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**An empirical test for the effectiveness of central bank
interventions in foreign exchange markets:
An application to the Canadian and Swiss Central Banks**

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Abstract. This paper investigates the effectiveness of foreign exchange intervention of central banks of Canada and Switzerland. We examine the effectiveness of Canada and Switzerland interventions policies on Canadian dollar against US dollar and Swiss franc against US dollar exchange rates volatility over the 1980-2014 period. A behavioral exchange rate equation is estimated with instrumental variables methodology. The main results indicate that interventions generally reduce exchange rates volatility. However, the Swiss National Bank seems to be more efficient by stabilizing the Swiss franc than the Bank of Canada, whose interventions, despite its effectiveness, remains weak.

Keywords. Volatility, Exchange rate, Official international reserves.

JEL. E51, E52, E58.

1. Introduction

Volatility is one of the prevalent features of financial data including exchange rates. The impact of monetary policy on exchange rates has been the subject of a large body of empirical research since the early 1990s. Excessive exchange rate volatility is believed to interfere with the efficiency of the foreign exchange market, the international flow of goods, services, investment capital and the conduct of monetary policy (Rogers & Siklos, 2003). Since official intervention data becoming publicly available, the empirical literature on central banks foreign exchange intervention has been growing rapidly. Official exchange rate intervention in the foreign exchange market occurs when the authorities buy or sell foreign exchange, normally against their own currency in order to affect the exchange rate (Taylor & Sarno, 2001). Many papers have explored the determinants and efficacy of intervention (Edison, 1993; Sarno & Taylor 2001). Under the Bretton Woods system of fixed exchange rates, interventions were used frequently to maintain the exchange rate within prescribed margins. The objective was to avoid the excessive volatility and prevent competitive depreciation (Dominguez, 1998). After the breakdown of the institution in 1973, interventions excessively increased.

In the current monetary system, many rich countries adopted “laissez-faire” approach towards foreign-exchange markets. Then, the exchange rates of major currencies such as the US dollar, Euro or the Yen fluctuate with market forces. Other medium-sized industrialized open economies, such as Canada, Australia and Switzerland, have also adopted a market-determined floating rate regime (IMF,

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2000). Central banks have the option to intervene and often do so in an attempt to correct imbalances in the current account. It is, therefore of importance to understand the consequences of central bank intervention (Beltratti & Morana, 2000; Kearns & Rogobon, 2005). In Neely's survey (survey of Bank for International Settlement on Foreign Exchange and Derivatives Market Activity), 47% of the respondents claimed that foreign exchange intervention is aimed at resisting short-term trends, 22% suggested that its main goal is to eliminate misalignments from fundamental values, while the rest indicated different and unspecified reasons for intervention (Nelly, 2000).

Is Foreign exchange intervention, especially in small open economies such as Canada and Switzerland, effective? Why Canada and Switzerland? Historically, the Canadian and Swiss economies have similarities and differences. First, these countries are small and open industrialized economies. Their individual activities have no influence on the level of global activity. Secondly, both countries' currencies are viewed as being sensitive to similar factors such as interest rate and inflation differentials vis-à-vis the US. Thirdly, they have an inflation target in their monetary policies formulations. The Bank of Canada aims to keep inflation at 2 percent, and its commitment to inflation targeting was considered more formal (Rogers & Siklos, 2003). However, the choice of these countries doesn't just rely on their similarities but also in their differences.

Prior to September 1998, Canada's policy was to systematically intervene in the foreign exchange market to automatically counter excessive pressure on the Canadian dollar. This policy changed in September 1998. The Swiss central bank is known to be one of the most interventionist central banks in the world.

This paper aims to evaluate the effectiveness of interventions of central banks of Canada and Switzerland. The rest of this paper is organized as follows. Section 2 briefly summarizes the extant literature. Section 3 describes data and econometric specifications, while Section 4 discusses the results. Section 5 concludes.

2. Literature review

We summarize the literature on why central banks intervene in foreign exchange markets, how they intervene, and how interventions can work.

2.1. Why central banks intervene in foreign exchange markets?

According to Adler & Mora (2011), the real motives for intervention can be grouped as: influence the level of the exchange rate, reduce the volatility of the exchange rate or increase the official reserves for precaution.

