The De Facto Flexibility/Fixity of Exchange Rates: A Simple Intervention Measure

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Abstract

This paper provides a foreign exchange intervention coefficient, constructed by change in exchange rates and the overall balance account, to measure a government's degree of intervention. Based on the estimated intervention coefficients there exists a tendency for severe intervention to become popular after the end of the 1990s. With findings from the intervention coefficient, comparisons with those countries which release their official intervention data and with several countries each adopting a distinct exchange rate regime indicate that our measure satisfactorily captures the flexibility of one country's exchange rate policy. The intervention coefficient therefore allows us to conduct close-to-reality intervention-related studies even if lacking intervention data.

JEL Codes: F31; F33

Key Words: intervention coefficients; exchange rate flexibility; monetary policy

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I. INTRODUCTION

Though economic theories of a floating exchange rate are distinct from those of a fixed exchange rate, in reality even the most representative float (the United States) changes its foreign reserves to intervene in the foreign exchange market. Thus it is not surprising to find that in using exchange rates of floats after the breakdown of Bretton Woods, no fundamental model of a floating exchange rate outperforms a time series model. Official intervention is one characteristic of the foreign exchange market that distinguishes it from any other asset market. Therefore, in order to choose a suitable economic theory to model the dynamics of exchange rates, we should ask the question: Do we really know how floating are "floats" and how fixed are "pegs" before we build a model of their exchange rates?

A large majority of studies that analyze the evolution of exchange rates follow the official exchange rate regime classification of the International Monetary Fund (abbreviated as IMF), yet Calvo and Reinhart (2002) and Levy-Yeyati and Sturzenegger (2005) consider whether the exchange rate regime announced by a government is consistent with the actual policy it adopts and conclude. The former authors find "fear of floating," where more and more nominal floats intervene, while the latter find "fear of pegging," where many *de facto* pegs shy away from an explicit commitment to a fixed case. Reinhart and Rogoff (2004) even argue the IMF official classification of exchange regimes as being "only a little better than random." There are many researchers who place efforts on re-classification based on de facto exchange rate policies (see Bubula and Ötker-Robe, 2002 for the survey). Actually, there is a variety of intermediate exchange regimes between a clean float and a peg, and it is not always easy to clearly classify a country as being a specific category or another.

Table 1 presents four previous studies of exchange rate classification in order to show the difficulty in categorization. In the table we first compare the *de jure* classification by

Ghosh, Gulde and Wolf (2002) (abb. GGW) with three works of the de facto classification: Bubula and Ötker-Robe (2002) (abb. BOR), Levy-Yeyati and Sturzenegger (2005) (abb. LYS), and Reinhart and Rogoff (2004) (abb. RR). According to the degree of intervention defined in these articles, we simplify their exchange rate regimes into four categories: (1) peg, (2) crawling peg, (3) managed float, and (4) float for comparison. The details about these categories are in Appendix 1. Panel A of Table 1 shows a big discrepancy between the de jure and the de facto classifications. Of the four categories, the fixed exchange rate regime appears to be the one having the strongest consensus, while the intermediate and float categories are largely controversial. Panel B of Table 1 compares Reinhart and Rogoff's (2004) de facto classification with the other de facto classifications of Levy-Yeyati and Sturzenegger (2005) and Bubula and Ötker-Robe (2002). Again, the fixed case is much easier to be identified than the intermediate and floating cases.

Instead of classifying one country into a specific exchange rate regime, for example, a "soft peg" or a "managed float," over a fixed time period and getting one observation of a discrete category index, this article tries to estimate the extent of official intervention as a time series over the sample period. Several studies construct continuous flexibility indices in relevant researches of exchange rate regimes. Calvo and Reinhart (2002) define an exchange rate flexibility index as the variance of the exchange rate to the sum of nominal interest variance and real monetary base variance and find that many economies claiming themselves as floats during 1970-1999 have had a flexibility index well below those of three benchmark floats: the United States, Japan, and Australia. Hausmann, Panizza and Stein (2001) find a strong relationship between the ability of a country to borrow internationally in its own currency and the degree of flexibility during the sample period of 1997-1999. There are four flexibility measures in their paper, with the most interesting defined as the ratio of the standard deviation of the rate of depreciation to the standard deviation of the stock of

reserves that are divided by the dollar value of the stock M2. Holden, Holden and Suss (1979) use the ratio of summed absolute values of percentage changes in the exchange rate to summed absolute changes in foreign reserves divided by the sum of their imports and exports between 1974 and 1975, to study the determinants of exchange rate flexibility. Weymark (1995, 1997, and 1998), on the other hand, builds a structural model for Canada and measures intervention by the proportion of foreign exchange market pressure relieved by foreign exchange market intervention. However, her index construction is model-dependent and country-specific, and thus application to a cross-country study is unfeasible.

The common criticism for the studies based on quantitative analysis is their lack of economic theory. Since no individual variable itself can be used to measure flexibility or fixity, there must be a multivariate indicator for measurement. What is the weight for each variable in the indicator? More to the point, what is the functional form for the indicator? Empirically, net purchases of a particular currency appear to be associated with a subsequent depreciation of this currency, and a "leaning against the wind" hypothesis for official intervention has therefore been supported (see, Longworth, 1980; Hutchison, 1984; Almekinders and Eijffinger, 1991; Baillie and Osterberg, 1997; Humpage, 1999; and Beine, Bénassy-Quéré and Lecourt, 2002).[1] Lai, Hsiao and Chang (1985) and Djajic and Bazzoni (1992) have a formula for describing "the leaning against the wind" operation of central bank intervention under a managed float. The coefficient to reflect the degree of central bank intervention in the foreign exchange market is defined as the negative ratio of change in foreign reserves to change in exchange rates. The index of Holden, Holden and Suss (1979) appears to share the same idea as Lai, Hsiao and Chang (1985) and Djajic and Bazzoni (1992).

Once we have developed the time series of intervention, we are able to analyze the

[1] Leaning-against-the-wind refers to intervention aimed at stabilizing the value of a particular currency.

evolution of the degree of intervention. Many interesting issues can thereby be investigated, such as the effectiveness of official intervention, the interaction between a central bank's intervention and its conventional monetary policy on changing the exchange rate, or real side topics: whether the exchange rate regime matters for business cycles, inflation performance, economic growth, a currency crisis, etc. In an available appendix of this paper, we apply the intervention index to investigate the effectiveness of official intervention for countries without intervention data.

Following this introduction, Section II explains how to construct the intervention degree coefficient and shows some important characteristics of it: there exists no pure float since the breakdown of the Bretton Woods System, and a tendency for severe intervention becomes popular after the end of the 1990s. Furthermore, our intervention indicator appears to capture the flexibility of one country's exchange rate policy, such as floating, currency board, crawling peg, and freely falling. Comparisons between the official intervention and our IC for the United States, Germany, Japan, and Australia are made as well. The last section presents our conclusions for the study.

II. MEASURING THE INTERVENTION DEGREE

Previous studies of exchange rate policy, like Lai, Hsiao and Chang (1985), as well as Djajic and Bazzoni (1992), describe the "leaning against the wind" approach of central bank intervention under a managed float as:

$$\Delta e = -\eta \Delta FR, \tag{1}$$

where e is the exchange rate and FR is the foreign reserves. It is easy to show that in a fixed exchange rate case, $\eta \to 0$ holds, and in a floating exchange rate case, $\eta \to \infty$ is true. Between the two extremes, a greater floating case occurs with a higher η while a more fixed regime occurs with a lower one.

