa = 0.0033.

To verify the existence of the trading days effects, we assumed the TF weights for each input involve only the contemporaneous term. All the estimates are found insignificant. So, there is no effect.

And for reported intervention (Rint), the estimates are as the following:

The estimates of c = 0.0004 (4.00), v0,v1,v2,v3 are significant , σa = 0.003237.

While for official statement (Sint), all the estimates are significant except the estimates of v8 and v9, the estimates for c and σa are 0.0004 (3.69) and 0.003294 respectively.

Period III

The estimates with outlier detection and adjustment are as the following:

For negative intervention (nint): all the estimates are found significant, except the estimates of v8, v9 and v10 are insignificant and the estimate for σa = 0.002689.

From the estimation output with outlier and adjustment, the 17 outliers are detected at t = 25,473,614, and 667 (AO-type), t = 44, 98, 541, 565, and 612 (IO-type), t = 260,270,432,491,523, and 731 (TC-type), and t = 629 and 680 (LS-type).

For positive intervention (pint): all the estimates are found insignificant, except the estimate of v0=0.0007 (1.83), it is slightly considered significant.

From the estimation output with outlier and adjustment, the 18 outliers are detected at t = 25,473,522 (AO-type), t = 44, 98, 464, 541, 565, 612, 680 (IO-type), t = 260,270,417,432,614, 672, and 731 (TC-type), and t = 629 (LS-type).

For holidays (H): all the estimates are found insignificant.

And for net market purchase (nmp): all the estimates of's are significant, except the estimates of v9 and v10, the estimates for c=-0.00008 (-0.84) and for σa = 0.00274.

From the estimation output with outlier and adjustment, the 13 outliers are detected at t = 417 and 522 (AO-type), t = 473 and 629 (IO-type), t = 270,432,614, and 731 (TC-type), and t = 44, 98, 541, 565, and 612 (LS-type).

For (News), all the estimates are significant, the estimates for c= -0.0028 (-1.36) and for σa = 0.00413.

To verify the existence of the trading days effects in this period, we find new results: the estimates for Monday=0.0009(1.94), Wednesday=0.0010 (2.35), and Friday= -0.0009(-2.47). This means that the Monday and Wednesday dummies are significant and are positive in sign, whereas the Friday dummy is significant but it is negative in sign. It suggests a depreciation of the $A on Fridays. This may be due to the fact that Friday is the last day of the business week.

From the estimation output with outlier and adjustment, only one outlier is detected at t = 25 (AO-type).

For reported intervention (Rint), all the estimates are significant, the estimates for c= -0.0005 (-0.64) and for σa = 0.00413.

And for official statement (Sint), all the estimates are significant, the estimates for c= -0.000079 (-0.06) and for σa = 0.0705.

Period V

The estimates with outlier detection and adjustment are as the following:

For negative intervention (nint): all the estimates are found insignificant, except the estimate of v4=0.0065 (2.06), it is found slightly significant, the estimates for c= -0.0001 (-0.84) and for σa = 0.00301.

But the interesting thing is that the estimates for (v0, v1, v3, v4, v5, v6) without outlier detection and adjustment are significant. This demonstrates the important role of outliers in time series analysis.

For positive intervention (pint): all the estimates are found insignificant, except the estimate for v0 = 0.0007 (1.83), it is slightly considered significant.

For holidays (H): all the estimates are found insignificant.

And for net market purchase (nmp): the estimates for v5, v6, v7, v8, v10 are insignificant, and the others are significant. The estimates for c= -0.00008 (-0.84) and for σa = 0.00274.

For (News), the estimates of (v0, v1, v2, v3, v4, v5) are significant, and the others are not. The estimates for c= -0.0093 (-0.79) and for σa = 0.04138.

To verify the existence of the trading days effects, we find all the estimates are insignificant. So, there is no effect.

While for official statement (Sint), the estimates of (v0,v1,v2,v3) are significant, The estimates for c= -0.000077 (-0.67) and for σa = 0.002791.

Based on our analysis, we can conduct a comparison between our results and Kim, Kortian and Sheen's results concentrating on the main points:

We know that the average absolute value of transaction in Period I is $US 8 million compared with $US 56 million for the whole period (all periods), and so, one can realize that purchase or sale of foreign exchange would have a big impact on the exchange rate in this period.

It is obvious from the output, concerning negative intervention (nint), positive intervention (pint) and net market purchase (nmp) by RBA, that there is a significant impact of the RBA intervention in the same day in which the RBA intervenes and this impact continues for several periods (days) [approximately 7- 9 days], the impact exists significantly and decreases in an exponential manner. This result in accord with Kim, Kortian and Sheen's result, but through our analysis, using simultaneous transfer function modeling, we had a clear idea about the contemporaneous effect due to simultaneity between the exchange rate returns and intervention, and after how many periods (days), the intervention impact will disappear.