For Chutasripanich & Yetman (2015), the real motives of the monetary authorities can be summarized into four main purposes:

- *Leaning against the wind*: the central banks used to intervene in foreign exchange markets not only to limit exchange rate volatility but also to smooth the trend path of the exchange rate.
- *Reducing exchange rate misalignment*: Central banks intervene when the exchange rate is too high and can reduce a country's competitiveness or too low to lead to an unsustainable growth and inflation (Chutasripanich & Yetman, 2005).
- *Accumulating reserves*: According to Adler & Mora (2011), 50 % of interventions by central banks on the foreign exchange market between 2004 and 2010 were motivated at least by the desire to accumulate reserves.
- *Ensuring liquidity*: Central banks also intervene in the market exchange rates to ensure liquidity in the market and to avoid financial stress.

2.2. How central banks intervene in foreign exchange markets

We first observe sterilized interventions and non-sterilized operations. Official intervention is said to be sterilized when the authorities simultaneously or with a very short lag take action to offset or “sterilize” the effects of a change in official foreign asset holdings on the domestic monetary base. On the other hand, non-sterilized intervention occurs when the authorities buy or sell foreign exchange, normally against their own currency without such offsetting actions (Sarno & Taylor, 2001). However, the means by which central banks intervene in foreign exchange markets vary across a number of dimensions. Intervention can be rule-based or discretionary. According to Canales-Kriljenko (2003), central banks need discretion to determine when to intervene. Discretion has the advantage of allowing the central bank to adapt to market conditions and to plan strategies. Some other theoretical studies support that “rule-based” intervention can be more effective (Krugman, 2001).

2.3. Central banks intervention's channels

We identify at least two channels through which central bank intervention in the foreign exchange market can influence agents' behavior: the portfolio channel and the expectations channel.

- *Portfolio-balance channel:* The portfolio-balance channel assumes that economic agents are risk averse, and that foreign and domestic bonds are imperfect substitutes for each other in an agent's portfolio. It operates when there is imperfect substitutability between domestic and foreign assets and the risk premium increases with the supply of domestic assets. That means that in closed financial markets the substitutability between domestic and foreign assets is likely to be low. If the central bank, as a major market player, influences the supply or demand of financial assets through its own trading activities, this is likely to result in other market participants rebalancing their financial asset portfolios (Sarno & Taylor, 2001)
- *Signalling or expectations channel:* The second is expectations or signaling channel. This channel works through the adjustment of expectations about future central bank policy. A highly-publicised transaction in foreign exchange markets may be interpreted as setting a precedent for future interventions, or revealing information about the level of the exchange rate that is considered desirable by policymakers (Chutasripanich & Yetman, 2015). This channel is effective if agents revise their expectations of current or future policy and the resulting exchange rate (Rogers & Siklos, 2003).

Morana & Beltratti (2000) focused on evaluating the effects of sterilized central bank interventions on the FX market for the period 1992 to 1995 with high-frequency data. Their results revealed that the interventions are not particularly effective. Dominguez (2003) examined the intervention effects of the monetary authorities of United States, Germany and Japan on the \$ US/Deutsch mark exchange rate and the volatility of the US dollar/yen exchange rate over the period 1977-1994. His results suggested that interventions increase the volatility of exchange rates. Rogers & Siklos (2003) found for Canada and Australia an ineffectiveness of interventions. Both central banks are largely ineffective and constitute an additional source of volatility in the foreign exchange market. Fatum (2005) analyzed the effects of the Bank of Canada's intervention on the CAD/USD exchange rate for the period from January 1995 to September 1998. He concluded that the Bank of Canada has failed to reduce the volatility of the exchange rate and the impact of its sterilized interventions is very low on the volatility of the exchange rate. Conversely, some studies pointed the effectiveness of sterilized interventions. Ramaswamy & Samiei (2000) used daily data on the period 1995-1999 to estimate a simple prospective

model of the exchange rate and concluded that foreign exchange interventions have weak but persistent effects on the yen-dollar exchange rate. Their results concluded that co-ordinated interventions by agreement between central banks, have a greater probability to reduce exchange rate volatility. Park (2008) examines the main features of daily foreign exchange intervention on the US dollar against the Australian dollar for the period 1983-1997. He finds a contemporary positive correlation between the direction of the intervention, the average and the conditional variance of exchange rate returns. His results suggest that large and sustainable interventions have a stabilizing influence in the foreign exchange market. Without these interventions, the market would have been exposed to more volatility.