II.1. Methodology Issues

Unlike previous studies that use a difference in international liquidity (Total Reserves Minus Gold, code 1l.d in *International Financial Statistics* of IMF) to get the change in foreign reserves data, this article chooses to measure them by using the Overall Balance Account (code: 78cbd) in the Balance of Payments. One merit of the overall balance over the international liquidity difference is the exclusion of all changes in reserve assets that are not attributable to transactions from the overall balance. That is to say, value changes resulting from fluctuations in the price of reserve assets, changes associated with the creation of reserve assets, and counterparts offsetting such changes are not recorded in balance of payments statements. For each of the 109 IMF member countries that provide both international liquidity and the overall balance data on *International Financial Statistics*, we calculate their correlation coefficients between the overall balance and the international liquidity difference series during the period of 1974Q1-2005Q4 and find that the resulting 109 correlation coefficients average to be only 0.74 (with a high standard error of 0.29). For many African and transition countries, the individual correlation coefficient is even lower than 0.5, and in three cases there exist negative correlation coefficients.

In measuring foreign exchange interventions, Sarno and Taylor (2001) and Calvo and Reinhart (2002) point out that "hidden" foreign exchange reserves transactions and domestic open market operations may hide the true levels and variations in reserves. However, such transactions that come mostly from a monetary authority against speculative attacks may not be so crucial in a country's exchange rate choice. Therefore, we think that it will not cause a serious problem for measuring the degree of foreign exchange market interventions with overall balances.

(1') $$\Delta e = -\eta BOP,$$

where *BOP* denotes the overall balance account in the balance of payments.

We use the data of exchange rates and the overall balance provided by IMF to construct

the time series of η statistics. As for exchange rates, this article chooses currencies referenced primarily by Levy-Yeyati and Sturzenegger (2005), excepting post-1999, when the Euro begins to be one main reference currency in the world. Appendix 2 offers the details for currencies of reference. To measure the fluctuation of exchange rates in calculating η, we use a devaluation rate (i.e., a percentage change of the exchange rate level) rather than a change of the exchange rate level in the numerator. However, instead of using the growth rate of foreign exchange in the denominator, we use the overall balance of payments divided by its foreign exchange market's "normal trading volume" which is constructed by adding all items in the balance of payments.[2]

Term η of this article is similar to the index of exchange rate flexibility in Holden, Holden and Suss (1979), which is defined as the ratio of the 24-month sum of the absolute value of monthly percentage changes in the nominal exchange rate to the 24-month sum of absolute change in foreign reserves divided by the sum of their past 12-month imports and exports. The first difference between our η and the index of Holden, Holden and Suss (1979) is that we take into account not only the items in the current account, but also those in the capital and the financial accounts.[3] Transactions on the financial account often cause

[2] These items include Goods: Exports f.o.b. (78aad), Goods: Imports f.o.b. (78abd), Services: Credit (78add), Services: Debit (78aed), Income: Credit (78agd), Income: Debit (78ahd), Current Transfers, n.i.e.: Credit (78ajd), Current Transfers: Debit (78akd), Capital Account, n.i.e.: Credit (78bad), Capital Accounts: Debit (78bbd), Direct Investment Abroad (78bdd), Direct Investment in Reporting Economy, n.i.e. (78bed), Portfolio Investment Assets (78bfd), Portfolio Investment liabilities, n.i.e. (78bgd), Financial Derivatives Assets (78bwd), Financial Derivatives Liabilities (78bxd), Other Investment Assets (78bhd), and Other Investment Liabilities, n.i.e. (78bid). To lower the unusual variance of the foreign exchange market, we interpolate annual data to quarterly to get the normal trading volume.

[3] Hausmann, Panizza, and Stein (2001) and Levy-Yeyati and Sturzenegger (2005) use the changes of reserves relative to the stock of broad money (M2) and the monetary base, respectively, rather than the percentage

more exchange rate fluctuations than transactions on the current account. The other main difference is that Holden, Holden and Suss (1979) use a 24-month sum to eliminate the effects of short-run (monthly) fluctuations in either reserves or exchange rates and obtain one record of December 1975 for each considered country, while we use quarterly data to eliminate the effects of short-run fluctuations and obtain a time series for each country considered. Therefore, we can analyze the evolution of the intervention degree for the countries concerned.

In order to normalize the degree of foreign exchange intervention so as it falls between one and zero, we translate η into an intervention coefficient (IC) by:

$$\text{IC} = \frac{1}{\exp|\eta|}. \tag{2}$$

Here, IC becomes 100 percent as $\eta \to 0$, while IC becomes 0 as $|\eta| \to \infty$. Specifically, a high value of IC means severe intervention. Note that η shows up in its absolute value in the transformation function. This is because in this article we care more about finding out the true degree of a central bank's intervention operations rather than its purchasing or selling being against the foreign exchange market pressure.

Our intervention measure, modified from Lai, Hsiao and Chang (1985) and Djajic and Bazzoni (1992), does not employ interest rates. The basic idea is that, if a central bank steps into the foreign exchange market to intervene, then foreign reserves are surely the instrument and any "leaning against/for the wind" operation causes a change in the stock of foreign reserves. However, the intervention may or may not change the interest rate, depending on whether a sterilization operation follows or not. A sterilized intervention operation is much more popular in practice. In addition, the interest rate always adjusts when the demand for money and/or the supply of money change(s), even though there is no central bank

change in reserves to reflect the intervention degree.

intervention in the foreign exchange market. For similar reasons, Levy-Yeyati and Sturzenegger (2005) think that abbreviating interest rates causes little loss of accuracy in their exchange rate regime classification.

II.2. The Indicators of Intervention in the Real World

This article constructs IC based on the data of exchange rates and the overall balance of payments available from all IMF-reporting countries over the period 1974Q1-2005Q4.[4] Samples for countries using other nations' currencies as legal tender or joining a monetary union are excluded due to their lack of a monetary autonomy. Figure 1 presents the proportion of countries under different ICs. It can be found that an IC higher than 0.9 has the highest proportion - nearly 1/3 of the cases in our panel. Our statistics are consistent with the classification by the IMF, in that since 1974 countries which adopted the fixed exchange rate regime are still in the majority. Using our measure, the second highest proportion (slightly higher than 20 percent) corresponds to the lowest IC (lower than 0.1 in the figure). Approximately 45 percent of ICs fall between the wide range of 0.1 to 0.9.

To further investigate the different degrees of intervention trends for the IMF member countries, we categorize countries into four groups based on the level of their ICs. We define severe intervention, mid-high intervention, mid-low intervention, and negligible intervention according to ICs being higher than 90 percent, from 90 percent to 60 percent, from 60 percent to 10 percent, and lower than 10 percent, respectively.[5]

Figure 2 plots the five-year moving average proportion for each group between 1975Q1 and 2005Q4. The plot confirms that severe intervention countries constitute the highest proportion during the entire sampling period. From the beginning, higher intervention

[4] This excludes countries that are not IMF members as well as those lacking data on the balance of payments.

