Assessing the impact of central bank intervention on exchange rate: New evidence from intervention modeling

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Abstract: *Recently, only econometric models like GARCH and EGARCH investigated the instant effects of central banks interventions. Humpage (2000) investigates the intervention policy of the Federal Reserve Bank of the USA in the period 23 September-31 December, 1985 by using a non-parametric test suggested by Merton (Journal of Business, 1981). In this paper, I rely on a new strategy implied by the intervention modeling that outperforms the used non-parametric test 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 my knowledge, this is the first study investigating the effects of foreign exchange market interventions on the exchange rate by using the intervention modeling.*

Keywords: Central bank intervention, dynamic effects, time series outliers, intervention modeling.

ملخص: *تم في الأبحاث الحديثة، فحص التأثيرات اللحظية لتدخل البنوك المركزية في سعر الـصرف بواسطة نماذج في الاقتصاد القياسي كالنموذج العام لاخـتلاف التبـاين المـشروط للانحـدار الـذاتي (GARCH) والنموذج المطور (EGARCH).*

لقد فحص Humpage التأثيرات اللحظية لسياسة تدخل البنك المركزي الأمريكي في سـعر الـصرف للدولار في الفترة 31/10/1985 - 9 باستخدام أسلوب اختبار لا معلمي اقترحه Merton عام 1981.

ولكن من خلال هذا البحث تم فحص وتحليل كل من التأثيرات اللحظية والديناميكية لسياسة تـدخل البنـك المركزي الأمريكي على حد سواء بواسطة نموذج دالة التدخل intervention modeling ولقـد تـم إثبات أن هذا الأسلوب الجديد كان أفضل من نماذج الاقتصاد القياسي المستخدمة في هذا المجال، حيث أن استخدام تلك المنهجية الجديدة (الطريقة المعلمية) يعتبر أداة هامة في تقييم التأثيرات على المدى الطويل مما يساعد على تجنب الهزات الاقتصادية التي قد تحدث في المستقبل. و حسب علمنـا، تعتبـر هـذه الدراسة هي الأولى من نوعها التي تعالج قضية فحص وتحليل تأثير تدخل البنوك المركزية علـى سـوق سعر الصرف الأجنبي بواسطة استخدام نموذج دالة التدخل.

Introduction

Intervention in the foreign exchange market is generally defined as the official purchases and sales of foreign currencies that the monetary authorities of a country undertake to influence a future currency movements. 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, I will investigate the empirical effects of central bank interventions on the short run dynamics of the exchange rate of the US dollar against the foreign currency. To this goal, I will rely on a quite new strategy, the intervention modeling that yields a more appropriate tool for investigating the effects of the interventions on the exchange rates than the non-parametric statistics approach does.

The purpose of this paper is to assessing the effects of central bank interventions on the exchange rates using the Intervention Modeling. I 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 Intervention model. Section 3 presents the data. Section 4 tests the effects of central bank interventions for the exchange rate of the US dollar against the foreign currency. Section 5 concludes.

The Intervention model

Time series are often affected by various external events such as political or economic policy changes, technological changes, sales promotions, advertising, and so forth. These external events are commonly known as interventions.

If a time series was subjected to an intervention at a particular time period, say T, its effect in changing the mean level of the series as determined by using a two-sample t-test. The mean level in the pre-intervention period was contrasted with that after the intervention occurred. Box and Tiao (1965) showed that the t-test is not appropriate in the case of serially correlated data. (Available procedures such as a Student's t test for estimating and testing for a change in mean have played an important role in statistics for a very long time. However, the ordinary t test would be valid only if the observations before and after the event of interest varied about means $\mu 1$ and $\mu 2$ not only normally and with constant variance but independently). Moreover, an intervention may not be a step change, which is the basic assumption of the two-sample t-test.

Box and Tiao (1975) provided a procedure for analyzing a time series in the presence of known external events. In their approach, a time series is represented by two distinct components: an underlying disturbance term, and the set of interventions of the series. In the case of a single intervention,

the form of the intervention model is:

$$Yt = C + [\omega(B)/\delta(B)]\, It + Nt$$

It is a binary indicator vector (that is, a vector assuming the values 0 or 1) that defines the period of the intervention. The term ω(B)/δ(B) is a characterization of the effect(s) of the intervention. The term Nt is called the disturbance, which can expressed as:

$$Nt = Yt - C - [\omega(B)/\delta(B)]\, It$$

Nt may be modeled as an ARIMA process. In the case that there are no exogenous events, then the model for Yt reduces to the ARIMA models.