3. Data and econometric approach

Some differences remain regarding to the econometric approach to investigate the effectiveness of central bank interventions on the foreign exchange market. However, data about official interventions are very scarce. To address the problem of intervention data paucity, some proxy variables have been constructed. Neely (2001) defended the use of changes in reserves exchange as a proxy for interventions by analyzing the correlation between interventions and international reserves of central banks. His paper concluded that changes in reserves are positively correlated with central bank interventions. His results have recently been supported by Suardi & Chang (2012) who have found that variations in international currency reserves of central banks area good proxy for interventions. Variations in international reserves were used by Taylor & Sarno (2001) and Hodgson (2011). We retain as variable for Canadian and Swiss interventions, the first difference in logarithm of international official reserves in US dollars as specified by Hodgson (2011). Using a theoretical macroeconomic model similar to the one of Taylor & Sarno (2001) and Adler & Mora (2011), we do not explicitly test through which channel interventions work, but simply if they affect the exchange rate variation. The central hypothesis is that intervention affects the exchange rate. However, the decision to intervene is not independent of the movements in the exchange rate. Moreover, even after a central bank has decided to intervene, the quantity of currency it buys or sells and its timing will typically depend on the response of the exchange rate to its initial trades (Kearns & Rigobon, 2005). Some papers have attempted to solve the problem of endogeneity by using high frequency data such as intraday data. The motive for using such data is that if the data are sampled at a higher frequency than the decision to intervene, then the contemporary relationship between interventions and the exchange rate would not be endogenous, but doubts that high-frequency data estimates are poorly informative about the persistent effects of interventions. According to Blanchard *et al.*, (2015), low-frequency data such as quarterly data would be more appropriate for studying the macroeconomic effects of interventions we instrumentalize the intervention variable to mitigate the endogeneity problem by using the lagged international reserves.

The sample period runs from January, 1980 to September, 2014 for Canada and January, 2000 to September, 2014 for Switzerland.

The theoretical equation is expressed as:

$$\Delta E_{i,t} = \varepsilon + \theta \sum_{p=1}^2 I_{i,t-p} + \beta X_{i,t} + \delta_{i,t}$$

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$E_{i,t}$ is the natural log of the exchange rate variation (domestic currency price in US dollar). Δ is the first difference operator and $\delta_{i,t}$ the error term.

$I_{i,t-p}$ stands for the natural log of interventions of central bank measured by lagged international official reserves in US dollar. X is a vector of macro-economic variables. The vector includes: interest rate differential (difference between domestic and US interest rates), inflation rate differential (difference between domestic inflation rate and the inflation rate of the United States), the trade balance (difference between exports and imports) of Canadian and Swiss economy, the growth rate of Canadian and Swiss economies, the returns of the S&P 500 and the S&P/TSX (Standard & Poor's Toronto Stock Exchange) and Swiss Market Index. Returns are the first log difference in percentage of price of the asset.

According to Suardi & Chang (2012), most of studies on reserves consider that the demand for reserves is a negative cost function of official reserves. We use the US short-term interest rate at the end of the quarter (interest rate on 3-month treasury bills) and the Canadian and Swiss short term interest rates.

According to Rogers & Siklos (2003), the dollar and the Swiss franc are sensitive to the variation gap between the American and Canadian and American and Swiss inflation rate.

The model to be estimated is:

$$\Delta e_{i,t} = \gamma_1 + \gamma_2 I_{i,t-1} + \gamma_3 I_{i,t-2} + \gamma_4 (s_{i,t} - s_{i,t}^*) + \gamma_5 (u_{i,t} - u_{i,t}^*) + \gamma_6 y_{i,t} + \delta_7 X_{i,t} + \gamma_8 Z_{i,t} + \gamma_9 T_{i,t} + \varepsilon_{i,t}$$

$e_{i,t}$ denotes the log of the nominal exchange rate (against the US dollar) for country i at time t . We introduce the variable in first and second differences for ensuring that is stationary. The volatility is measured by the first quadratic difference in exchange rate returns (Dominguez, 1998).