[5] Our four degrees of intervention can roughly correspond to the four types of exchange rate arrangements of the IMF, i.e., peg, limited flexibility, managed float, and free float.

policies dominated the policies of lower intervention just after the breakdown of the Bretton Woods, but the phenomenon is more flexible in the determination of exchange rates. As time went by, the fading inflation pressure from the first oil price shock as well as the volatile exchange rates caused concern and therefore directed some countries back to a more fixed exchange rate policy. However, in the early 1980s many severe intervention countries turned to be mid-high or negligible interventions after the second oil price shock. The other swing coincides with the Plaza Agreement of September 1985 that promoted central bank cooperation in order to induce depreciation in the U.S. dollar. The proportion of severe intervention increased while that of negligible intervention declined. Since the beginning of the 1990s, severe intervention gave way to mid-high and negligible intervention until the end of the European Monetary System (EMS) crisis, followed by a stable period until 1996.

At the end of the 1990s, there began a new trend of severe intervention policies replacing the other three policies. Following the introduction of the Euro currency unit and the effectiveness of the new European exchange rate mechanism, the trend for severe intervention is distinct. Moreover, the proportion of mid-high intervention increased while that of lower intervention declined as of 2003. Therefore, our result from trend analysis indicates that there is neither a tendency for a country to adopt an "intermediate" case nor support for the bipolar view, where a country leaves the intermediate case and develops a tendency to shift to greater flexibility or greater fixity.[6]

[6] Note that the level and trend of the four interventions depend on the transformation function we use. However, this article tries seven additional transformations that can normalize the intervention degree to be one to zero, and in all cases we find that the relative importance of intervention application between severe intervention and a negligible one reversed twice from the late 1970s to the mid-1980s, and that there was a trend toward severe intervention after 1999. Therefore, these normalizations are not critical to the analysis of the intervention evolution.

II.3. The Indicators of Intervention in Several Typical Regimes

In the first part of the section, we pay attention to four typical floats: the United States, Japan, Germany, and Australia which have released their daily data for intervention since the beginning of the 1990s. The official intervention data available for this research are 1974/1/1-2005/12/31 for the United States, 1974/1/1-1994/12/31 for Germany, 1991/4/1-2005/12/31 for Japan, and 1983/12/12-2005/12/31 for Australia.[7] Because we have no interest in the high frequency data features of exchange rates, the daily data are aggregated to quarterly data for comparison.[8]

Table 2 lists the correlation between the official intervention data and the two measures of change in reserves - that is, the change in international liquidity and the overall balance of payments. It shows that the official intervention data are more related to the overall balance on the balance of payments than the change of international liquidity for the United States. The correlation coefficient between official intervention data and the overall balance is slightly higher than that between official intervention data and the change of international liquidity for Germany, Japan, and Australia. The overall balance appears to mirror the intervention operations of Japan's monetary authority, while the balance is not as close, but still satisfactorily reflects the German government's intervention behavior. The results for the United States and Australia are surprising due to their low correlation between intervention data and the two proxy variables, which suggests the finding needs additional

[7] Following previous literature, we use an aggregation of net purchases of foreign currency with government (series ID: AUINTDGT) and with dealers (series ID: AUINTDDL) as a proxy of Australian intervention data.

[8] Intervention data are released in their own currency by Australian, German and Japanese governments. This article first aggregates daily data into monthly data and uses the end of the month exchange rate to translate the monthly data in terms of the U.S. dollar. Monthly data are then aggregated into quarterly data.

investigation.[9]

Figures 3 to 6 show the time series of the ICs for the four economies: the United States, Japan, Germany, and Australia. The shaded area in these figures corresponds to the periods for which official intervention data are available and there is an intervention adopted.[10] At first glance, the ICs are extremely volatile and in some cases they fall into the severe intervention area for the four typical floats. However, the majority are still located in "negligible intervention" for the United States and Germany and "mid-low intervention" for Japan and Australia.

Even being recognized as representative floats, both the U.S. and German governments intervened in their foreign exchange markets intensively until the early 1990s. No wonder no economic model of a floating exchange rate can work well when using the data after the breakdown of Bretton Woods. There are a total of 124 observations for official intervention data as well as our ICs for the U.S. foreign exchange market. Compared with official intervention periods, many of our intermediate intervention periods correspond to the periods in which there is an official intervention, and negligible intervention periods correspond to no official intervention ones for the United States. There are several separate exceptions: our ICs in the intervention quarters of 1974Q4-1975Q3 are very low while the ICs in the no intervention quarters of 1996Q3-Q4 and 2005Q3 are too high. However, when considering

[9] The difference between the U.S. overall balance and its intervention data may arise from the fact that the U.S. dollar is the international currency. An example for the guess is from *Survey of Current Business* (July 2006 report, p. 59) "The first quarter decrease (in the U.S. reserve) was more than accounted for by a decline in the U.S. reserve position in the IMF, reflecting the net repayment of U.S. dollars to the IMF, mostly by Argentina, which completed the repayment of its IMF debts ahead of schedule." Additionally, the Australian proxy intervention data gathered by researchers appears imprecise and seems to require further consideration.

[10] The dotted patterned area in the figures of the United States, Japan, Germany, and Australia is the absolute value of the released intervention volume.

the whole sample for the United States, the mismatch probability is relatively low.

The period for German intervention data ends in 1995Q4. Due partly to the *Deutsche* Mark being the central currency of the EMS, Germany's government intervened throughout almost the entire sample period. These mostly intensive intervening periods coincided with the EMS crisis in the early 1990s. The ICs basically reflected the German government's intervention operations. However, because of the relatively large change in the depreciation (appreciation) rate of the Deutsche Mark, there were some inconsistencies between German ICs and the official intervention periods: 1981Q2, 1983Q3-Q4, 1984Q2-Q4, 1985Q3-1986Q1, 1988Q4-1989Q4, and 1991Q1-Q2.

Japan, although classified as a representative float by the IMF as of February 1973, shows intensive intervention in the sample. Like many other Asian economies, Japan's government prefers to see its money undervalued rather than overvalued. In their released intervention history, Japan's monetary authority always bought the U.S. dollar and sold the Japanese yen to stop the yen's appreciation, except in two periods. In the first period, Japan's central bank sold the U.S. dollar in the early 1990s right after German Unification, when the Deutsche Mark was very strong and there was a high downward pressure on the price of the U.S. dollar. The other period involves the 1997 Asian financial crisis in which the government kept selling the U.S. dollar to fight speculators who bought huge amounts of U.S. dollars in the Japanese foreign exchange market. Nonetheless, due to the relative large change in the depreciation rate of the yen, our IC cannot capture the intervention in 1992Q1-Q3 and 1997Q4, as well as during the intervention after the Plaza Accord in 1985Q4 and 1986Q1 (Note that the intervention data before 1990 were not released by the government).

Chen and Taketa (2006) assess Weymark's measures of exchange market intervention by comparing the "Weymark index" with a "true Weymark index," which is constructed by the

official intervention data of Japan instead of changes in reserves data. Likewise, we can compare our IC with a "true IC" that is constructed by using the official intervention data instead of the overall balance data. It is interesting to find that the two indices of Japan in this article are highly correlated and exhibit a significant correlation coefficient of 0.875, contrary to the finding of Chen and Taketa (2006) that Japanese Weymark indices are negatively correlated with a robust relationship.