An indicator variable representing an intervention that takes place for one time period only is called a pulse function. It is usually represented as Pt**T, where T is the time that the intervention occurs (i.e., has the value 1). An indicator variable representing an intervention that remains in effect beginning from a particular time period is called a step function. The variable is usually represented as St**T, where T is the time that the intervention begins. The response to an intervention is characterized by the rational polynomial ω(B)/δ(B).

The operator in the numerator, ω(B), represents the impact(s) of the intervention and the length of time (delay) it takes the impact(s) to be reflected in the time series. For example, the effect of a strike may only be in the time period in which it occurred, while the effect of an advertising campaign may affect the current time period and have a residual effect on the next period. Hence we may use the characterization ω(B)= ω0 to indicate a contemporaneous effect; ω(B)= ω1(B) to describe an effect not felt until the next time period; or ω(B)= ω0+ ω1(B) to describe an event that affects the measured response in both the current and next time period.

The operator in the denominator, δ(B), represents the way in which an impact dissipates. In most cases, the δ(B) of an intervention model is a low order polynomial, for example, δ(B) =1 – δ1(B).

If an intervention has a relatively long term residual effect (or growth pattern), then the value of δ1 will be moderate to large. However, if the effect is short term, then the value of δ1 will be small. In an extreme case, the intervention may not have any residual effect. In such a case, we have δ1=0.

To summarize, the rational polynomial ω(B)/δ(B) consists of the operators:
ω(B)= ω0+ ω1(B)+ ω2(B)**2+……+ ω[s-1](B)**[s-1]
and δ(B) =1 – δ1(B)- δ2(B)**2-……..- δr(B)**r. However, in practice ω(B) usually consists of only a few terms (often no more than 1 or 2 terms) while δ(B) usually can be represented as either δ(B) =1 or δ(B) =1 – δ1(B).

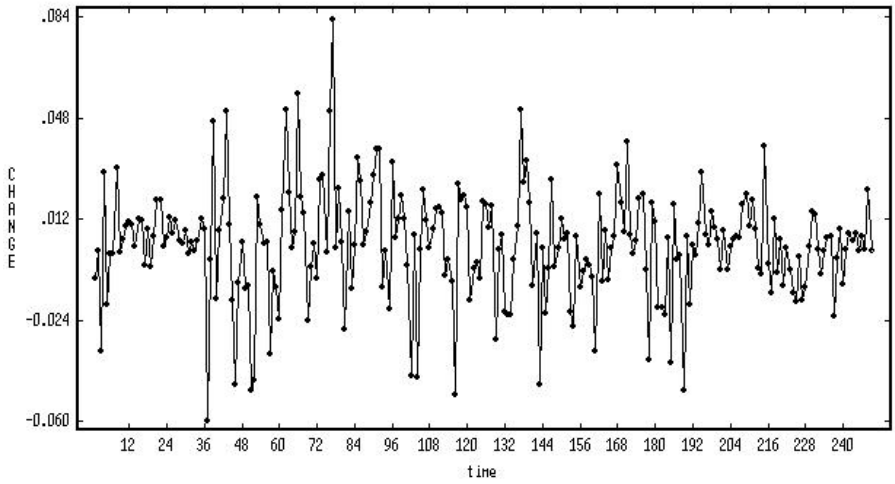
Finally, an intervention can be described equally well be either a pulse or a step function because there is an exact relationship between a step and a pulse function. That is, (1-B) St**T = Pt**T.

This intervention model can be directly extended to include more than one

interventions. And we know that the intervention model is considered as a special case of transfer function model.

Data

Humpage (2000) finds some evidence that intervention policy of the Federal Reserve Bank has value as a forecast that the previous day's exchange rate movements will be dampened today. He achieved this evidence by using a non-parametric test suggested by Merton (Journal of Business, 1981). His work depends on determination of the number of successful interventions. He defined the successful intervention in terms of four specific criteria. The first success criterion presumes that US monetary authorities sell or purchase foreign exchange when they expect the spot exchange rate to appreciate or depreciate, respectively. Accordingly, under this criterion, w1st equals one - indicating a success - whenever an official US sale of foreign currency is associated with a dollar appreciation:
w1st = 1 if It > 0 and Δ St > 0, w1st = 0 otherwise.
He defines w1bt, analogously for official US purchases of foreign exchange:
w1bt =1 if It < 0 and Δ St < 0, w1bt = 0 otherwise.



Change[difference between the closing (16:00 pm)and the morning opening (09:00h) German marks per dollar, bid quotations in the NY market over the period from 3 January-31 December 1985] time series of Humpage's data.