In Kim, Kortian and Sheen's article, they address that a negative coefficient indicates that the exchange rate moves in the desired direction for the intervention, that is, a sale of $A depresses its value. This is in accord with our results which shows that the estimates of negative intervention (from to) are significant and have negative coefficients for periods I,II, III. Whereas for period V, all the estimates with outlier detection and adjustment are found insignificant, except for v4 = 0.1165 (2.06), it is found slightly significant, the estimate for $\sigma a = 0.00301$. But the interesting thing is that the estimates for (v0, v1, v3, v4, v5, v6) without outlier detection and adjustment are significant, the estimate for $\sigma a = 0.0036$. This demonstrates the important role for outlier detection and adjustment.

Some seasonal dummy variables contribute to the modeling of the daily exchange rate return behavior. Kim, Kortian and Sheen find that the Wednesday and the holiday (H) dummies are significant in more than one periods. All significant coefficients are positive in sign suggesting an appreciation of the $A on these days. In contrast to Kim, Kortian and Sheen's result, we did not find any significant effect for trading day variation and the holiday dummies for all periods, except for period III. I found an interesting result, the Monday and Wednesday dummies are significant and are positive in sign, whereas the Friday dummy is significant but it is negative in sign. It suggests a depreciation of the $A on Fridays. This may be due to the fact that Friday is the last day of the business week.

For period III, Kim, Kortian and Sheen test whether the RBA was successful in substituting of monetary policy imperatives by intervention instrument, and they find that it was not. Our results are in accord with that, for positive intervention (pint) as example: all the estimates are found insignificant, except v0 = 0.0007 (1.83), it is slightly considered significant. This result supports that the RBA was unsuccessful in substituting of monetary policy imperatives by intervention instrument.

Kim, Kortian and Sheen find that the reported intervention (rint) dummy is negative for period I and II, suggesting that known interventions move the $A in the right direction, and they find for period III, reported interventions had an opposite impact that may suggest the market in general was speculating against the RBA, and so the positions taken against the known intervention exceeded the amount of intervention for the day. In contrast to Kim, Kortian and Sheen's result, our results show that the reported intervention (rint) dummy is positive for periods I, II, suggesting that known interventions do not move the $A in the right direction. Whereas the reported intervention dummy is negative for period III, suggesting that known interventions move the $A in the right direction.

Kim, Kortian and Sheen find that the official statement (sint) dummy is positive in general but significant only for period I. This indicates that market participants do not appear to pay attention to official statements regarding the current direction of the exchange rate level. Our results show that official statement (sint) dummy is positive for periods I, II, V and significant. But for period III, it is negative and significant. This indicates that market participants sometimes appear to pay attention to the official statements regarding the current direction of the exchange rate.

Kim, Kortian and Sheen find that the release of official information (news) regarding RBA's position on foreign exchange market conditions did not have any effect, except a significant and positive effect in period II, in which one of the stated aims of the intervention was to signal to the market the RBA's position on the current direction of the exchange rate. This will add more uncertainty to the market undetermining the purpose of information release. It is leading to higher daily volatility. Our results show that official information (news) have a significant and positive effect for periods II, III and V.

Table (7): Results of the EGARCH (1,1) and the transfer function modeling.

The effect of*	EGARCH(1,1)	Transfer function modeling
Negative intervention	negative	negative (I,II,III) **
Positive intervention	positive	positive (I,II)
Net market purchase	positive (I,II,III)	positive (I,II,III,V)
Holiday	positive (V)	no effect
Monday	no effect	positive (III)
Wednesday	positive (I)	positive (III)
Friday	no effect	negative (III)
Reported intervention	negative(I,II)	positive (I,II), negative(III)
Official statement	positive (I)	positive (I,II,V), negative (III)
News	positive(II)	positive(II,III,V)

* The effect exists significantly and is diminishing in exponential manner.

** Periods.

Concluding comments

- The effects of intervention can be destabilizing, with purchases of Australian dollars (local currency) being associated with leaning against the wind phenomenon of depreciation of the

Australian dollar. But in general, we have found evidence that the Reserve Bank of Australia has had some success in its foreign exchange intervention policy.

- Intervention effects can moderate the exchange rate process change compared with what would have occurred in its absence.
- The case study using real data treated economic questions, in particular, intervention policies acted by Federal Reserve Bank of Australia when financial market changes occurred.
- By adopting the transfer function modeling strategy as a parametric approach with outlier detection and adjustment for evaluating the impact intervention policy, we achieved the goals in obvious and flexible way. Also we got more accurate results. The idea here is: that by using the Kim, Kortian and Sheen's method, we can only find the instant effects of the central bank interventions and we can't do anything about the dynamic effects , but by using the transfer function modeling strategy as a parametric approach we can evaluate the instant and dynamic effects in long term and make any necessary forecasts.
- By this study, we added a new empirical evidence on the impacts of foreign exchange interventions acted by the Federal Reserve Bank of Australia by using transfer function modeling that is forward-looking. It will capture both the immediate and longer term effects of intervention.
- This paper added a considerable methodology for the treatment of time series modeling in the presence of outliers. This methodology is considered a very important tool; it leads to evaluating the instant and dynamic effects in long term and for avoiding future economic shocks.

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