Calvo and Reinhart (2002) also present Australia as a representative float for small open economies. Australia's IC fluctuates even more than that of Japan's; not surprising, as Australia is a smaller industrial nation, its dollar is not an international currency, and its terms of trade exhibit a higher volatility than those of the United States, Germany, and Japan. In addition, the average of Australian ICs is much higher before 1983, where Australia adopted a float regime. The average IC is 0.53 during 1974-1983, yet only 0.28 between 1984 and 2005. 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. Australia's float is the dirtiest among the four floating countries. Looking at Figure 6, it is found that the IC fits intervention data better pre-1999 than post-1999. There are a few exceptions over the former period: 1987Q3, 1988Q4-1989Q2, 1991Q3, 1992Q3, 1993Q2, and 1996Q3. The lack of correlation between the IC and the proxy of Australian intervention data becomes more significant after 1999.

The other exchange rate regimes of interest are currency board, crawling peg, and one special float - free falling.[11] A currency board is interesting, because it is an extreme example of a peg, which itself is a contrast to float. According to Reinhart and Rogoff (2004), the exchange rate regime of Argentina after the breakdown of Bretton Woods was free falling before 1990 and a currency board during the period of 1991-2001. The

[11] This case is broached and stressed by Reinhart and Rogoff (2004).

exception is the pre-announced crawling peg in 1979-1980 and the peg in 1985. Argentina's IC index is plotted in Figure 7. We find that between 1979-1991 the IC index is relatively low and most of the indices are located in seldom/low intervention, except those in the severe/intermediate cases of 1979-1980 and 1985. It is distinct that Argentina's IC index is extremely high during the currency board period.

It was difficult to distinguish between a crawling peg and a freely falling by observing the change in the exchange rate in the past, since there were huge devaluation rates in both cases. In theory, a government must intervene in the foreign exchange market to adopt a crawling peg, while it is the foreign exchange market itself that forces an exchange rate to be free falling. Therefore, the degree of intervention is definitely different for the two exchange rate regimes. We provide Nicaragua and Romania's IC in Figures 8 and 9 as a representative for each regime. Nicaragua adopted a de facto crawling peg during 1993-2001 following a two-year peg, while Romania was in a free falling regime during 1991-2000.[12] It can be found that Nicaragua's IC decreased from its maximum value of 1.0 after 1992, but remained at a high level. Figure 8 shows that all its ICs before 2001 are either located in the severe or intermediate intervention area. On the contrary, except for one outlier that is higher than 0.9 and five other cases slightly higher than 0.6 (as shown in Figure 9), the majority of ICs in Romania are lower than 0.6, and the average of Romania's ICs during its free falling period of 1991-2000 is even lower than 0.2.[13]

[12] As classified by Reinhart and Rogoff (2004).

[13] Reinhart and Rogoff (2004) also emphasize the difficulty in distinguishing a peg and a float by observing the exchange rate level with the scale of free falling countries. They highlight the difference by plotting the Canadian dollar-US dollar exchange rate against Argentina's scale and showing that the exchange rate looks like that of a fixed rate. However, this article's IC by construction does not have the scale problem.

Based on the above analyses, this article's IC index satisfactorily identifies the degrees of government intervention in foreign exchange markets under different exchange regimes. Applying this IC, we can thereby address issues about foreign exchange market intervention even though no official intervention data is released. In an appendix (available upon request) we employ structural panel VAR models to investigate central banks' foreign exchange market intervention operations and monetary policy mix. The empirical results conclude that: (1) higher intervention lowers exchange rate volatility within a relatively short time, but does not significantly influence changes in the short-run interest rate; (2) there is no systematic relationship between foreign exchange market intervention and short-run interest rate changes (traditional monetary policy); (3) a more volatile exchange rate does not lead to economically significant intervention; and (4) there is no evidence for the effectiveness of an "interest rate defence" for the countries considered in this paper. Several robustness tests, including the orders on the recursive structural assumption, are conducted to support the tenability of our empirical findings.

III. CONCLUSIONS AND REMARKS

Economic theories imply that the foreign reserves of a pure floating country can be kept intact. In reality, even the most representative floats manipulate their foreign reserves to intervene in the foreign exchange markets. To improve the theoretical explanation of the exchange rate dynamics, we recommend economists try considering that every country operates under a managed floating regime, with an environment-varying degree of float. In order to convince economists to do so, this article provides an indicator to measure a government's intervention degree in its foreign exchange market.

We find that the intervention degree is time-varying and there exists no clean float since the breakdown of the Bretton Woods Agreement. The result of our trend analysis for foreign exchange market intervention during the period of 1974-2005 is consistent with

general images about the world's foreign exchange regime evolution as well as theoretical implications of most international finance models. In addition, comparisons between the official intervention and our intervention coefficients (IC) for the United States, Germany, Japan, and Australia indicate that our intervention measure in most cases coincides with the practices of intervention in the foreign exchange market. Correspondences with several economies each owning a distinct exchange rate regime of floating, currency board, crawling peg, and freely falling indicate that the IC appears to capture the flexibility of a country's exchange rate policy very well. Therefore, with this IC series, one can conduct close-to-reality studies about a country's foreign exchange market even if lacking its intervention data.

In an available appendix we employ structural panel VAR models to investigate central banks' foreign exchange market intervention operations and monetary policy mix. The empirical results conclude that higher intervention lowers exchange rate volatility briefly, but a more volatile exchange rate does not lead to economically significant intervention. In addition, there is no evidence for the effectiveness of an "interest rate defence" for our sample countries.

Even though the IC index makes it possible to study some intervention issues without intervention data, there must be some skepticism for this IC's simplicity. One could question the use of aggregate data being problematic caused by summing up high frequency data to lower frequency data. Some volume of intervention may be cancelled out making the intervention coefficient to be underestimated. However, this characteristic will not significantly hinder an investigation into one economy's evolution of exchange rate regime or cross country comparisons.

In addition, this IC is based on the idea of "leaning against/for the wind" only. On the contrary, the Weymark index is constructed from a structural model and thus is

country-specific. For example, the Weymark index specified for Canada may not be proper for another country, e.g., Japan, as mentioned in Section II. Another view sees Calvo and Reinhart (2002) arguing that developing countries do not rely exclusively on foreign exchange market intervention to smooth fluctuations in the exchange rates and that interest rate defences are commonplace. If interest rate defence is significant, a measure like our IC, composed of exchange rates and the overall balance but not interest rates, may be problematic. However, some authors, including Levy-Yeyati and Sturzenegger (2005), do not think abbreviating interest rates causes much loss of accuracy. We find no evidence of interest rate defence for industrialized economies or most newly-industrialized Asian economies from our empirical results of VAR models estimation, as is in line with Taylor (2001). Thus this may deserve further investigation.

Appendix 1. Description about Exchange Rate Regime Classification

This appendix presents a brief introduction and the original exchange rate regime classification of Ghosh, Gulde and Wolf's (2002) de jure classification, and the de facto classification of Bubula and Ötker-Robe (2002), Levy-Yeyati and Sturzenegger (2005), and Reinhart and Rogoff (2004) (see Table A1). The re-classification of the exchange rate regime is reported in Table A2.