$I_{i,t-p}$ is the lagged official intervention of central bank also used as instruments to address the endogeneity issue when $(s_{i,t} - s_{i,t}^*)$ is the difference between domestic (domestic policy interest rate) and US interest rates (interest rate on 3-month treasury bills).

$(u_{i,t} - u_{i,t}^*)$ is the difference between domestic inflation rate and US inflation rate.

$y_{i,t}$ is the domestic economic growth rate.

$X_{i,t}$ is the domestic asset returns. To capture the impact of domestic and foreign financial markets on the Switzerland franc and the Canadian dollar, we use the returns of the Swiss Market Index (SMI), S&P/TSX (Standard & Poor's, Toronto Stock Exchange) returns.

$Z_{i,t}$ is the return of the S&P 500. Returns are built as the first difference as percentage of the log of asset prices.

$T_{i,t}$ is the domestic trade balance. Canada and Switzerland are major producers of raw materials.

The demand for these products and their prices on world markets are also determinants of the value of the Canadian dollar and Switzerland franc. Canada and Switzerland are highly dependent on their exchange rate vis-à-vis the American dollar. The United States remains the second largest bilateral trading partner of Switzerland and the first bilateral trading partner of Canada. We introduce the trade balance of Canada and Switzerland to capture the impact of international trade on the exchange rate of each country.

$\varepsilon_{i,t}$ is the error term.

4. Results and discussion

Table 1 presents the results for instrumental variables regression analysis estimating the effectiveness of interventions on exchange rate volatility. The Sargan-Hansen over identification test concludes on the validity of the instruments. (P -val=0.843). The results show that over the sample period, (first quarter of 1980 to the third quarter of 2014) the Bank of Canada's interventions were effective by changing the path of the exchange rate and reducing the volatility of the Canadian. There is a negative relationship between interventions of Bank of Canada and the volatility of Canadian dollar exchange rate against the \$ US. The negative sign associated to the interventions coefficient means the Bank of Canada is acting on the exchange rate in the direction desired. An increase (decrease) in international official reserves induces depreciation (appreciation) of the exchange rate. An increase of one percentage point of international official reserves is significantly associated with 0.019% exchange rate depreciation. Monetary interventions are therefore essentially stabilizing the volatility of the exchange rate of the Canadian dollar against the US dollar. Thus, in order to reverse a pronounced upward trend in the rate of its currency or to slow down the rate of appreciation of its currency, the Bank of Canada is selling on the foreign exchange market its own currency from its own cash in exchange for American dollar. That result confirms the conclusions of Adler & Tovar (2011) and Daude *et al.*, (2014). Furthermore, the results reveal a positive and significant relationship between the interest rate differential between Canada and United States and the volatility of the exchange rate. A 1% increase in the difference between Canadian and US interest rates induces an increase in the volatility of the exchange rate of 0.05%.

The coefficient of inflation rate differential remains very marginal and weak on the volatility of exchange rate. This is partly explained by the fact that in the beginning of 1980s, the inflation rate in United States experienced a downward trend because of the restrictive monetary policy and the control of inflation. Over the same period, the level of inflation has significantly decreased in Canada especially from 1984 to the decade 1990-2000. The variability of the inflation differential has been low between Canada and the United States over the 1980s and 1990s. A surplus of the trade balance induces variability in the order of 0.0045% of the exchange rate between Canadian and US currencies. Both American and Canadian financial markets affect the Canadian dollar differently. While the S&P 500 appears to be positively and significantly correlated with the volatility of Canadian dollar, the S&P/TSX affects negatively the exchange rate. Investors' portfolios in the US financial market affect the volatility of the Canadian dollar. In fact, changes in interest rates applied to assets by affecting the costs and returns of different financial assets generally lead to speed movements in financial stocks as investors rebalance most of their portfolios. In doing so, the financial markets re-adjust very quickly and the exchange rate over-reacts strongly so that the financial markets can recover their balance. This creates exchange rate volatility. S&P/TSX negatively and significantly impacts the volatility of the Canadian dollar by reducing about 0.20% of the volatility of Canadian dollar against the US dollar. Equation (1) reports the estimation over the entire sample period. Equation (2) and (3) report the Chow test results for 1980Q1-1998Q3 and 1998Q4-2014Q3.