In these expressions, It is the official US intervention on day t, with positive (negative) values indicating sales (purchases) of foreign exchange. The exchange rate change is given as: Δ St =SPMt - SAMt , where SAMt

and SPMt are the morning opening (09:00 h) and afternoon closing (16:00 h) bid quotations, respectively, taken from the New York market.

I pursued Humpage's work for determining the number of successful interventions for the Plaza period: 23 September-31 December, 1985 under the above criterion. He found 6 out of 14 interventions being considered as successful mark purchases.

I used a new strategy (the intervention modeling strategy) for determining the successful interventions for the same data I am very grateful to Owen F. Humpage for kindly providing the data.

Intervention modeling

Based on the ACF (autocorrelation function), PACF (partial autocorrelation function) and EACF (extended autocorrelation function) of change series (a time series of the difference between the closing (16:00 pm) and the morning opening (09:00 h) German marks per dollar, bid quotations in the NY market) over the period from 3 January-31 December 1985, an ARIMA (1,1,0) model for\ change series is selected. Accordingly to the known Federal Reserve Bank interventions, the following intervention time series model is found to be appropriate to describe the intervention events under consideration:

$$(1 - \phi B)(1 - B)\text{change}_t = \text{const} + \omega_i \, \text{Pit**T} + a_t,$$

where Pit**T =1 if t = the known intervention date and Pit**T = 0 otherwise.

intervention parameters to be estimated, and i = 1,2,.....,14. ωi

Using the exact maximum likelihood, with outlier detection and adjustment, the following estimates of the model are obtained [by using the Scientific Corporation Associate statistical system (SCA) program]:

parameter	estimate	standard error	t-value
ω1	-0.0142	0.0130	-1.09
ω2	0.0309	0.0152	2.03
ω3	0.0335	0.0151	2.22
ω4	-0.0027	0.0151	-0.18
ω5	-0.0005	0.0150	-0.03
ω6	0.0266	0.0151	1.77
ω7	0.0171	0.0151	1.13
ω8	0.0138	0.0160	0.86
ω9	0.0016	0.0184	0.09
ω10	-0.0059	0.0160	-0.37
ω11	0.0027	0.0130	0.21
ω12	0.0282	0.0151	1.87

ω13	0.0388	0.0151	2.57
ω14	0.0283	0.0131	2.17
ϕ	-0.6492	0.0491	-13.22

Parameter estimates, the standard error, and t-values of intervention time series model for Humpage's data

From the estimation output with outlier and adjustment the nine outliers are detected at t = 37,46,62,116, and 137 additive outliers (AO-type), t = 43 and 53 innovational outliers (IO -type), t = 66 and 76 transient change outliers (TC-type) that might be caused fluctuations in the exchange rate market.
Based on this results, one can see that we have only four intervention successes that are significant (their t-values > 2.0), plus two interventions with (t-values ≥ 1.77). So, we can say that we have approximately 6 interventions, four of them are significant, but the other two interventions are slightly significant. Whereas Humpage determines the same 6 significant intervention\ successes using a specific success criterion as a special non-parametric test. So, we got approximately the same result. But the idea here is: that by using the Humpage's method, we can only find the instant effects of the central bank interventions and we can't do anything about the dynamic effects (he doesn't use any model), but by using the intervention modeling strategy as a parametric approach we can evaluate the instant and dynamic effects in long term.
Therefore, by using the intervention modeling strategy as a parametric approach, we may be able to determine the number of intervention successes more accurately and make any necessary forecasts.

Concluding comments

1) I used the intervention modeling strategy for determining the successful interventions for the Humpage's data. This strategy gives encouraging results as compared to other strategies such as special non-parametric tests.

2) The encouraging results of this empirical study show that the strategy of the intervention modeling is reliable to use in evaluation of the intervention policy impact in many practical fields in real life.

3) The case study using real data treated economic questions, in particular, intervention policies acted by Federal Reserve Bank of the USA when financial market changes occurred.

4) 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.

5) The effects of intervention can be destabilizing, with purchases of US dollars (local currency) being associated with leaning against the wind phenomenon of depreciation of the US dollar and also increase in volatility. But in general, I have found evidence that the Reserve Bank of the US has had some success in its foreign exchange intervention policy.

6) By adopting the intervention modeling strategy as a parametric approach with outlier detection and adjustment for evaluating the impact intervention policy, I achieved the goals in obvious and flexible way. Also I got more accurate results.

7) So, by this study, I added a new empirical evidence on the impacts of foreign exchange interventions acted by the Federal Reserve Bank of\ the US by using intervention modeling.

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