Table A1. Main features of various exchange rate regime classifications

	GGW	BOR	LYS	RR
maximum coverage	165	187	183	153
maximum time span	1970-1999	1990M1-2001M12	1974-2000	1946M1-2001M12
types of regimes	(1) dollarized	(1) another currency as legal tender	(1) inclusive	(1) no separate legal tender
	(2) currency board	(2) currency union	(2) flexible	(2) pre-announced peg or currency board arrangement
	(3) monetary union	(3) currency board	(3) dirty float	(3) pre-announced horizontal band (≤+/-2%)
	(4) single currency pegs	(4) fixed peg	(4) crawling peg	(4) de facto peg
	(5) published basket pegs	(5) peg to composite	(5) fixed	(5) pre-announced crawling peg
	(6) secret basket pegs	(6) horizontal band		(6) pre-announced crawling band (≤+/-2%)
	(7) cooperative regimes (EMS)	(7) forward-looking crawling peg		(7) de factor crawling peg
	(8) crawling pegs	(8) back-looking crawling peg		(8) de facto crawling band (≤+/-2%)
	(9) target zones and bands	(9) forward-looking crawling band		(9) pre-announced crawling band (≥+/-2%)
	(10) unclassified rule-based systems	(10) back-looking crawling band		(10) de facto crawling band (≤+/-5%)
	(11) managed floats with heavy intervention	(11) tightly managed		(11) moving band (≤+/-2%)

(12) unclassified managed floats	(12) managed floating	(12) managed floating
(13) other floats	(13) independently floating	(13) freely floating
(14) floats with light intervention		(14) freely falling
(15) floats with no intervention		(15) dual market

Note: GGW: Ghosh, Gulde and Wolf (2002); BOR: Bubula and Ötker-Robe (2002); LYS: Levy-Yeyati and Sturzenegger (2005); RR: Reinhart and Rogoff (2004).

Table A2. Exchange rate regime re-classification

	GGW	BOR	LYS	RR
Peg (1)	(1), (2), (3), (4), (5), (6)	(1), (2), (3), (4), (5)	(5)	(1), (2), (4)
Crawling peg (2)	(8)	(7), (8), (9), (10)	(4)	(5), (6), (7), (8), (9)
Managed float (3)	(7), (9), (10), (11), (12), (13)	(6), (11), (12)	(3)	(3), (10), (11), (12)
Float (4)	(14), (15)	(13)	(2)	(13), (14)

Note: GGW: Ghosh, Gulde, and Wolf (2002); BOR: Bubula and Ötker-Robe (2002); LYS: Levy-Yeyati and Sturzenegger (2005); RR: Reinhart and Rogoff (2004).

Appendix 2

To the US Dollar

Argentina, Armenia, Aruba, Australia, Rep. of Azerbaijan, The Bahamas, Bangladesh (79-), Belarus, Bolivia, Brazil, Bulgaria (74-95), Cambodia, Canada, Chile, China, P.R.: Hong Kong, Colombia, Costa Rica, Ecuador, El Salvador, Eritrea, Ethiopia, Georgia, Germany, Greece (74), Guatemala, Hungary, India (75-), Indonesia, Israel, Japan, Jordan (88-), Kenya (74-75Q3; 87-), Kyrgyz Republic, Lao People's Dem. Rep, Lebanon, Lithuania (74-01), Malaysia, Mauritius (83-), Mexico, Mongolia, Mozambique, Nepal, Netherlands Antilles, New Zealand, Nicaragua, Nigeria, Pakistan, Papua New Guinea, Paraguay, Peru, Philippines, Poland, Romania, Russia, Seychelles (97-), Singapore, South Africa, Sri Lanka (77-), Sudan, Suriname, Tajikistan, Thailand, Turkey, Uganda, Ukraine, Uruguay, Rep. Bol. Venezuela, Vietnam, Republic of Yemen, Zimbabwe.

To the German Mark (74-98)

Albania, Austria, Belgium, Bosnia & Herzegovina, Bulgaria (96-98), Croatia, Cyprus (74-79Q2), Czech Republic, Denmark, Estonia, Finland, France, Greece (75-98), Iceland, Ireland (79-98), Italy, FYR Macedonia, Moldova, Netherlands, Norway, Portugal, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, United Kingdom, United States.

To the British Pound

Bangladesh (74-78), India (74), Ireland (74-78), Seychelles (74-79Q3).

To French Franc (74-98)

Cape Verde, Morocco, Vanuatu.

To the SDR

Jordan (74-87), Kazakhstan, Kenya (75Q4-86), Latvia, Mauritius (74-82), Myanmar, Seychelles (79Q4-96).

To the Euro (99-)

Albania, Austria, Belgium, Bosnia & Herzegovina, Bulgaria, Cape Verde, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Greece, Iceland, Ireland, Italy, Lithuania (02-), Luxembourg, FYR Macedonia, Malta, Moldova, Morocco, Netherlands, Norway, Portugal, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, United Kingdom, United States, Vanuatu.

Others

Cyprus (79Q3-98), ECU

Lesotho, South African Rand

Luxembourg (74-98), Belgium Franc

Malta (74-98), Italian Lira

Namibia, South African Rand

Tonga, Australian Dollar

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Table1. Comparison of Exchange Rate Regime Classifications

A. Between Ghosh, Gulde, and Wolf (2002)'s de jure classification and:

		(1) peg	(2) crawling peg	(3) managed float	(4) float	Total
BOR	(1) peg	574	1	52	26	653
	(2) crawling peg	26	22	111	29	188
	(3) managed float	53	1	192	164	410
	(4) float	0	0	7	185	192
	Total	653	24	362	404	1443
LYS	(1) peg	1428	3	210	114	1755
	(2) crawling peg	62	13	149	85	309
	(3) managed float	72	5	87	67	231
	(4) float	112	29	229	231	601
	Total	1674	50	675	497	2896
RR	(1) peg	1091	0	149	25	1265
	(2) crawling peg	331	17	334	171	853
	(3) managed float	425	21	116	133	695
	(4) float	184	18	159	197	558
	Total	2031	56	758	526	3371

B. Between Reinhart and Rogoff (2004)'s de facto classification and:

		(1) peg	(2) crawling peg	(3) managed float	(4) float	Total
BOR	(1) peg	329	52	78	57	516
	(2) crawling peg	16	79	42	44	181
	(3) managed float	59	170	58	86	373
	(4) float	3	31	46	78	158
	Total	407	332	224	265	1228
LYS	(1) peg	839	162	258	106	1365
	(2) crawling peg	25	140	29	97	291
	(3) managed float	26	83	41	63	213
	(4) float	29	198	143	201	571
	Total	919	583	471	467	2440

Note: BOR: Bubula and Ötker-Robe (2002); LYS: Levy-Yeyati and Sturzenegger (2005); RR: Reinhart and Rogoff (2004).