Table 1. *Estimation of Canadian behavioral exchange rate equation*

Variables	Equation (1)	Equation (2)	Equation (3)
Official reserves	-0.0197 (0.0078)	-0.0151 (0.0045)	0.0161 (0.0218)
Inflation rate	0.0036 (0.0004)	0.0041 (0.0003)	-0.0022 (0.004)
Growth rate	0.00451 (0.0036)	0.00227 (0.0026)	0.00667 (0.0053)
S&P500	0.247 (0.123)	0.0164 (0.0898)	0.720 (0.279)
Interest rate	0.0056 (0.0028)	0.0069 (0.0015)	-0.0047 (0.011)
Trade balance	0.0045 (0.0013)	0.0011 (0.00083)	0.0096 (0.0018)
S&P TSX	-0.201 (0.0619)	-0.919 (0.0359)	-0.320 (0.0706)
constante	-00869 (0.145)	-0.0157 (0.0960)	-1.521 (0.683)
Sargan/Hansen	0.813	0.128	0.1011
F instruments	F=169.2	F=133.4	F=238.6
R ²	0.413	0.467	0.574

The results of the estimation of the behavioral equation by instrumental variables reveal that the interventions of the Swiss National Bank are effective. One percentage point increase in international reserves is significantly associated with 0.33% of reduction for the volatility of the Swiss franc. We conclude that the interventions of the National Bank Switzerland stabilize exchange rate volatility of Swiss franc against the US dollar. In addition, the associated coefficient for interventions in the foreign exchange market is significantly stronger (0.33%) than Canadian interventions (0.019%).

The health of the Swiss economy has greatly affected the Swiss franc. Growth rate is negatively and significantly associated to the volatility of the Swiss franc. The good health of the Swiss economy in recent years has protected the Swiss franc from high volatility. When we consider the exchange rate between the Swiss franc and the US dollar, we are led to question the impact of Swiss health on its exchange rate. A 1% increase in the growth rate reduces volatility by 0.21% against the dollar American. However, if strong growth in Switzerland is followed by vigorous growth in United States, the effect on the demand for Swiss francs will be weak.

Table 2. *Estimation of Swiss behavioral exchange rate equation*

Variables	Equation (1)	Equation (2)
Official reserves	-0.330 (0.0301)	-0.328 (0.0327)
Inflation rate	-0.0623 (0.0680)	-0.0676 (0.0691)
Growth rate	-0.218 (0.0524)	-0.214 (0.0532)
S&P500	-0.0327 (0.00952)	-0.0317 (0.00998)
Interest rate	-0.0781 (0.0637)	-0.0744 (0.0663)
Trade balance	-0.0208 (0.0122)	-0.0193 (0.0128)
SMI	-0.0257 (0.0138)	-0.0257 (0.0138)
constante	0.0323 (0.145)	-0.0126 (0.0960)
Sargan/Hansen	0.4797	0.5255
F instruments	F=205.7	F=184.3
R ²	0.794	0.795

Furthermore, US and Swiss financial markets significantly affect the price of the Swiss franc against the US dollar. S&P 500 returns negatively and significantly reduces 0.032% volatility of the Swiss franc.

5. Conclusion

This paper is particularly interested in the effectiveness of Canadian and Swiss central bank intervention in the foreign exchange market. The recent excessive movements in the exchange rate of several economies relative to the US dollar have seen most monetary authorities intervene in the foreign exchange market to support their currencies.

The choice of Canada and Switzerland is based on a number of reasons: The Canadian and Swiss economies have similarities and divergences. They are small open industrialized economies. Moreover, these two economies have an inflation target in monetary policy formulation and their currencies are considered to be quite sensitive to factors such as the interest rate and inflation differentials vis-à-vis the United States. Finally, as divergences, Canada's policy is to intervene on the foreign exchange market in a discretionary rather than a systematic way, and only in exceptional circumstances when the Swiss National Bank is reputed to be one of the most interventionist central banks in the world. The interventions of the two central banks were effective and stabilizing the exchange rates of the two economies vis-à-vis the US dollar. Although the economic literature presented in this study mentioned the various intervention channels, our study focused mainly on assessing the effectiveness of the interventions of the two central banks on their respective currencies. Subsequent works may involve explicitly testing which channel seems more effective in impacting exchange rate volatility through interventions.

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