Table 2. Correlation between Official Intervention Data and Two Proxy Data

	United States	Germany	Japan	Australia
Overall balance	0.58	0.86	0.99	0.14
Change in international liquidity	0.35	0.83	0.97	0.10

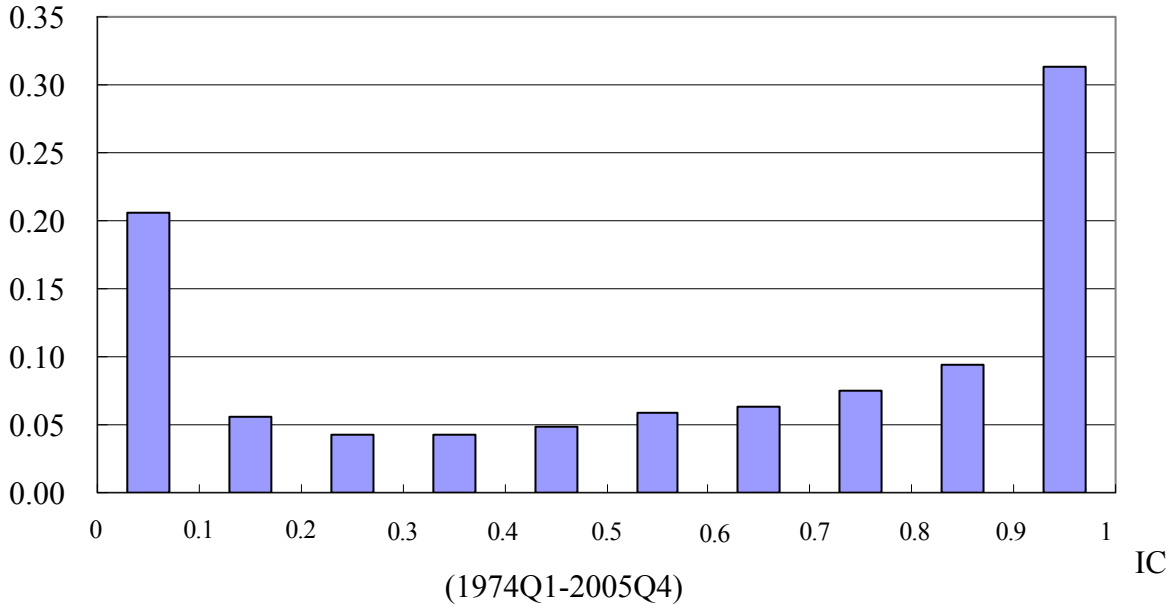

FIGURE 1

Proportion of Different ICs

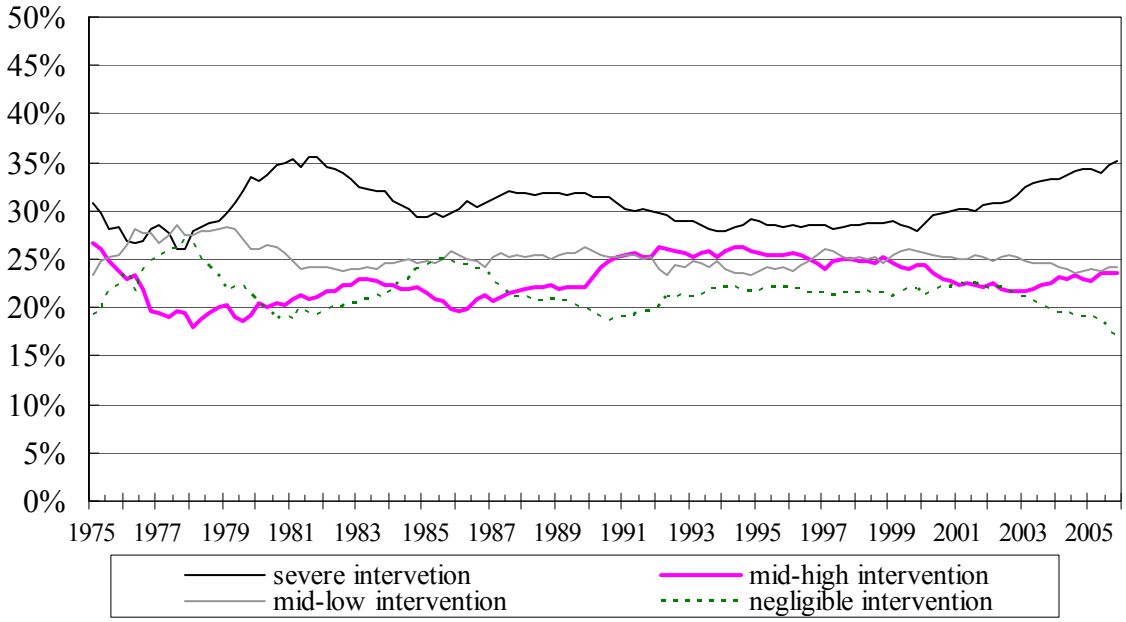

FIGURE 2

Five-year Moving Average Series for Four Intervention Groups

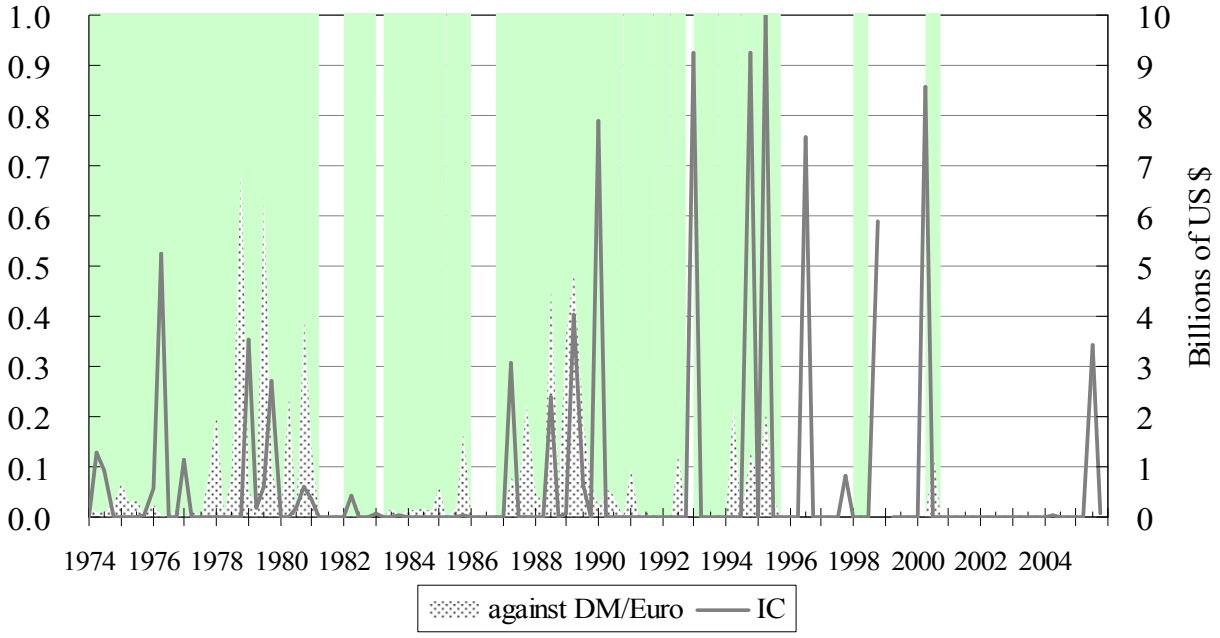

FIGURE 3

IC and Intervention Data in U.S. Foreign Exchange Market

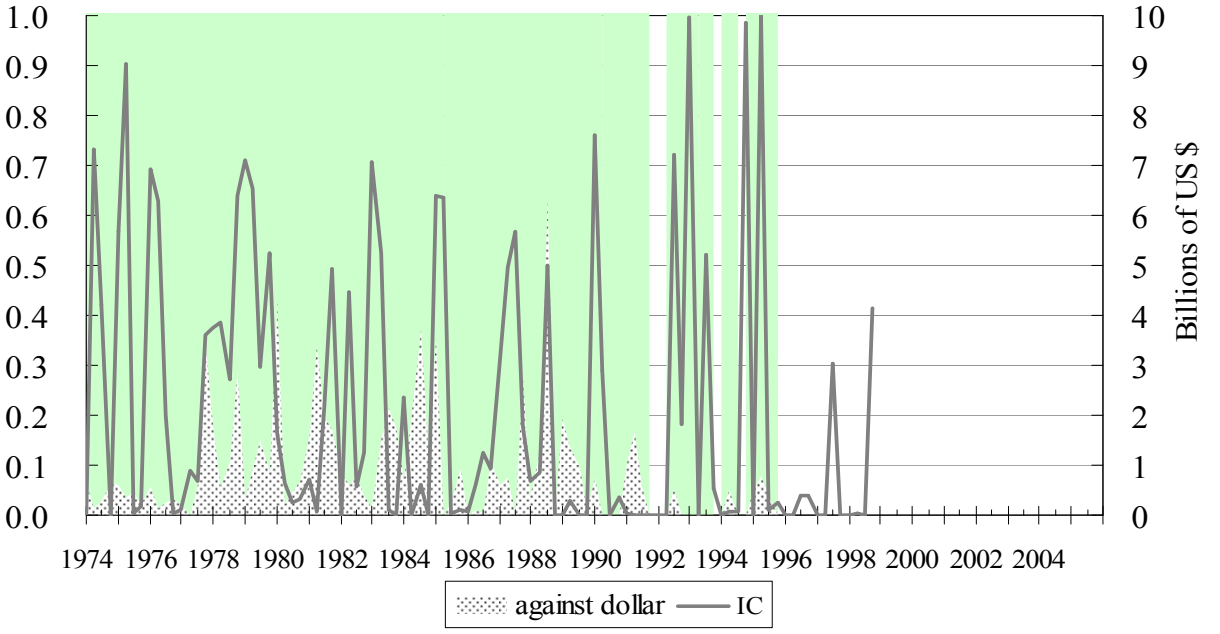

FIGURE 4

IC and Intervention Data in Germany's Foreign Exchange Market

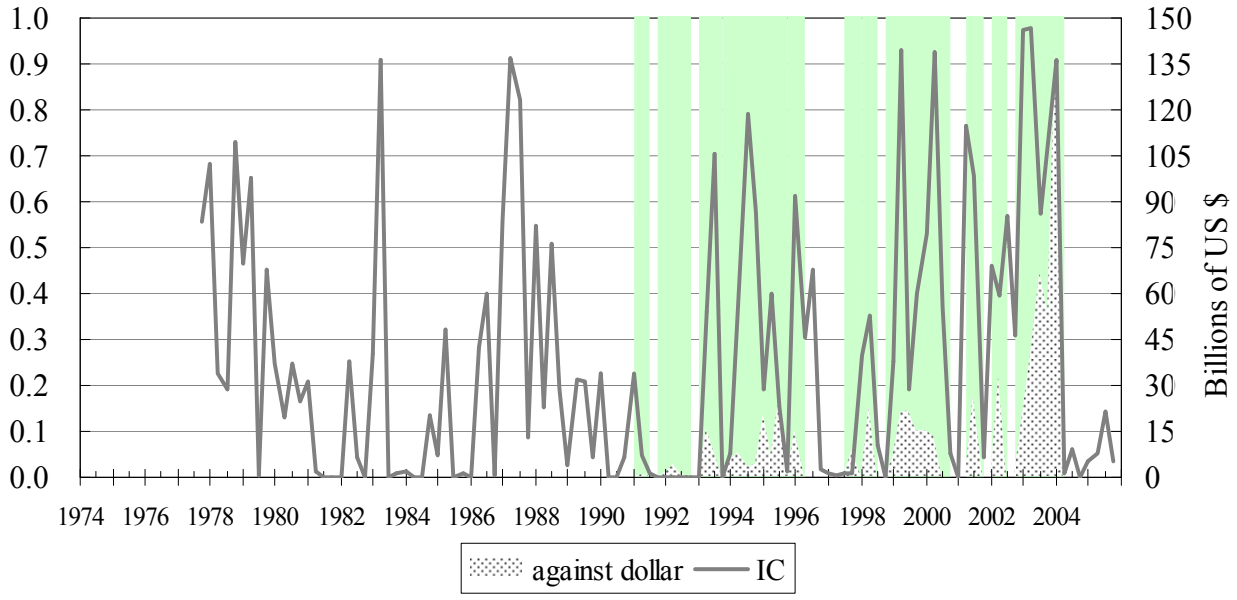

FIGURE 5

IC and Intervention Data in Japan's Foreign Exchange Market

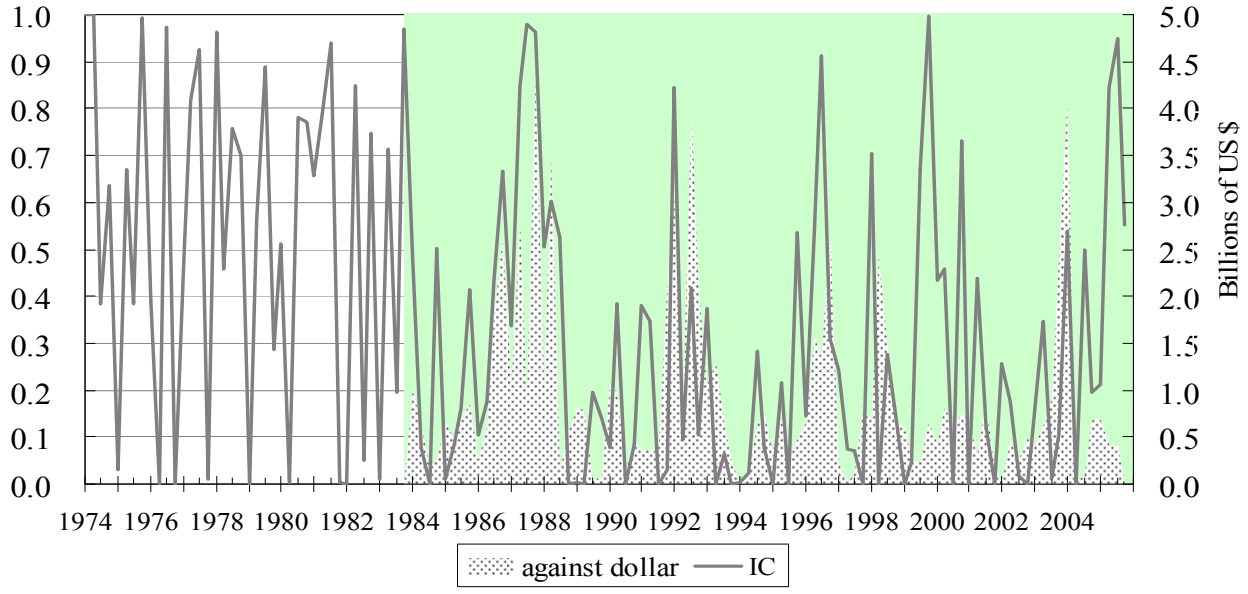

FIGURE 6

IC of Australia's Foreign Exchange Market

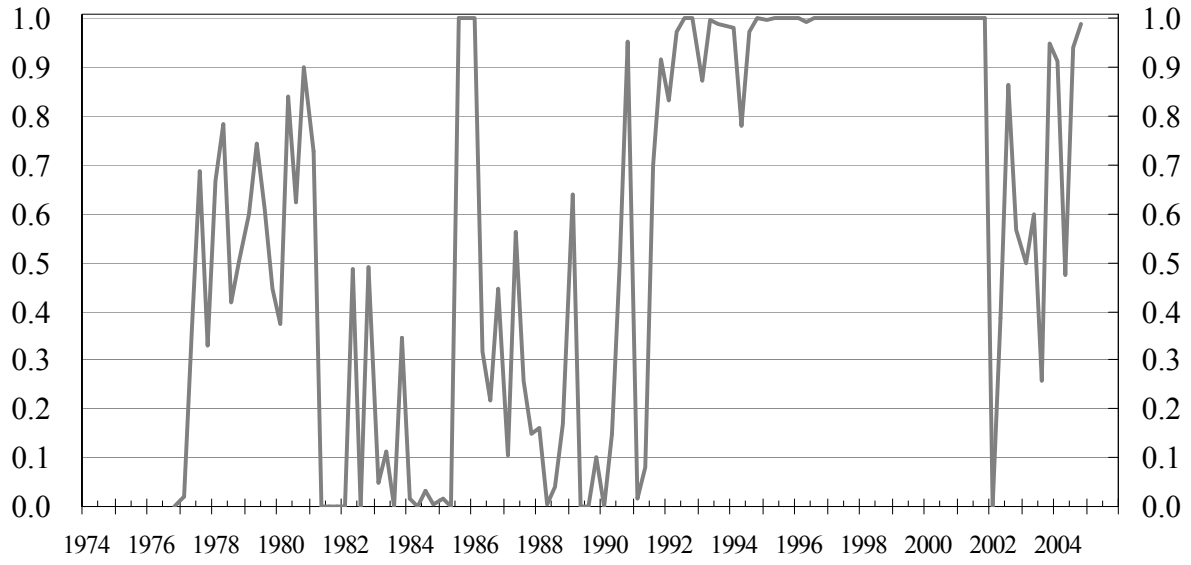

FIGURE 7

IC of Argentinia's Foreign Exchange Market

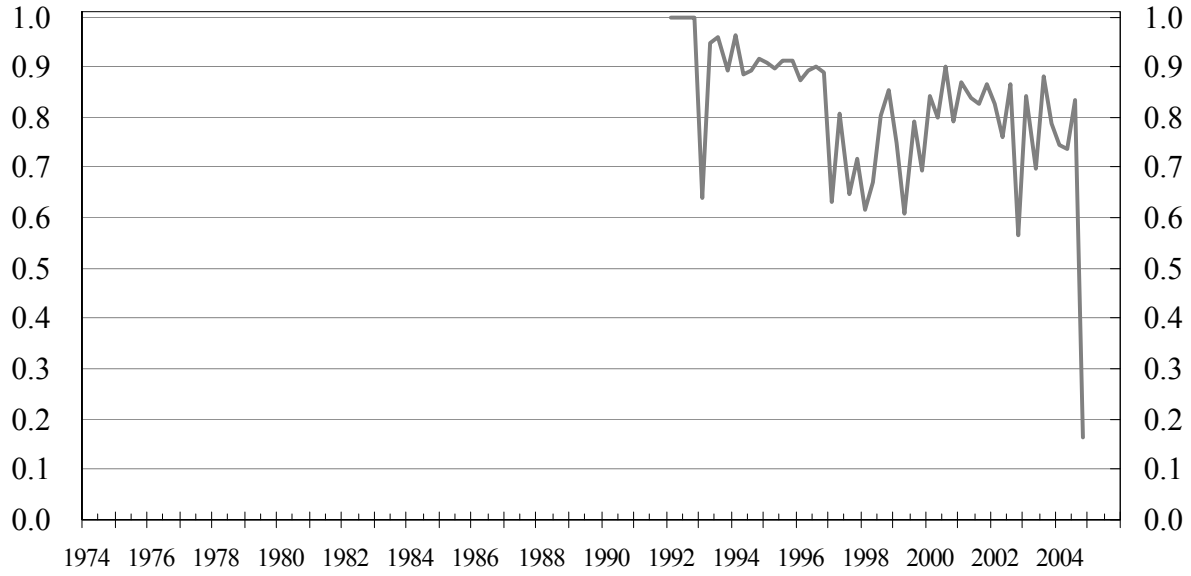

FIGURE 8

IC of Nicaragua's Foreign Exchange Market

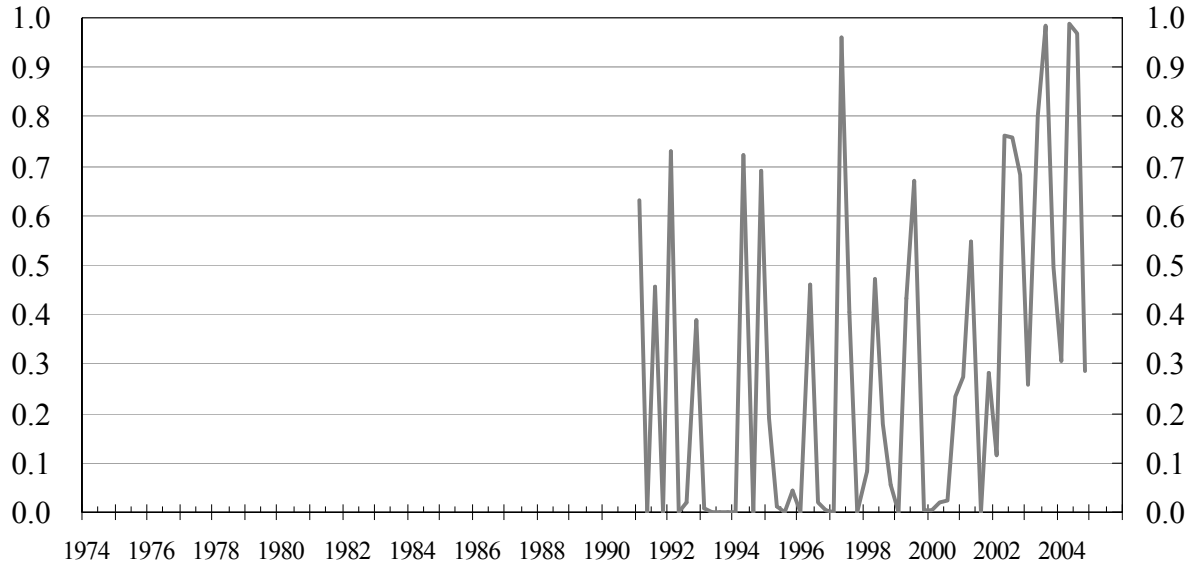

FIGURE 9

IC of Romania's Foreign Exchange Market